   

Draft Environmental Impact Statement on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs

July 2014

NOAA FISHERIES
West Coast Region

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
PROGRAM PLANNING AND INTEGRATION
Silver Spring, Maryland 20910

Dear Reviewer:

In accordance with provisions of the National Environmental Policy Act (NEPA), we enclose for your review the *Draft Environmental Impact Statement (DEIS) on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs*.

This DEIS is prepared pursuant to NEPA to assess the environmental impacts associated with the National Oceanic and Atmospheric Administration proceeding with the National Marine Fisheries Service (NMFS) review and evaluation of two resource management plans and appended hatchery and genetic management plans submitted jointly by the fishery co-managers for hatchery programs in Puget Sound, under Limit 6 of the 4(d) rules for Puget Sound Chinook salmon and steelhead that are listed under the Endangered Species Act.

Additional copies of the DEIS may be obtained from the Responsible Program Official identified below. The document is also accessible electronically through the NMFS West Coast Region's website at http://www.westcoast.fisheries.noaa.gov/hatcheries/ps_deis/ps_deis.html.

Written comments should be submitted through mail, facsimile (fax), or email to the Responsible Program Official identified below. Written comments submitted during the agency's 90-day public comment period must be received by **October 23, 2014**. When submitting fax or email comments, include the following document identifier in the comment subject line: **Puget Sound Hatcheries EIS**.

Responsible Program Official:

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Sincerely,

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Patricia A. Montanio
NOAA NEPA Coordinator

Enclosure

TITLE OF ENVIRONMENTAL REVIEW	Draft Environmental Impact Statement on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs
RESPONSIBLE AGENCY AND OFFICIAL	William W. Stelle, Jr., Regional Administrator National Marine Fisheries Service, West Coast Region 7600 Sand Point Way NE, Building 1 Seattle, WA 98115-0070 (206) 526-6150
CONTACT	Steve Leider NMFS Sustainable Fisheries Division, West Coast Region 510 Desmond Drive SE, Suite 103 Lacey, WA 98503 Steve.Leider@noaa.gov (Note: not for commenting) (360) 753-4650
LOCATION OF PROPOSED ACTIVITIES	The Puget Sound basin in Washington
PROPOSED ACTION	NMFS would review and evaluate two resource management plans and appended hatchery and genetic management plans submitted by the fishery co-managers. NMFS would evaluate and make Endangered Species Act (ESA) take determinations under the ESA Limit 6 of 4(d) rules for listed Puget Sound Chinook salmon and steelhead. Adaptive management provisions in the resource management plans would apply.
ABSTRACT	The Washington Department of Fish and Wildlife and the Puget Sound treaty tribes jointly submitted to NMFS two resource management plans for salmon and steelhead hatchery programs in Puget Sound. The resource management plans are the proposed frameworks through which the co-managers would jointly manage Puget Sound salmon and steelhead hatchery programs. The plans include the foundation and general principles for adaptive management, which would guide decisions on a continuing basis as new information emerges. Appended to the resource management plans are 117 hatchery and genetic management plans describing 133 individual salmon and steelhead hatchery programs, including State, tribal, and one Federal program. These plans describe each program in detail, including fish life stages produced and potential measures to minimize risks of negative impacts that may affect listed fish. NMFS' determination of whether the plans achieve the conservation standards of the ESA, as set forth in Limit 6 of 4(d) rules for listed salmon and steelhead, is the Federal action requiring National Environmental Policy Act (NEPA) compliance. The analysis within the environmental impact statement (EIS) informs NMFS, hatchery operators, and the public about the current and anticipated direct, indirect, and cumulative environmental effects of operating Puget Sound salmon and steelhead hatchery programs under the full range of alternatives.

Executive Summary

Draft Environmental Impact Statement on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs

Introduction

Salmon and steelhead have been produced in Puget Sound hatcheries since the late 1800s. The benefit of hatcheries at the outset was to produce large numbers of hatchery-origin fish for harvest purposes. Hatcheries have contributed 70 to 80 percent of the catch in coastal salmon and steelhead fisheries. As the fish's natural habitat was degraded by human development and activities like dams, forest practices, and urbanization, the role of hatcheries shifted toward mitigation for lost natural production and reduced harvest opportunity. In recent decades, the hatcheries and associated hatchery practices have evolved to support conservation and recovery of natural-origin salmon populations (i.e., wild or native salmon) by preserving important genetic resources, reintroducing fish to areas where local populations have been lost, and guarding against the catastrophic loss of naturally spawned populations at critically low abundance levels. Hatchery production also presents risks to natural-origin salmon and steelhead. These include genetic risks from hatchery-origin fish to natural-origin fish as a result of poor broodstock and rearing practices, risks of competition with and predation on naturally spawned populations, and incidental harvest of natural-origin fish in fisheries targeting hatchery-origin fish.

The Washington Department of Fish and Wildlife (WDFW) and the Puget Sound treaty tribes (hereafter referred to as the co-managers) have jointly submitted to the National Marine Fisheries Service (NMFS) two resource management plans (RMPs) for hatchery programs in Puget Sound. The RMPs are the proposed frameworks through which the co-managers would jointly manage Puget Sound salmon and steelhead hatchery programs to achieve the conservation requirements of the Endangered Species Act (ESA). The plans are consistent with the framework of the Puget Sound Salmon Management Plan implemented under *United States v. Washington* (1974) for coordination of treaty fishing rights, non-tribal harvest, artificial production objectives, and artificial production levels. One RMP describes hatchery programs that produce Chinook salmon (titled *Puget Sound Chinook Salmon Hatcheries - A Component of the Comprehensive Chinook Salmon Management Plan*). The other RMP describes hatchery programs for steelhead and coho salmon, pink salmon, fall-run chum salmon, and sockeye salmon (titled *Puget Sound Hatchery Strategies for Steelhead, Coho Salmon, Chum Salmon, Sockeye Salmon & Pink Salmon*).

Appended to the hatchery RMPs are hatchery and genetic management plans (HGMPs) that describe the hatchery programs that produce salmon and steelhead, including fish life stages produced and potential measures proposed by the co-managers to minimize the risk of negatively affecting listed salmon and steelhead (Table S-1). These measures include research, monitoring, and evaluation actions that would guide future program adjustments under adaptive management. Adaptive management is the deliberate process of using research, monitoring, and scientific evaluation in making decisions in the face of uncertainty.

Table S-1. ESA status of listed Puget Sound salmon and steelhead.

Species	ESU/DPS	Current Endangered Species Act Listing Status
Chinook salmon (*Oncorhynchus tshawytscha*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Chum salmon *(O. keta)*	Hood Canal summer-run (includes Strait of Juan de Fuca summer-run)	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Steelhead (*O. mykiss*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Coho salmon (*O. kisutch*)	Puget Sound/Strait of Georgia	Species of Concern (69 Fed. Reg. 19975, April 15, 2004)

Source: NMFS

NMFS' determination of whether the RMPs and appended HGMPs achieve the conservation standards of the ESA, as set forth in Limit 6 under the salmon and steelhead 4(d) rules, is the Federal action requiring National Environmental Policy Act (NEPA) compliance. Although this environmental impact statement (EIS) itself will not determine whether the RMPs or HGMPs meet ESA requirements—those determinations are made under the specific criteria of the ESA and the section 4(d) rule—the analyses within the EIS will inform NMFS, hatchery operators, and the public about the current and anticipated cumulative environmental effects of operating Puget Sound hatchery programs under the full range of alternatives.

What are 4(d) rules?

Section 4(d) of the Endangered Species Act (ESA) directs NMFS to issue regulations to conserve species listed as threatened. This applies particularly to "take," which can include any act that kills or injures fish, and may include habitat modification. The ESA prohibits any take of species listed as endangered, but some take of threatened species that does not interfere with survival and recovery may be allowed.

The salmon and steelhead 4(d) rules apply take prohibitions to all actions except those within the 13 limits to the rules. The limits, or exemptions, describe specified categories of activities that contribute to conserving listed salmon. A separate, but closely related, tribal 4(d) rule creates an additional limit for tribal resource management plans.

Limit 5 of the 4(d) rule, using specific criteria, provides limits on the prohibitions of “take” for a variety of hatchery purposes, based on NMFS’ evaluation and approval of hatchery and genetic management plans (HGMPs) submitted by hatchery operators. Limit 6 of the 4(d) rule provides limits on the prohibitions of “take” for joint tribal and state plans developed under *United States v. Washington* processes, including artificial production actions.

Proposed Action

Under the Proposed Action, NMFS would evaluate the two proposed Puget Sound hatchery RMPs and appended HGMPs for ESA compliance. The two RMPs and appended HGMPs for Puget Sound hatcheries would be implemented by the co-managers. Adaptive management provisions in the resource management plans would apply.

Project Area

The project area covered in this EIS includes Puget Sound freshwater and marine areas within the United States from the Canadian border south and west to exclude rivers and marine areas in the Strait of Juan de Fuca west of the Elwha River (Figure S-1). Portions of 12 counties in Washington State are included. There are 133 salmon and steelhead hatchery programs in the project area described in 117 HGMPs. The programs are operated by WDFW and the Puget Sound treaty tribes, including one program that is operated by the U.S. Fish and Wildlife Service. These hatchery programs operate using 49 hatcheries and 34 net pens, and produce over 146 million salmon and steelhead per year.

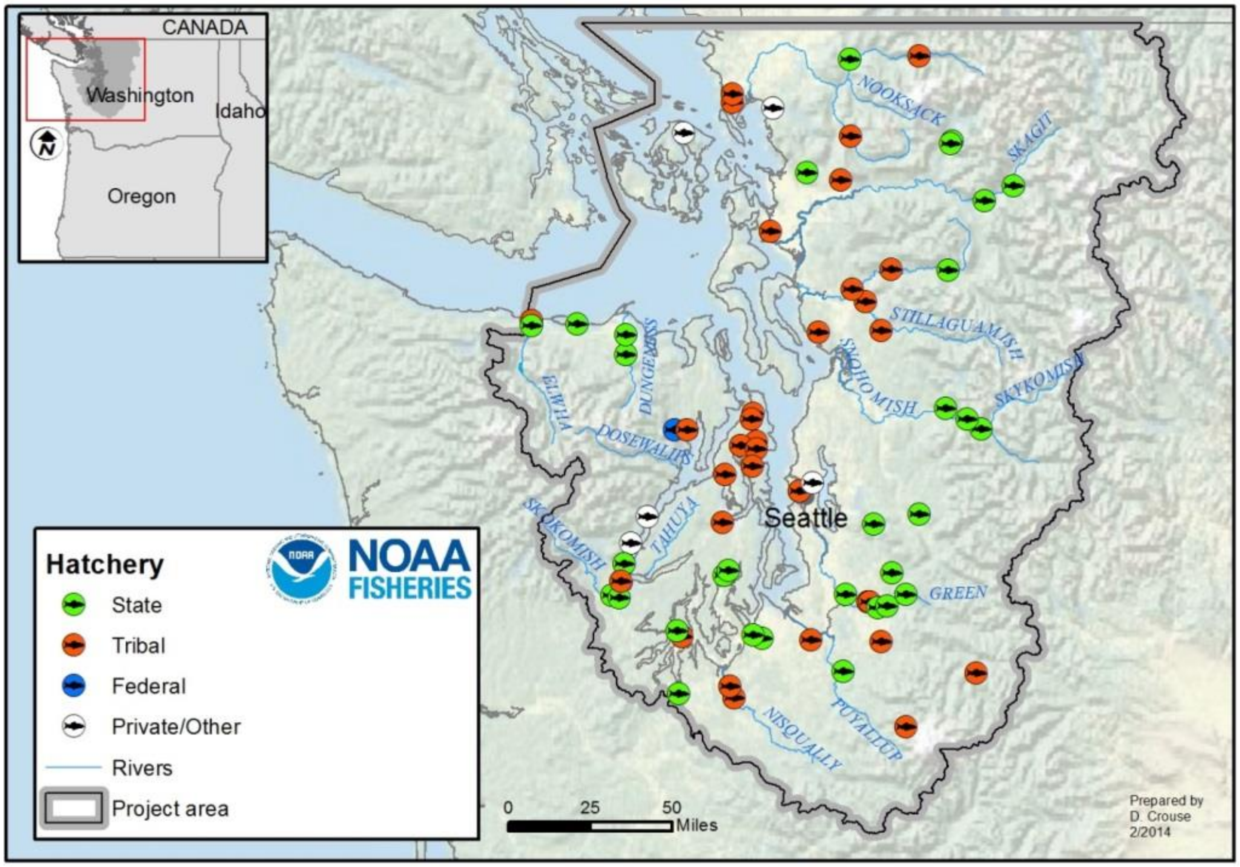

Figure S-1. Project area and general hatchery locations.

Purpose and Need

NMFS' purpose for the Proposed Action is to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity, and distribution of listed species of salmon and steelhead in Puget Sound.

NMFS' need for the Proposed Action is to:

- Respond to the request of the co-managers for an exemption from the take prohibitions of section 9 of the ESA for their hatchery programs triggered by submission of RMPs and appended HGMPs under Limit 6 of the 4(d) rule.

- Provide, as appropriate, tribal and non-tribal fishing opportunities as described under the state and tribal co-managers' Puget Sound Salmon Management Plan implemented under *United States v. Washington.*

The co-managers' purpose in developing and submitting RMPs and HGMPs is to operate their hatcheries to meet resource management and protection goals with the assurance that any harm, death, or injury to fish within a listed evolutionarily significant unit (ESU) or distinct population segment (DPS) does not appreciably reduce the likelihood of a species' survival and recovery and is not in the category of prohibited take under the ESA's 4(d) rule.

What is an ESU? What is a DPS?

NMFS lists salmon as threatened or endangered according to the status of their Evolutionarily Significant Units (ESUs). An ESU is a salmon population that is 1) substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

In contrast to salmon, NMFS lists steelhead under the joint NMFS-U.S. Fish and Wildlife Service (USFWS) policy for recognizing distinct population segments (DPSs) under the ESA. This policy adopts criteria similar to, but somewhat different than, those in the ESU policy for determining when a group of vertebrates constitutes a DPS. A group of organisms is discrete if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors." NMFS lists steelhead according to the status of the steelhead DPS.

The co-managers' need for the Proposed Action is to continue to maintain and operate salmon and steelhead hatchery programs for conservation, mitigation, and tribal and non-tribal fishing opportunity pursuant to the Puget Sound Salmon Management Plan implemented under *United States v. Washington,* and treaty rights preservation purposes while meeting ESA requirements. WDFW and the Puget Sound treaty tribes strive to protect, restore, and enhance the productivity, abundance, and diversity of Puget Sound salmon and steelhead and their ecosystems to sustain treaty ceremonial and subsistence fisheries, treaty and non-treaty commercial and recreational fisheries, non-consumptive fish benefits, and other cultural and ecological values.

Relationship of New or Changed HGMPs to this EIS

The two hatchery RMPs reviewed in this EIS were submitted to NMFS in 2004. The appended HGMPs are identified and analyzed in this EIS. Under the RMPs, changes to HGMPs (including new programs) resulting from adaptive management, new information, or actions may occur over time. If changed or new

HGMPs are submitted to NMFS while this EIS is being developed, they will be addressed in the final EIS, or publication of a draft supplemental EIS may be required per Council on Environmental Quality regulations for supplemental reviews.

Relationship between the ESA and the National Environmental Policy Act (NEPA)

The relationship between the ESA and NEPA is complex, in part because both laws address environmental values related to the impacts of a Proposed Action. However, each law has a distinct purpose, and the scope of review and standards of review under each statute are different.

The purpose of an EIS under NEPA is to promote disclosure, analysis, and consideration of the broad range of environmental issues surrounding a proposed major Federal action by considering a full range of reasonable alternatives, including a No-action Alternative. Public involvement promotes this purpose.

The purpose of the ESA is to conserve listed species and the ecosystems upon which they depend. Determinations about whether hatchery programs in Puget Sound meet ESA requirements are made under section 4(d) or section 7 of the ESA. Each of these ESA sections has its own substantive requirements, and the documents that reflect the analyses and decisions are different than those related to a NEPA analysis.

It is not the purpose of this EIS to suggest to the reader any conclusions relative to the ESA analysis for this action. While the NEPA Record of Decision (ROD) identifies the selected NEPA alternative, the ROD does not determine whether that alternative complies with the ESA.

NMFS acknowledges that the terminology and analyses of environmental effects on listed species under the ESA and under NEPA are similar and can lead to confusion. Language in this draft EIS has been chosen in an effort to minimize the confusion between a NEPA analysis and an ESA analysis. For instance, 'jeopardize,' 'endanger,' 'recover,' and similar terms are commonly used to describe the effect of actions under an ESA analysis. This EIS minimizes use of those terms by alternatively using in their place terms and phrases, such as 'risks and benefits' that describe how hatchery actions affect natural-origin fish.

Alternatives Analyzed in Detail

Alternative 1 (No Action)

Under this alternative, NMFS would not evaluate and make take determinations under the ESA section 4(d) rules for the co-managers' Puget Sound hatchery RMPs and appended HGMPs. For analysis purposes, it is assumed that hatchery production would continue at current levels (Table S-2). It is also assumed that adaptive management provisions would not be applied.

Table S-2. Annual hatchery releases of juvenile salmon and steelhead (in thousands) under the alternatives and percent changes relative to Alternative 1.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
Species	Number	Number	Percent Change from Alt. 1	Number	Percent Reduction from Alt. 1	Number	Percent Increase from Alt. 1
Chinook Salmon	45,317	45,317	0	37,182	18	51,307	13
Coho Salmon	14,592	14,592	0	11,391	22	18,478	27
Steelhead	2,468	2,468	0	1,409	43	2,561	4
Chum Salmon	44,995	44,995	0	44,475	1	57,495	28
Pink Salmon	4,500	4,500	0	4,500	0	5,000	11
Sockeye Salmon	35,125	35,125	0	35,125	0	35,125	0
Total	**146,997**	**146,997**	**0**	**135,082**	**8**	**169,967**	**16**

Source: Draft HGMPs.

Alternative 2 (Proposed Action)

This alternative consists of hatchery operations as proposed under the co-managers' RMPs and appended HGMPs. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Hatchery production would be the same as under existing conditions (Table S-2), program sizes would meet conservation requirements for listed species, harvest benefits would continue, and adaptive management conservation measures would be applied to all programs to reduce risks to listed species.

Alternative 3 (Reduced Production)

Compared to Alternative 2, this alternative would provide greater conservation benefits to salmon and steelhead. Under this alternative, hatchery production for the purpose of harvest would be reduced 50 percent for all Chinook salmon, coho salmon, and steelhead programs in watersheds where watershed management strategies are oriented at protecting and recovering indigenous Chinook salmon populations where they still occur, and where management actions use the most locally adapted stock to re-establish natural production in watersheds in which suitable habitat exists but indigenous Chinook salmon populations no longer occur (Table S-2). Reductions would not occur in watersheds that may not have historically supported self-sustaining natural Chinook salmon populations. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Harvest benefits would be reduced but would continue, and conservation measures would be applied to all programs to reduce risks to listed species.

Alternative 4 (Increased Production)

Compared to Alternative 2, this alternative would provide more harvest benefits. Under this alternative, hatchery production would increase for programs where existing facility and funding capacity exists (Table S-2). No new facilities or water sources would be developed. The additional production would depend on the match of available hatchery capacity with the broodstock collection, spawning, incubation, and rearing needs of the fish species produced. Increases could occur for programs whose purposes include harvest and/or conservation. Increases in production would need to be in compliance with the ESA. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Program size and harvest benefits would increase, and conservation measures would be applied to all programs to reduce risks to listed species.

A summary of key distinguishing features of the alternatives is shown in Table S-3.

Table S-3. Summary of key distinguishing features of the alternatives.

Alternative	NMFS Review, Evaluation, and Approval of Plans under 4(d) Rules	Number of Hatchery-origin Fish Released	Adaptive Management and Mitigation Measures[1]	Changes in Hatchery Programs	Conservation Benefit to Salmon and Steelhead
Alternative 1 (No Action)	No evaluation and determination under the 4(d) rules	146,997,000	Unknown	Unknown	Unknown
Alternative 2 (Proposed Action)	Evaluation and determination under the 4(d) rules	146,997,000	Adaptive management provisions of plans would apply, and mitigation measures would reduce risks	Conservation measures would be applied to all programs to reduce risks and increase benefits while meeting conservation requirements	Conservation requirements for listed salmon and steelhead would be met
Alternative 3 (Reduced Production)	Same as Alternative 2	135,082,000	Same suite of measures as Alternative 2, but potentially fewer measures applied than under Alternative 2	Same as Alternative 2 Hatchery production for harvest purposes would be reduced 50 percent in watersheds with recovery categories 1 and 2 Chinook salmon populations	Greater than Alternative 2
Alternative 4 (Increased Production)	Same as Alternative 2	169,967,000	Same suite of measures as Alternative 2, but potentially more measures applied than under Alternative 2	Same as Alternative 2 Hatchery production would increase to the extent there is capacity at existing facilities	Less than Alternative 2

[1] The purpose of adaptive management mitigation measures is to reduce risks to salmon and steelhead from hatchery programs. The suite of potential mitigation measures to apply is the same for each action alternative, but implementation of the measures may vary depending on the specific risk being addressed.

Summary of Resource Effects

Provided in Table S-4 is a summary of the predicted resource effects under each of the four alternatives. The summary reflects the detailed resource discussions in Chapter 4, Environmental Consequences.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Fish				
Listed Salmon, Steelhead, and Trout: Chinook salmon and summer-run chum salmon, steelhead, and bull trout	Hatchery production would pose a moderate risk and low benefit to the Chinook salmon ESU.	Risks would be reduced and benefits would increase through adaptive management compared to Alternative 1.	Overall risk to the Chinook salmon ESU would decrease compared to Alternative 2, and the overall benefit would be the same as Alternative 1.	Overall risk to the Chinook salmon ESU would be similar to Alternative 1, and the overall benefit would increase.
	Hatchery production would pose a low risk to the Hood Canal summer-run chum salmon ESU.[3]		Same as Alternative 1.	Same as Alternative 1.
	Hatchery production would pose a moderate risk and low benefit to the steelhead DPS.		Overall risk to the steelhead DPS would decrease compared to Alternative 2, and the overall benefit would be the same as Alternative 1.	Same as Alternative 1.
	Hatchery production would pose a low risk and low benefit to bull trout.		Same as Alternative 1.	Same as Alternative 1.
Non-listed Salmon: coho salmon, chum salmon, pink salmon, and sockeye salmon	Hatchery production would pose competition, predation, genetics, and hatchery facilities and operation risks and would provide total return, viability, and marine-derived nutrient benefits.	Risks would be potentially reduced and benefits would be potentially increased through adaptive management compared to Alternative 1.	Risks and benefits are further reduced compared to Alternative 2.	Risks and benefits are further increased compared to Alternative 2.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Other Fish Species	Depending on the species, other fish species would be affected if they compete with, are prey of, or prey on salmon and steelhead.	Adaptive management would not be expected to affect abundance compared to Alternative 1.	Potential reductions in the food supply for fish species that prey on salmon and steelhead, and reduced risk to other fish species that are preyed on, compete with, or are caught in fisheries targeting salmon and steelhead compared to Alternative 1.	Potential increases in the food supply for fish species that prey on salmon and steelhead while also increasing risk to other fish that are preyed on, compete with, or are caught in fisheries targeting salmon and steelhead compared to Alternative 1.
Socioeconomics				
Commercial Salmon and Steelhead Fishing	Annual non-tribal and tribal commercial harvest value would be 2,679,392 fish and $15,577,897 in gross economic value.	Same as Alternative 1.	Commercial harvest value would decrease by 4 percent and gross economic value would decrease by 7 percent compared to Alternative 1.	Commercial harvest value would increase by 7 percent and gross economic value would increase by 10 percent compared to Alternative 1.
Recreational Salmon and Steelhead Fishing	Annual net economic value of recreational fisheries is $58,965,077. Recreational fishing trips and expenditures would be 997,380 trips and $70,245,440 in expenditures.	Same as Alternative 1.	Annual net economic value of recreational fisheries, fishing trips, and expenditures would decrease by 8 percent compared to Alternative 1.	Annual net economic value of recreational fisheries, fishing trips, and expenditures would increase by 18 percent compared to Alternative 1.
Regional and Subregional Economic Impacts	Annual hatchery operations and personal income would be $106,888,758 and 2,060 jobs. Overall personal income would be $92,249.981.	Same as Alternative 1.	Annual hatchery operations and personal income would decrease by 10 percent, jobs would decrease by 8 percent, and personal income would decrease by 8 percent compared to Alternative 1.	Annual hatchery operations and personal income would increase by 15 percent, jobs would increase by 13 percent, and personal income would increase by 14 percent compared to Alternative 1.
Fisheries in Major River Systems	Tribal commercial and recreational fisheries would occur in 15 major river systems.	Same as Alternative 1.	Decreases in hatchery production would have a major negative effect on fisheries for nine of the major river systems for at least one species of salmon and steelhead compared to Alternative 1.	Increases in hatchery production would have a major positive effect on fisheries for six of the major river systems for at least one species of salmon and steelhead compared to Alternative 1.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource.

Resource	Alternative 1 (No Action) [1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Ports and Fishing Communities	Annual personal income from commercial and recreational fishing would be $41,724,837 in north Puget Sound, $46,838,604 in south Puget Sound, and $5,686,540 in the Strait of Juan de Fuca. Annual employment from commercial and recreational fishing would be 975 jobs in north Puget Sound, 913 jobs in south Puget Sound, and 173 jobs in the Strait of Juan de Fuca.	Same as Alternative 1.	Annual personal income and employment from commercial and recreational fishing would decrease by 6 percent to 12 percent for each subregion compared to Alternative 1.	Annual personal income and employment from commercial and recreational fishing would increase by 10 percent to 19 percent for each subregion compared to Alternative 1.
Environmental Justice				
Native American Tribes of Concern	Annual tribal harvest would be 1,321,156 fish and tribal gross economic values would be $9,148,467. Harvest would contribute to ceremonial and subsistence uses.	Same as Alternative 1	Annual tribal harvest would decrease by 7 percent and tribal gross economic values would decrease by 11 percent compared to Alternative 1. Harvest would contribute to ceremonial and subsistence uses similar to Alternative 1.	Annual tribal harvest would increase by 8 percent and tribal gross economic values would increase by 11 percent compared to Alternative 1. Harvest would contribute to ceremonial and subsistence uses similar to Alternative 1.
Non-tribal User Groups of Concern	Annual net revenues for commercial fishers would be $3,335,926.	Same as Alternative 1	Annual net revenues for commercial fishers would decrease by 1 percent compared to Alternative 1.	Annual net revenues for commercial fishers would increase by 8 percent compared to Alternative 1.
Communities of Concern	Annual per capita income would range from $18,056 to $29,521 for King, Mason, Pierce, and Clallam Counties.	Same as Alternative 1.	Annual per capita income would decrease by less than 1 percent for each of the four counties compared to Alternative 1.	Annual per capita income would increase by less than 1 percent for the four counties compared to Alternative 1.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource.

Resource	Alternative 1 (No Action) [1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Wildlife				
Hatchery Operations and Wildlife	Potential for slight transfer of pathogens from hatchery-origin fish to wildlife, hatchery weirs may restrict some wildlife movements, wildlife may benefit from salmon and steelhead carcasses, and hatchery program operations (e.g., use of screens and water) may have a negative effect on wildlife presence and mortality.	Same as Alternative 1.	Potential water use would decrease, which would be beneficial to wildlife, compared to Alternative 1.	Potential water use would increase, which would make slightly less water available for wildlife, compared to Alternative 1.
ESA-listed Species: Southern Resident killer whale	Southern Resident killer whales would occupy their existing habitat in the project area with a similar abundance, and would continue to prey on salmon, especially Chinook salmon.	Same as Alternative 1.	Supply of salmon as food would decrease (i.e., adult hatchery-origin Chinook salmon would decrease by 13 percent), which may negatively impact Southern Resident killer whales, compared to Alternative 1.	Supply of salmon as food would increase (i.e., adult hatchery-origin Chinook salmon would increase by 11 percent), which may benefit Southern Resident killer whales, compared to Alternative 1.
Non-listed Species: Birds	Bald eagles and other birds that feed on salmon and steelhead would continue to occupy their existing habitat in the project area with similar abundances, and would continue to feed on salmon and steelhead. Similarly, other birds that are not as dependent on salmon as a food supply would also continue to occur in the project area similar to existing conditions.	Same as Alternative 1.	Supply of hatchery-origin salmon and steelhead as food for bald eagles and other birds that feed primarily on salmon and steelhead would decrease up to 8 percent, compared to Alternative 1. This effect would generally not affect other birds that only occasionally feed on salmon and steelhead.	Supply of hatchery-origin salmon and steelhead as food for bald eagles and other birds that feed primarily on salmon and steelhead would increase up to 16 percent compared to Alternative 1. The effect on other birds that only occasionally feed on salmon and steelhead would be the same as Alternative 3.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Non-listed Marine Mammals: Steller sea lion, California sea lion, and harbor seal	Steller sea lions, California sea lions, and harbor seals would continue to occupy their existing habitat in the project area with similar abundances, and the species would continue to feed as generalists on fish species that include salmon and steelhead.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Other Wildlife Species	Other wildlife species would continue to occupy their existing habitat in the project area with similar abundances, and would continue to feed on a variety of prey including salmon and steelhead.	Same as Alternative 1.	Supply of hatchery-origin salmon and steelhead as food would decrease 8 percent, which would primarily affect river otter, compared to Alternative 1. Other wildlife species are generalists and feed on a variety of prey species, and thus would not be affected by the decrease in salmon and steelhead.	Supply of hatchery-origin salmon and steelhead as food would increase 16 percent, which would primarily benefit river otter. The effect on other wildlife species that are generalists and feed on a variety of prey species would be the same as Alternative 3.
Water Quality and Quantity	Hatchery operations would comply with NPDES permits. The potential would exist for effluents to periodically exceed permit limits and for instances of non-reporting, and the nutrient contributions from decomposition of salmon carcasses would continue.	Potential improvements in water quality and reduction in water use through adaptive management.	Same as Alternative 2.	Same as Alternative 2.
Human Health	Chemical and antibiotic use would be consistent with Federal and state guidelines. Potential exposure to pathogens.	Potential decrease in the use of chemicals and antibiotics through adaptive management.	Potential for further decrease in the use of chemicals and antibiotics relative to Alternative 2. Potential exposure to pathogens would be the same as Alternative 2.	Potential increase in the use of chemicals and antibiotics relative to Alternative 1. Potential exposure to pathogens would be the same as Alternative 2.

1 An adaptive management process is not part of Alternative 1.
2 Potential differences between the no-action and the action alternatives would be due to differences in hatchery production and application of adaptive management mitigation measures under the action alternatives.
3 Effects of releases of listed hatchery-origin summer-run chum salmon are not evaluated in this EIS because they are addressed in previous environmental reviews.

Preferred Alternative

This draft EIS does not contain a preferred alternative. NMFS anticipates identifying the preferred alternative in the final EIS after considering the comments received on this document. The preferred alternative may be a blend of more than one of the alternatives evaluated in this EIS. The preferred alternative may or may not be the environmentally preferred alternative, which will be identified in the ROD. The environmental effects of the preferred alternative will be explained in the final EIS and summarized in the ROD.

How should reviewers approach this EIS?

NMFS encourages reviewers to perform the following activities:

1. Review the draft EIS to gain an understanding of how it is organized and how the alternatives are framed and analyzed.
2. Carefully consider the information provided in Chapters 4 and 5, Environmental Consequences and Cumulative Effects, respectively.

After considering the effects, comment on how NMFS should formulate a preferred alternative for publication in the final EIS and ROD.

Acronyms and Abbreviations

BIA	Bureau of Indian Affairs
BOD	Biochemical oxygen demand
BMPs	Best Management Practices
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAO	Departmental Administrative Order
DDT	Dichlorodiphenyltrichloroethane
DPS	Distinct population segment
EA	Environmental Assessment
Ecology	Washington Department of Ecology
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ERD	Evaluation and recommended determination
ESA	Endangered Species Act
ESU	Evolutionarily significant unit
FONSI	Finding of no significant impact
FRAM	Fishery Regulation Assessment Model
HGMP	Hatchery and genetic management plan
HPV	Hatchery Program Viewer
HSRG	Hatchery Scientific Review Group
Magnuson-Stevens Act	Magnuson-Stevens Fishery and Conservation Act
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service (also called NOAA Fisheries Service)
NPDES	National Pollutant Discharge Elimination System
NWIFC	Northwest Indian Fisheries Commission
PCBs	Polychlorinated biphenyls
pHOS	Proportion of hatchery-origin spawners
PL	Public Law
PNI	Proportionate natural influence
PSSMP	Puget Sound Salmon Management Plan

RM	River mile
RMP	Resource management plan
ROD	Record of Decision
SEPA	State Environmental Policy Act
Services	USFWS and NMFS
TMDL	Total Maximum Daily Load
TRT	Technical Recovery Team
TSS	Total Suspended Solids
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
VSP	Viable salmonid population
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

Glossary of Key Terms

Abundance: Generally, the number of fish in a defined area or unit. It is also one of four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Adaptive management: A deliberate process of using research, monitoring, and scientific evaluation in making decisions in the face of uncertainty.

Acclimation pond: A concrete or earthen pond or a temporary structure used for rearing and imprinting juvenile fish in the water of a particular stream before their release into that stream.

Adfluvial: A term used to describe fish migrating between lakes and rivers or streams.

Adipose fin: A small fleshy fin with no rays, located between the dorsal and caudal fins of salmon and steelhead. The adipose fin is often "clipped" on hatchery-origin fish so they can be differentiated from natural-origin fish.

All H Analyzer (AHA): The technical tool used to assess genetic risks from hatcheries for Chinook salmon. See Appendix E, Overview of the All H Analyzer.

Alevin: A newly hatched salmon or steelhead that is still attached to its yolk sac.

Amphipod: A small aquatic freshwater or marine crustacean with a segmented body, of the order Amphipoda.

Anadromous: A term used to describe fish that hatch and rear in fresh water, migrate to the ocean to grow and mature, and return to freshwater to spawn.

Analysis area: Within this Environmental Impact Statement (EIS), the analysis area is the geographic extent that is being evaluated for each resource. For some resources (e.g., socioeconomics and environmental justice), the analysis area is larger than the project area. See also **Project area**.

Best management practice (BMP): A policy, practice, procedure, or structure implemented to mitigate adverse environmental effects.

Biological Review Team: A group of scientists organized by the National Marine Fisheries Service to perform a technical assessment of biological information for a species associated with the Endangered Species Act.

Blackmouth salmon: Immature Chinook salmon that enter and reside in Puget Sound until they reach sexual maturity.

Broodstock: A group of sexually mature individuals of a species that is used for breeding purposes as the source for a subsequent generation.

Bycatch: Fish, marine birds, or mammals unintentionally captured during fisheries using any of a variety of gear types.

Catch area: A salmon management catch reporting area designated by Washington State statute (WAC 220-22-030), used in the socioeconomic analysis in this EIS.

Co-managers: Washington Department of Fish and Wildlife and Puget Sound treaty tribes, which are jointly responsible for managing fisheries and hatchery programs in the state of Washington.

Commercial harvest: The activity of catching fish for commercial profit.

Conservation: Used generally in the EIS as the act or instance of conserving or keeping fish resources from change, loss, or injury, and leading to their protection and preservation. This contrasts with the definition under the United States Endangered Species Act (ESA), which refers to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to the ESA are no longer necessary.

Conservation hatchery program: A program whose purpose is to benefit a listed natural-origin fish population and contribute to its recovery. See also **Integrated hatchery program**.

Copepod: Any of numerous minute marine and freshwater crustaceans of the subclass Copepoda, having an elongated body and a forked tail.

Critical habitat: A specific term and designation within the ESA, referring to habitat area essential to the conservation of a listed species, though the area need not actually be occupied by the species at the time it is designated.

Dewatering: Typically, the immediate downstream habitat effects associated with a water withdrawal action that diverts the entire flow of a stream or river to another location.

Dissolved oxygen (DO): The amount of oxygen that is dissolved in a particular body of water. The amount of DO can be an important indicator of the condition of the water body.

Distinct Population Segment (DPS): Under the ESA, the term "species" includes any subspecies of fish or wildlife or plants, and any "Distinct Population Segment" of any species or vertebrate fish or wildlife that interbreeds when mature. The ESA thus considers a DPS of vertebrates to be a "species." The ESA does not however establish how distinctness should be determined. Under NMFS policy for Pacific salmon, a population or group of populations will be considered a DPS if it represents an Evolutionarily Significant Unit (ESU) of the biological species. In contrast to salmon, NMFS lists steelhead runs under the joint NMFS-U.S. Fish and Wildlife Service (USFWS) Policy for recognizing DPSs (DPS Policy: 61 Fed. Reg. 4722, February 7, 1996). This policy adopts criteria similar to those in the ESU policy, but applies to a broader range of animals to include all vertebrates.

Diversion screen: A screen used at a hatchery facility, dam, or weir to direct fish, usually to keep fish from entering a water intake. See also **Water intake screen**.

Diversity: Variation at the level of individual genes (polymorphism); provides a mechanism for populations to adapt to their ever-changing environment. It is also one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Domestication: See **Hatchery-induced selection**.

Endangered species: As defined in the ESA, any species that is in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act (ESA): A United States law that provides for the conservation of endangered and threatened species of fish, wildlife, and plants.

Environmental justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Escapement: Adult salmon and steelhead that survive fisheries and natural mortality, and return to spawn.

Estuary: The area where fresh water of a river meets and mixes with the salt water of the ocean.

Euphasiid: A tiny crustacean that resembles shrimp, from the genus *Euphausia*.

Evolutionarily Significant Unit (ESU): A concept NMFS uses to identify Distinct Population Segments of Pacific salmon (but not steelhead) under the ESA. An ESU is a population or group of populations of Pacific salmon that 1) is substantially reproductively isolated from other populations, and 2) contributes substantially to the evolutionary legacy of the biological species. See also **Distinct Population Segment** (pertaining to steelhead).

Ex-vessel value: The dollar value that commercial fishers receive for their product once it leaves the fishing vessel.

Federal Register: The United States government's daily publication of Federal agency regulations and documents, including executive orders and documents that must be published per acts of Congress.

Fingerling: A juvenile fish.

First Nation: A term referring to the aboriginal people located in what is now Canada.

Fishery: Harvest by a specific gear type in a specific geographical area during a specific period of time.

Fishway: Any structure or modification to a natural or artificial structure for the purpose of providing or enhancing fish passage.

Fitness: As used in this EIS, the propensity of a group of fish (e.g., populations) to survive and reproduce.

Fluvial: A term used to describe fish that migrate between rivers as a part of their life history.

Forage fish: Small fish that breed prolifically and serve as food for predatory fish.

Fork length: The length of an individual fish measured from the tip of the snout to the end of the middle caudal (tail) fin rays.

Fishery Regulation Assessment Model (FRAM): Simulation model developed to estimate the impacts of Pacific Coast fisheries on Chinook salmon and coho salmon.

Fry: Juvenile salmon and steelhead that are usually less than one year old and have absorbed their egg sac.

Gross economic value: For commercial fisheries, the price received for a product "at the dock" (also referred to as ex-vessel value). For recreational fisheries, total trip-related expenditures.

Habitat: The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal; the place where an organism naturally lives.

Habitat capacity: A category of habitat attributes for salmon and steelhead associated with the species food supply, growth, and growth efficiency in their natural environment.

Hatchery and genetic management plan (HGMP): Technical documents that describe the composition and operation of individual hatchery programs. Under Limit 5 of the 4(d) rule, NMFS uses information in HGMPs to evaluate impacts on salmon and steelhead listed under the ESA.

Hatchery facility: A facility (e.g., hatchery, rearing pond, net pen) that supports one or more hatchery programs.

Hatchery-induced selection: The process whereby genetic characteristics of hatchery populations become different from their source populations as a result of selection in hatchery environments (also referred to as domestication).

Hatchery operator: A Federal agency, state agency, or Native American tribe that operates a hatchery program.

Hatchery-origin fish: A fish that originated from a hatchery facility.

Hatchery-origin spawner: A hatchery-origin fish that spawns naturally.

Hatchery program: A program that artificially propagates fish. Most hatchery programs for salmon and steelhead spawn adults in captivity, raise the resulting progeny for a few months or longer, and then release the fish into the natural environment where they will mature.

Hatchery program viewer (HPV): A technical tool used in the EIS to evaluate risks to Chinook salmon and steelhead and from hatchery programs. See Appendix F, Hatchery Program Viewer (HPV) Analysis.

Hatchery scientific review group (HSRG): The independent scientific panel established and funded by Congress to provide an evaluation of hatchery reform in Puget Sound from 2000 to 2005.

Haulout: A site where seals, sea lions, and other marine mammals climb out of water to rest on land.

Headwaters: The place from which the water flowing through a watershed originates (also referred to as the source).

Hydropower: Electrical power generation through use of gravitational force of falling water at dams.

Inbreeding depression: Reduced fitness as a result of inbreeding associated with mating between closely related individuals.

Incidental: Unintentional, but not unexpected.

Integrated hatchery program: A hatchery program that intends for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the natural environment. Differences between hatchery-origin and natural-origin fish are minimized, and hatchery-origin fish are integrated with the local populations included in an ESU or DPS.

Introgression: Gene flow from non-local hatchery-origin salmon and steelhead into natural-origin populations.

Isolated hatchery program: A hatchery program that intends for the hatchery-origin population to be reproductively segregated from the natural-origin population. These programs produce fish that are different from local populations. They do not contribute to conservation or recovery of populations included in an ESU or DPS.

Limit 6: Under section 4(d) of the ESA (see **Section 4(d) rule**), a limit on "take" prohibitions that applies to joint state/tribal resource management plans developed under the *United States v. Washington* (1974) or *United States v Oregon* (1969) proceedings.

Limiting factor: A physical, chemical, or biological feature that impedes species and their independent populations from reaching a viable status.

Macroinvertebrate: An invertebrate that is of visible size, such as a clam or worm.

Mainstem: The principle channel of a drainage system into which other smaller streams or rivers flow.

Mouth (of river): The location where a river flows into a larger body of water (e.g., estuarine or marine water).

National Environmental Policy Act (NEPA): A United States environmental law that established national policy promoting the enhancement of the environment and established the President's Council on Environmental Quality (CEQ).

National Marine Fisheries Service (NMFS): A United States agency within the National Oceanic and Atmospheric Administration and under the Department of Commerce charged with the stewardship of living marine resources through science-based conservation and management, and the promotion of healthy ecosystems.

National Pollutant Discharge Elimination System (NPDES): A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation.

Native fish: Fish that are endemic to or limited to a specific region.

Natural-origin: A term used to describe fish that are offspring of parents that spawned in the natural environment rather than the hatchery environment, unless specifically explained otherwise in the text. "Naturally spawning" and similar terms refer to fish spawning in the natural environment.

Net economic value: For commercial fisheries, the gross economic value received by vessel operators and fish processors minus costs (e.g., wages, operational expenses, and fixed costs). For recreational fisheries, the net willingness to pay for recreational fishing opportunities, over and above expenditures.

Net pen: A fish rearing enclosure used in marine areas.

Northwest Indian Fisheries Commission (NWIFC): A support service organization to 20 treaty Indian tribes in western Washington, created following the *U.S. vs Washington* ruling, that assists member tribes in their role as natural resources co-managers.

Out-migration: The downstream migration of salmon and steelhead toward the ocean.

Parr: A young salmon or steelhead in its first 2 years of life, when it lives in freshwater.

Parts per million (ppm): The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations.

Pathogen: An infectious microorganism that can cause disease (e.g., virus, bacteria, fungus) in its host.

PCD Risk 1 Assessment: The technical tool used to assess competition and predation risks in fresh water from Chinook salmon hatchery programs. See Appendix D, PCD RISK 1 Assessment.

pH: A measure of the relative acidity or alkalinity of a solution, expressed on scale from 0 to 14, with the neutral point at 7.0. Acid solutions have pH values lower than 7.0, and basic (i.e., alkaline) solutions have pH values higher than 7.0.

Piscivorous: A term used to describe an animal, such as a bird or fish, that eats fish.

Planktivorous: A term used to describe an animal, such as a fish, that eats plankton.

Pod: A social unit of Orca (e.g., Southern Resident Killer Whales) comprised of related families along maternal lines that form a loose aggregation of individuals.

Polychlorinated biphenyls (PCBs): A group of synthetic, toxic industrial chemical compounds that are chemically inert and not biodegradable; they once were used in making paint and electrical transformers.

Polycyclic aromatic hydrocarbons (PAHs): A group of more than 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances such as tobacco or charbroiled meat.

Population: A group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group.

Precocial: A term used to describe juvenile hatchery-origin salmon and steelhead males that exhibit qualities of sexual maturity at an unusually early age.

Preferred alternative: The alternative selected or developed from an evaluation of alternatives. Under NEPA, the preferred alternative is the alternative an agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

Productivity: The rate at which a population is able to produce reproductive offspring. It is one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Project area: Geographic area where the Proposed Action will take place. See also **Proposed Action**.

Proportion of hatchery-origin spawners (pHOS): The proportion of naturally spawning salmon or steelhead that are hatchery-origin fish.

Proportionate natural influence (PNI): A measure of hatchery influence on natural populations that is a function of both the proportion of hatchery-origin spawners spawning in the natural environment (pHOS) and the percent of natural-origin broodstock incorporated into the hatchery program (pNOB). PNI can also be thought of as the percentage of time all the genes of population collectively have spent in the natural environment.

Proposed Action: NMFS' review and evaluation of the Puget Sound hatchery resource management plans and appended HGMPs (and hatchery releases) submitted by the co-managers.

Puget Sound treaty tribes: Indian tribes in the project area with treaty fishing rights pursuant to *United States v. Washington*. The tribes are the Jamestown S'Klallam, Lower Elwha Klallam, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Port Gamble S'Klallam, Skokomish, Suquamish, Puyallup, Sauk-Suiattle, Squaxin Island, Stillaguamish, Swinomish, Tulalip, and Upper Skagit Tribes.

Record of decision (ROD): The formal NEPA decision document that is recorded for the public. It is announced in a Notice of Availability in the Federal Register.

Recovery: Defined in the ESA as the process by which the decline of an endangered or threatened species is stopped or reversed, or threats to its survival neutralized so that its long-term survival in the wild can be ensured, and it can be removed from the list of threatened and endangered species.

Recovery category: A category of hatchery management goals and watershed management strategies developed by the co-managers that are based on the current and historical distribution of Chinook salmon populations and their potential for protecting, restoring, and enhancing salmon and steelhead productivity.

Recovery plan: Under the ESA, a formal plan from NMFS (for listed salmon and steelhead) outlining the goals and objectives, management actions, likely costs, and estimated timeline to recover the listed species.

Recreational harvest: The activity of catching fish for non-commercial reasons (e.g., sport or recreation).

Recruitment: The number of fish that enter the harvestable stock due to growth and/or migration.

Recurrent relationship (for wildlife): A relationship between a wildlife species and salmon and steelhead that may affect some wildlife populations, but in general does not affect the distribution, abundance, viability, and/or population status of the wildlife species as a whole.

Redd: The spawning site or "nest" in stream and river gravels in which salmon and steelhead lay their eggs.

Redd superimposition: A form of spawning competition when later arriving fish spawn in the same places (i.e., redds) as earlier arriving spawners, disturbing and causing mortality to the eggs of the previous spawners.

Resident fish: Fish that reside in fresh water or marine water throughout their life cycle.

Residuals: Hatchery-origin fish that out-migrate slowly, if at all, after they are released. Residualism occurs when such fish residualize rather than out-migrate as most of their counterparts do.

Resource management plan (RMP): A plan that includes a process, management objectives, specific details, and other information required to manage a natural resource. For this EIS, the resources are salmon and steelhead hatchery programs in Puget Sound.

Restoration spawner abundance: The number of Chinook salmon spawners needed to achieve population replacement (where one progeny replaces each parent) under Properly Functioning Conditions (i.e., historical, pristine habitat conditions). Described in detail in Ford (2011).

Run: The migration of salmon or steelhead from the ocean to fresh water to spawn. Defined by the season they return as adults to the mouths of their home rivers.

Run size: The number of adult salmon or steelhead (i.e., harvest plus escapement) returning to their natal areas. See also **Total Return**.

Salish Sea: The network of coastal waterways located between the southwestern tip of British Columbia and the northwestern tip of the state of Washington.

Salmonid: A fish of the taxonomic family Salmonidae, which includes salmon, steelhead, and trout.

Scoping: In NEPA, an early and open process for determining the extent and variety of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).

Section 4(d) rule: A special regulation developed by NMFS under authority of Section 4(d) of the ESA, modifying the normal protective regulations for a particular threatened species when it is determined that such a rule is necessary and advisable to provide for the conservation of that species.

Section 7 consultation: Federal agency consultation with NMFS or USFWS (dependent on agency jurisdiction) on any actions that may affect listed species, as required under section 7 of the ESA.

Section 10 permit: A permit for direct take of listed species for scientific purposes or to enhance the propagation or survival of listed species. Issued by NMFS or USFWS (dependent on agency jurisdiction) as authorized under section 10(a)(1)(A) of the ESA.

Selective fishery: A fishery that targets specific fish or fish runs. Selective fisheries often target hatchery-origin fish.

Smolts: Juvenile salmon and steelhead that have left their natal streams, are out-migrating downstream, and are physiologically adapting to live in salt water.

Smoltification: The process of physiological change that juvenile salmon and steelhead undergo in fresh water while out-migrating to salt water that allow them to live in the ocean.

Spatial structure: The spatial structure of a population refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. It is one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Spawner abundance: The number of spawners.

Stock: A group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place in a different season.

Straying (of hatchery-origin fish): A term used to describe when hatchery-origin fish return to and/or spawn in areas where they are not intended to return/spawn.

Strong relationship (for wildlife): A relationship between a wildlife species and salmon and steelhead where the fish provide an important role in the distribution, abundance, viability, and/or population status of the wildlife species, especially at particular life stages or specific seasons.

Subsistence harvest: Harvest by Puget Sound treat tribes to meet the nutritional needs of tribal members.

Subyearling: Juvenile salmon less than 1 year of age.

Supplementation: Release of fish into the natural environment to increase the abundance of naturally reproducing fish populations.

Take: Under the ESA, the term "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Take for hatchery activities includes, for example, the collection of listed fish (adults and juveniles) for hatchery broodstock, the collection of listed hatchery-origin fish to prevent them from spawning naturally, and the collection of listed fish (juvenile and adult fish) for scientific purposes.

Terminal area: The area of fisheries that take place in the last portion of the migration route of fish returning to fresh water to spawn (usually in marine water, but for some species can also occur in fresh water).

Thalweg: The deepest part of the stream that carries water during low-flow conditions.

Threat: A human action or natural event that causes or contributes to limiting factors; threats may be caused by past, present, or future actions or events.

Threatened species: As defined by section 4 of the ESA, any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Total maximum daily load (TMDL): A calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards.

Total return: The number of adult salmon or steelhead (i.e., harvest plus escapement) returning to their natal areas. See also **Run size**.

Tributary: A stream or river that flows into a larger stream or river.

Turbidity: The amount of solid particles that are suspended in water and that cause light rays shining through the water to scatter. Turbidity makes water cloudy or even opaque in extreme cases.

Viability: As used in this EIS, a measure of the status of listed salmon and steelhead that uses four criteria: abundance, productivity, spatial distribution, and diversity.

Viable salmonid population (VSP): An independent population of salmon or steelhead that has a negligible risk of extinction over a 100-year timeframe (McElhany et al. 2000).

Volitional: A term used to describe the method of passively releasing fish that allows fish to leave hatchery facilities when the fish are ready.

Water intake screen: A screen used to prevent entrainment of salmonids into a water diversion or intake. See also **Diversion screen**.

Watershed: An area of land where all of the water that is under it or drains off of it goes into the same place.

Weir: An adjustable dam placed across a river to regulate the flow of water downstream; a fence placed across a river to catch fish.

Yearling: Juvenile salmon or steelhead that has reared at least 1 year in the hatchery.

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1.0 PURPOSE OF AND NEED FOR THE PROPOSED ACTION

1.1 Introduction

The Washington Department of Fish and Wildlife (WDFW) and the Puget Sound treaty tribes[1] (hereafter referred to as the co-managers) have jointly submitted to the National Marine Fisheries Service (NMFS) two resource management plans (RMPs) for hatchery programs in Puget Sound. One RMP describes hatchery programs that produce Chinook salmon (titled *Puget Sound Chinook Salmon Hatcheries - A Component of the Comprehensive Chinook Salmon Management Plan*) (WDFW and Puget Sound Treaty Tribes [PSTT] 2004). The other RMP describes hatchery programs for steelhead, coho salmon, pink salmon, fall-run chum salmon, and sockeye salmon (titled *Puget Sound Hatchery Strategies for Steelhead, Coho Salmon, Chum Salmon, Sockeye Salmon & Pink Salmon*) (PSTT and WDFW 2004). The RMPs are available on NMFS' website at: http://www.westcoast.fisheries.noaa.gov/hatcheries/ps_deis/ps_deis.html.

The RMPs are the proposed frameworks through which the co-managers would jointly manage Puget Sound salmon and steelhead hatchery programs to achieve the conservation requirements of the Endangered Species Act (ESA). The plans are consistent with the framework of the Puget Sound Salmon Management Plan implemented under *United States v. Washington* (1974) (Box 1-1) for coordination of treaty fishing rights, non-tribal harvest, artificial production objectives, and artificial production levels (for more detail see Subsection 1.7.2.2, *United States v. Washington*, and Subsection 1.7.2.3, Puget Sound Salmon Management Plan). Treaty fishing rights include tribal subsistence, ceremonial, and commercial harvests, and non-tribal harvests include commercial and recreational fishing. The plans also include the foundation and general principles for adaptive management that will guide hatchery management decisions on a continuing basis as new information about hatchery operations and effects emerges.

[1] There are 16 tribes with fishing rights (pursuant to *United States v. Washington*) within the analysis area. The tribes are Jamestown S'Klallam, Lower Elwha Klallam, Lummi, Muckleshoot, Nisqually, Nooksack, Port Gamble S'Klallam, Skokomish, Suquamish, Puyallup, Sauk-Suiattle, Squaxin Island, Stillaguamish, Swinomish, Tulalip, and Upper Skagit Tribes. Another tribe (Makah Tribe) is included within the analysis area for environmental justice (Subsection 3.4.2, Native American Tribes of Concern). The Samish and Snoqualmie Tribes also are federally recognized within the analysis area but they are not parties to *United States v. Washington* (Subsection 1.7.2.2, *United States v. Washington*) and do not have federally recognized treaty fishing rights at the present time.

Box 1-1. What is *United States v. Washington,* and what does it do?

United States v. Washington is the 1974 Federal court proceeding that enforces and implements treaty fishing rights for salmon and steelhead (and other species) returning to Puget Sound (and other areas). Fishing rights and access to fishing areas in Puget Sound were reserved in treaties that the Federal government signed with the tribes in the 1850s. Under *United States v. Washington*, the Puget Sound Salmon Management Plan is the implementation framework for the allocation, conservation, and equitable sharing principles defined in *United States v. Washington* that governs the joint management of harvest of salmon resources between the Puget Sound treaty tribes and State of Washington. The joint hatchery Resource Management Plans (RMPs) reviewed in this EIS, and joint harvest RMPs such as the Puget Sound Chinook harvest management plan, are components of the Puget Sound Salmon Management Plan.

Appended to the hatchery RMPs are 77 WDFW hatchery and genetic management plans (HGMPs) and 39 tribal plans (Table 1.1-1) (Box 1-2). There is also one plan for a U.S. Fish and Wildlife Service (USFWS) program[2]. Thus, the EIS includes a total of 117 HGMPs, including state, tribal, and Federal programs. The HGMPs describe in detail each hatchery program, including fish life stages produced and potential measures proposed by the co-managers to minimize the risk of negatively affecting listed fish. These measures include research, monitoring, and evaluation actions that would guide future program adjustments. Some HGMPs include programs for more than one type of life stage at release or release location. Thus, the 117 HGMPs describe a total of 133 individual salmon and steelhead programs.

Table 1.1-1. Number of HGMPs in each RMP.

RMP	State	Tribal	Federal	Total
Puget Sound Chinook Salmon Hatcheries - A Component of the Comprehensive Chinook Salmon Management Plan	28	13	0	41
Puget Sound Hatchery Strategies for Steelhead, Coho Salmon, Chum Salmon, Sockeye Salmon & Pink Salmon	49	26	1	76
TOTAL	**77**	**39**	**1**	**117**

[2] The state and tribes are cooperators with the Federal program. In addition to on-site releases, fish from the program are used by the Skokomish Tribe and Port Gamble S'Klallam Tribe net pen programs.

Box 1-2. What are hatchery resource management plans, and what are the differences between hatchery facilities, hatchery programs, and hatchery and genetic management plans?

Resource Management Plans - Puget Sound hatchery resource management plans, or hatchery RMPs, are jointly prepared by the Washington Department of Fish and Wildlife and Puget Sound treaty tribes and describe the overall role of hatcheries in achieving the co-managers' resource management goals in a manner intended to be consistent with the ESA. The plans encompass tribal, state, and Federal hatchery programs and facilities, which often operate in the same watersheds, exchange eggs, and share rearing space to maximize effectiveness. Hatchery programs are defined by how artificial production for individual species at facilities are managed and operated. Hatchery facilities are defined by the physical structures required for artificial production.

Hatchery and Genetic Management Plans - Hatchery and genetic management plans, or HGMPs, are specific to the ESA and are outlined under Limit 5 of the section 4(d) rule. They are the plans that describe hatchery programs and reflect the fish species propagated, the main hatchery facility used, the life stage when the fish are released, and the location of fish releases. In general, several hatchery programs and their associated HGMPs are associated with each primary hatchery facility. For example, the Kendall Creek Hatchery facility supports a spring Chinook salmon, steelhead, and two coho salmon programs described in four HGMPs (Table 1.5-1). Although most HGMPs describe single programs, some HGMPs include more than one program. Adaptive management is a key provision of the RMPs and appended HGMPs, providing a framework for each plan type to evolve over time in response to new information.

NMFS' determination of whether the RMPs and appended HGMPs achieve the conservation standards of the ESA, as set forth in the salmon section 4(d) rule [50 CFR 223.203(b)(6)], is the Federal action requiring National Environmental Policy Act (NEPA) compliance. Although this EIS itself will not determine whether the RMPs or HGMPs meet ESA requirements – those determinations are made under the specific criteria of the ESA and the section 4(d) rule – the analyses within the EIS will inform NMFS, hatchery operators, and the public about the current and anticipated direct, indirect, and cumulative environmental effects of operating Puget Sound hatchery programs under the full range of alternatives. A single environmental impact statement (EIS) has been prepared for the two RMPs and the appended HGMPs, because the two RMPs are similar and have related actions within the same action area. Although NEPA compliance exists for Elwha River hatchery programs (Subsection 1.8, Related NEPA

Analyses), those programs are included in this EIS because they are included in the RMPs and to allow a comprehensive analysis of all Chinook salmon, fall-run chum salmon, coho salmon, sockeye salmon, pink salmon, and steelhead hatchery programs operating within the geographic boundaries of the Puget Sound Chinook Salmon ESU and the Puget Sound Steelhead DPS.

The RMPs, and thus the EIS, do not have specific terms or durations. The HGMPs are appended to the RMPs and may or may not have specific terms or durations, depending on the circumstances of the different programs. Therefore, the term of the EIS will continue until such time as adaptive management, new information, actions, or changes in existing or baseline conditions warrant additional review under NEPA and the ESA. Such review may be triggered by a number of different mechanisms. For example, because many or all of the activities described in the HGMPs would require compliance with the ESA, substantial new information or project descriptions would likely require re-initiation of consultation for listed species under the ESA as provided in 50 CFR 402.16.

1.1.1 The Endangered Species Act

The ESA (16 U.S. Code [USC] 1531 *et seq.)* provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The purposes of the ESA are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in the act. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future.

NMFS and the USFWS (jointly referred to as the Services) share responsibility for implementing the ESA. Generally, USFWS manages land and freshwater species, while NMFS manages marine and anadromous species, such as salmon and steelhead. NMFS lists salmon as threatened or endangered according to the status of their Evolutionarily Significant Units (ESUs). An ESU is a salmon population that is 1) substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species (Johnson et al. 1994).

In 1996, NMFS and USFWS adopted a joint policy for recognizing Distinct Population Segments (DPSs) under the ESA (61 Fed. Reg. 4722, February 7, 1996). This policy adopts criteria similar to, but somewhat different than, those in the ESU policy for determining when a group of vertebrates constitutes a DPS: the group must be discrete from other populations, and it must be significant to its taxon. A group of organisms is discrete if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors" (61 Fed. Reg. 4722, February 7, 1996). NMFS lists steelhead according to the status of their DPS.

There are currently two salmon ESUs and one steelhead DPS that are federally listed as threatened in Puget Sound. Coho salmon are a species of concern (Table 1.1-2). Hatchery-origin salmon and steelhead that are part of an ESU or DPS are considered in making listing determinations for those ESUs and DPSs, and are included in the listings (70 Fed. Reg. 37204, June 28, 2005) (Box 1-3).

Table 1.1-2. ESA status of Puget Sound salmon and steelhead.

Species	DPS/ESU	Current Endangered Species Act Listing Status
Chinook salmon (*Oncorhynchus tshawytscha*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Chum salmon *(O. keta)*	Hood Canal summer-run (includes Strait of Juan de Fuca summer-run)	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Steelhead (*O. mykiss*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Coho salmon (*O. kisutch*)	Puget Sound/Strait of Georgia	Species of Concern (69 Fed. Reg. 19975, April 15, 2004)

Box 1-3. What is NMFS' policy on listing hatchery-origin fish under the ESA?

The viability of salmon and steelhead is defined by their abundance, productivity, spatial structure, and genetic/behavioral diversity. High abundance alone is not adequate to demonstrate viability of a salmon ESU or steelhead DPS.

NMFS' 1993 interim policy on artificial propagation of Pacific salmon stated that hatchery-origin fish should be listed only if they were essential to the conservation of the species. In 2001, however, the United States District Court in Oregon ruled that any hatchery-origin component that is part of a listed ESU must also be listed under the ESA (*Alsea Valley Alliance v. NMFS*, 161 F. Supp. 2d 1154, [D. Or. 2001]). NMFS subsequently modified its hatchery policy to conform to this ruling. NMFS' revised hatchery listing policy provides for the listing of a population that is found to be part of the ESU (for salmon) or DPS (for steelhead), regardless of whether it was naturally or artificially produced. Listing of fish from hatchery programs is warranted when they contain a substantial portion of the genetic diversity remaining in an ESU or DPS.

The revised hatchery listing policy (70 Fed. Reg. 37204, June 29, 2005) was upheld by the 9th Circuit in *Trout Unlimited v. Lohn*, 559 F3d 946 (2009).

1.1.2 Take of a Listed Species

The ESA contains several sections that set the foundation for managing listed species. Section 9 of the ESA prohibits the "take" of an endangered species. The term take is defined under the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct [16 USC 1532(19)]. NMFS' definition of harm includes significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, spawning, migrating, rearing, and sheltering (64 Fed. Reg. 60727, November 8, 1999).

In 2000, NMFS applied the section 9 take prohibitions to several threatened salmon species and steelhead (65 Fed. Reg. 42422, July 10, 2000). However, the prohibitions included some exceptions, or "limits," describing when section 9 take prohibitions would not apply. These 4(d) limits specify categories of activities where section 9 take prohibitions may not apply when activities contribute to conserving species listed as threatened or are governed by programs that adequately limit impacts on listed salmon and steelhead.

On June 28, 2005, NMFS promulgated and published an ESA section 4(d) rule for threatened salmon and steelhead on the Pacific coast (50 Code of Federal Regulations [CFR] 222.203; 70 Fed. Reg. 37160, June 28, 2005). On September 25, 2008, NMFS promulgated and published an ESA section 4(d) rule for threatened Puget Sound steelhead (70 Fed. Reg. 55451, September 25, 2008). For a full discussion of section 4(d) limits, see http://www.westcoast.fisheries.noaa.gov/permits/section_4d.html.

Limit 6 of this rule applies to joint tribal/state resource management plans developed under the *United States v. Washington* (1974) or *United States v. Oregon* (1969) court proceedings.

Under Limit 6 of the 4(d) rule, state and tribal governments conducting jointly managed hatchery or fishery activities would not be subject to the ESA section 9 take prohibitions, provided that activities are implemented under an RMP that meets the substantive requirements of Limit 6. Procedures for NMFS to determine that an RMP meets the requirements, including public notice of and comment on the RMPs, are also specified in Limit 6. While this EIS outlines the effects of hatchery operations on the human environment, it is not the documentation that determines whether the two RMPs meet the requirements of Limit 6.

The Puget Sound Hatchery RMPs and HGMPs

The co-managers' RMPs and associated HGMPs were submitted to NMFS for evaluation under the ESA on March 31, 2004. Those plans form the basis of the evaluations in this EIS. Programs terminated by the co-managers since 2004 are not included in the analyses, and programs developed since 2004 are analyzed (e.g., 2012 Elwha HGMPs). Environmental analyses of changed or new HGMPs submitted since 2012 (e.g., Chambers Creek winter-run steelhead programs) will be analyzed in the final EIS or in a draft supplemental EIS, as appropriate. The plans will continue until such time as adaptive management, new information, actions, or changes in existing or baseline conditions warrant additional review under NEPA and the ESA. As warranted, changed plans will be submitted to NMFS for approval. NMFS and the co-managers anticipate that the substance of any changes to the plans will remain within the scope of this EIS. However, should the substance of any new or changed plan, or new scientific information, fall outside the scope of this EIS, additional NEPA compliance may be necessary. Public review and comment opportunities are described in Subsection 1.6.6, Future Public Review and Comment.

Background on Use of Hatcheries in Puget Sound

Salmon and steelhead have been produced in hatcheries in Puget Sound since the late 1800s. The benefit of hatcheries at the outset was to produce large numbers of hatchery-origin fish for harvest purposes. Hatcheries have contributed 70 to 80 percent of the catch in coastal salmon and steelhead fisheries. As the fish's natural habitat was degraded by activities like dams, forest practices, and urbanization, the role of hatcheries shifted toward mitigation for lost natural production and reduced harvest opportunity.

In recent decades, the hatcheries and associated hatchery practices have evolved to support conservation and recovery of natural-origin salmon populations (i.e., wild or native salmon) by preserving important genetic resources, reintroducing fish to areas where local populations have been lost, and guarding against the catastrophic loss of naturally spawned populations at critically low abundance levels. In the broadest context, hatchery production also benefits the Puget Sound ecosystem by providing a food source for terrestrial wildlife (e.g., eagles and bears) and marine mammals (e.g., Southern Resident killer whales), and by contributing unique marine-derived nutrients to freshwater environments that can only be obtained from salmon returning from the ocean.

Hatchery production has also presented risks to natural-origin salmon and steelhead (Busack and Currens 1995; Campton 1995; Integrated Hatchery Operations Team 1995; National Research Council 1996;

Lichatowich 1999; Independent Scientific Advisory Board 2003; Brannon et al. 2004; Recovery Implementation Science Team 2009). These risks include:

- Behavioral differences that reduce fitness and survival of hatchery-origin fish relative to naturally spawned fish
- Genetic degradation of hatchery-origin and natural-origin fish as a result of poor broodstock and rearing practices (inbreeding, outbreeding, domestication selection)
- Increased rates of competition with and predation on naturally spawned populations
- Incidental harvest of natural-origin fish in fisheries targeting hatchery-origin fish

Changes to hatchery programs intended to address genetic, ecological, and other risks of hatchery production may reduce benefits. For example, changes that include reduction in the level of fish production can conflict with the original mitigation goals for which the hatcheries were constructed and can result in fewer fish available for harvest.

1.2 Purpose and Need for Action

The EIS identifies the purpose and need for the NMFS action as well as that of the state and tribal fisheries co-managers.

NMFS' purpose for the Proposed Action is to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity, and distribution of listed species of salmon and steelhead in Puget Sound.

NMFS' need for the Proposed Action is to:

- Respond to the request of the co-managers for an exemption from the take prohibitions of section 9 of the ESA for their hatchery programs triggered by submission of RMPs and appended HGMPs under Limit 6 of the 4(d) rule.
- Provide, as appropriate, tribal and non-tribal fishing opportunities as described under the state and tribal co-managers' Puget Sound Salmon Management Plan implemented under *United States v. Washington*.

The co-managers' purpose in developing and submitting RMPs and HGMPs is to operate their hatcheries to meet resource management and protection goals with the assurance that any harm, death, or injury to fish within a listed ESU or DPS does not appreciably reduce the likelihood of a species' survival and recovery and is not in the category of prohibited take under the ESA's section 4(d) rule.

The co-managers' need for the Proposed Action is to continue to maintain and operate salmon and steelhead hatchery programs for conservation, mitigation, and tribal and non-tribal fishing opportunity pursuant to the Puget Sound Salmon Management Plan implemented under *United States v. Washington,* and treaty rights preservation purposes while meeting ESA requirements.

WDFW and the Puget Sound treaty tribes strive to protect, restore, and enhance the productivity, abundance, and diversity of Puget Sound salmon and steelhead and their ecosystems to sustain treaty ceremonial and subsistence fisheries, treaty and non-treaty commercial and recreational fisheries, non-consumptive fish benefits, and other cultural and ecological values.

As described in Box 1-4, NMFS has an obligation to administer the provisions of the ESA and to protect listed salmon and steelhead, and also has a Federal trust responsibility to treaty Indian tribes. Thus, NMFS seeks to harmonize the reduction in the negative effects of hatchery programs with the provision of hatchery-origin fish for tribal harvest and for conservation purposes.

Box 1-4. How does NMFS harmonize its conservation mandate under the ESA with stewardship of treaty Indian fishing rights?

In addition to the biological requirements for conservation under the ESA, NMFS has a Federal trust responsibility to treaty Indian tribes. In recognition of its treaty rights stewardship obligation and consistent with Secretarial Order 3206 (see Subsection 1.7.2.4, Secretarial Order 3206), NMFS, as a matter of policy, will accept some impacts that may result in increased risk to the listed species to provide limited tribal fishing opportunity. This approach recognizes that the treaty tribes have a right to conduct their fisheries within the limits of conservation constraints. Because of the Federal government's trust responsibility to the tribes, NMFS is committed to considering the tribal co-managers' judgment and expertise regarding conservation of trust resources. Limit 6 of the 4(d) rule explicitly requires this. However, the opinion of tribal co-managers and their immediate interest in fishing must be balanced with NMFS' responsibilities under the ESA.

This EIS will not document whether specific actions of hatchery programs meet the requirements of Limit 6 of the 4(d) rule under the ESA. Documentation of those ESA decisions will be made in separate processes consistent with applicable regulations as required by the ESA (Box 1-5).

Box 1-5. What is the relationship between the ESA and the National Environmental Policy Act (NEPA)?

The relationship between the ESA and NEPA is complex, in part because both laws address environmental values related to the impacts of a Proposed Action. However, each law has a distinct purpose, and the scope of review and standards of review under each statute are different.

The purpose of an EIS under NEPA is to promote disclosure, analysis, and consideration of the broad range of environmental issues surrounding a proposed major Federal action by considering a full range of reasonable alternatives, including a No-action Alternative. Public involvement promotes this purpose.

The purpose of the ESA is to conserve listed species and the ecosystems upon which they depend. Determinations about whether hatchery programs in Puget Sound meet ESA requirements are made under section 4(d) or section 7 of the ESA. Each of these ESA sections has its own substantive requirements, and the documents that reflect the analyses and decisions are different than those related to a NEPA analysis.

It is not the purpose of this EIS to suggest to the reader any conclusions relative to the ESA analysis for this action. While the NEPA Record of Decision (ROD) identifies the selected NEPA alternative, the ROD does not determine whether that alternative complies with the ESA.

NMFS acknowledges that the terminology and analyses of environmental effects on listed species under the ESA and under NEPA are similar and can lead to confusion. Language in this draft EIS has been chosen in an effort to minimize the confusion between a NEPA analysis and an ESA analysis. For instance, 'jeopardize,' 'endanger,' 'recover,' and similar terms are commonly used to describe the effect of actions under an ESA analysis. This EIS minimizes use of those terms, using in their place terms and phrases, such as 'risks and benefits' that describe how hatchery actions affect natural-origin fish.

1.3 Decisions to be Made

NMFS must decide on the following before the Proposed Action can be implemented:

- The preferred alternative following an analysis of all alternatives in this EIS and review of public comment on the EIS
- Whether the Proposed Action complies with ESA criteria under the section 4(d) rule

1.3.1 Preferred Alternative to be Identified in the Final EIS

A preferred alternative is not identified in this draft EIS; it will be identified in the final EIS. The preferred alternative could be the Proposed Action or it could be a combination of alternatives evaluated in the draft EIS. Information from the public review process will be used in selecting a preferred alternative.

1.3.2 Record of Decision

This NEPA process will culminate in a Record of Decision (ROD) that will record the selected alternative. The ROD will identify the environmentally preferred alternative; describe the preferred alternative and the selected alternative; and summarize the impacts expected to result from implementation of the selected alternative. The ROD will also address comments and responses on the final EIS. The ROD will be completed after public review and comment on the final EIS, and after the ESA determinations and public review processes associated with them are complete.

1.3.3 NMFS' Determination as to Compliance with the Section 4(d) Rule

Discussions between the co-managers and NMFS during the development of hatchery RMPs are conducted with the knowledge and understanding that the specific criteria under Limit 5 and Limit 6 of the 4(d) rule must be met before take coverage under the ESA can be issued. Criteria for ESA evaluation of HGMPs appended to the RMPs are the same as for Limit 5 (Artificial Propagation). HGMPs must:

1. Specify the goals and objectives for the hatchery program.
2. Specify the donor population's critical and viable threshold levels.
3. Prioritize broodstock collection programs to benefit listed fish.
4. Specify the protocols that will be used for spawning and raising the hatchery-origin fish.

5. Determine the genetic and ecological effects arising from the hatchery program.

6. Describe how the hatchery operation relates to fishery management.

7. Ensure that the hatchery facility can adequately accommodate listed fish if collected for the program.

8. Monitor and evaluate the management plan to ensure that it accomplishes its objective.

9. Be consistent with tribal trust obligations (65 Fed. Reg. 42422, July 10, 2000).

The decision as to whether the ESA 4(d) rule Limit 6 criteria have been met will be documented in NMFS' ESA decision documents at the end of the ESA evaluation process. Included with the ESA decision documents will be responses to comments on the RMPs and HGMPs received during public review as required by the 4(d) rule.

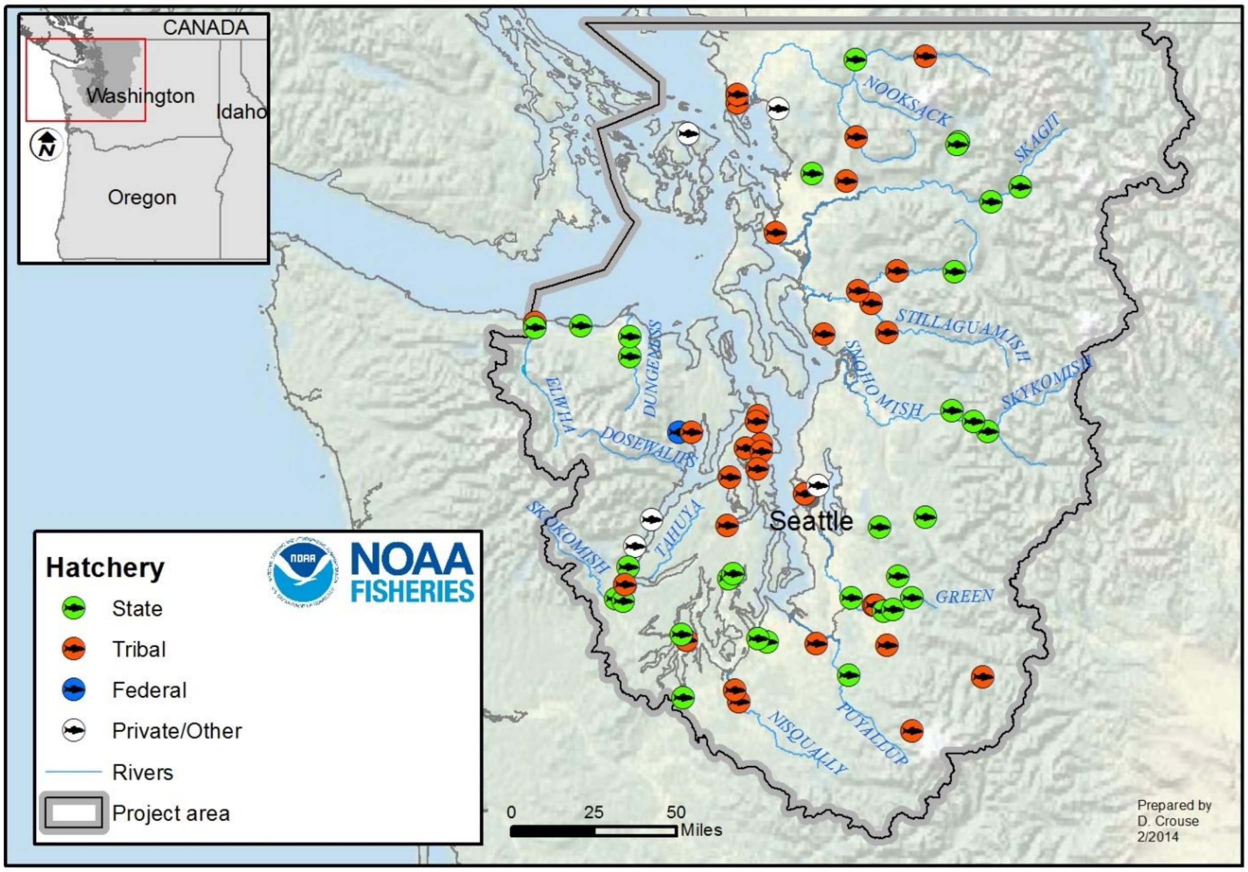
1.3.4 Biological Opinion on NMFS' Determination as to Compliance with the Section 4(d) Rule

ESA section 7(a)(2) provides that any action authorized, funded, or carried out by a Federal agency shall not jeopardize the continued existence of any endangered or threatened species or result in the adverse modification or destruction of designated critical habitat. NMFS' actions under section 4(d) are Federal actions, and NMFS must comply with section 7(a)(2). The USFWS funds and operates a hatchery program, and the Bureau of Indian Affairs (BIA) funds many of the tribal hatchery programs in Puget Sound; thus, both agencies have an obligation to consult with NMFS under section 7. NMFS' consultations under section 7 on those actions may be informed by this NEPA analysis. The results of these consultations are documented in biological opinions developed by the Services for the species under their jurisdiction. Biological opinions are produced near the end of the ESA evaluation and determination process, providing the Services conclusions regarding the likelihood that the proposed hatchery actions will jeopardize the continued existence of any listed species or adversely modify designated critical habitat for any listed species.

The biological opinions will identify conditions for implementing the RMPs and HGMPs. The 4(d) rule addresses the conservation of ESA-listed salmon and steelhead. Consultation under section 7 of the ESA considers effects on all listed species, including rockfish, Southern Resident killer whales, and marbled murrelets.

1.4 Project and Analysis Areas

The project area is the geographic area where the Proposed Action will take place. It includes marine and freshwater areas in Puget Sound and excludes rivers and marine areas in the Strait of Juan de Fuca west of the Elwha River (Figure 1.4-1). Portions of 12 counties in Washington State are included. Generally, natural and physical resources described in this EIS are for the aquatic component of the project area, except for the locations of hatchery facilities, which are also included in this EIS (Figure 1.4-1).



Source: HGMPs

Figure 1.4-1. Project area and general hatchery locations.

The analysis area is the geographic extent that is being evaluated for a particular resource. For some resources, the analysis area may be larger than the project area, because some of the effects of the alternatives may occur outside the project area. The analysis area is described at the beginning of Chapter 4, Environmental Consequences, under each resource.

1.5 Background on Puget Sound Hatcheries

1.5.1 Hatchery Facilities in Puget Sound

There are 49 hatcheries and 13 net pens that support 133 hatchery programs described in 117 HGMPs for salmon and steelhead that are operated by WDFW and the Puget Sound treaty tribes, including one hatchery that is operated by the USFWS (Figure 1.4-1 and Table 1.5-1). Hatcheries and their operations vary depending on the needs of individual programs, but there are many similarities (Box 1-6).

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS.

Primary Hatchery Facility[1]	Fish Population/Program Name	Draft HGMP Name and Year	Operator
Kendall Creek Hatchery	North Fork Nooksack Chinook Salmon/Kendall Creek Spring Chinook Salmon	Kendall Creek Chinook (North Fork Nooksack) (2005)	WDFW
	Chambers Creek (out-of-DPS) Winter Steelhead/Kendall Creek Winter Steelhead	Kendall Creek Winter Steelhead (2005)	
	Nooksack Coho Salmon/Kendall Creek Coho Salmon	Kendall Creek Coho (2003)	
	Nooksack Coho Salmon/Squalicum Harbor Coho Salmon Net Pen	Whatcom Creek Coho – Squalicum Harbor Net Pens (2003)	
Lummi Bay Hatchery	Green (out-of-ESU)/Lummi Bay Hatchery Summer-Fall Chinook Salmon	Lummi Bay Hatchery Fall Chinook (2000)	Lummi Indian Nation
	Nooksack Coho/Lummi Bay Coho Salmon	Lummi Nation Coho (2003)	
Skookum Creek Hatchery	South Fork Nooksack Chinook Salmon/Skookum Creek Spring Chinook Salmon	Skookum Creek Chinook (2006)	Lummi Indian Nation
	Nooksack Coho Salmon/Skookum Creek Hatchery Coho Salmon	Lummi Nation Coho (2003)	
Samish Hatchery	Green (out-of-ESU) Chinook Salmon/Samish Hatchery Summer-Fall Chinook Salmon (fingerlings)	Samish Hatchery Summer/Fall Chinook (fingerlings) (2005)	WDFW
	Nooksack (out-of-ESU) Chinook Salmon/Samish Hatchery Summer-Fall Chinook Salmon (yearlings)	Samish Hatchery Summer/Fall Chinook (yearlings) (2005)	
Whatcom Creek Hatchery	Chambers Creek (out-of-DPS) Winter Steelhead/Whatcom Creek Hatchery	Whatcom Creek Winter Steelhead Program (2005)	WDFW
	Nooksack Fall Chum Salmon/Whatcom Creek Chum Salmon	Whatcom Creek Chum Program (2005)	
	Nooksack Pink Salmon/Whatcom Creek Pink Salmon	Whatcom Creek Pink Program (2005)	

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	**Fish Population/Program Name**	**Draft HGMP Name and Year**	**Operator**
Glenwood Springs Hatchery	Green (out-of-ESU) Chinook Salmon/Glenwood Springs Fall Chinook Salmon	Glenwood Springs Fall Chinook (2005)	WDFW and Long Live the Kings
	Green (out-of-ESU) Chinook Salmon/Glenwood Springs Coho Salmon	Glenwood Springs Coho (2003)	
	Kendal Creek Chum Salmon/Glenwood Springs Chum Salmon	Glenwood Springs Chum (2003)	
Upper Skagit Hatchery	Skagit Fall Chum Salmon/Upper Skagit Hatchery	Upper Skagit Chum (2003)	Upper Skagit Indian Tribe
Marblemount Hatchery	Lower Skagit/Marblemount Fall Chinook Salmon/	Marblemount (Skagit River) Fall Chinook (fingerlings) (2005)	WDFW
	Cascade/Marblemount Spring Chinook Salmon Subyearling	Marblemount (Skagit River) Spring Chinook (fingerlings) (2005)	
	Cascade/Marblemount Spring Chinook Salmon Yearling	Marblemount (Skagit River) Spring Chinook (yearlings) (2005)	
	Upper Skagit/Marblemount Summer Chinook	Marblemount (Skagit River) Summer Chinook (2005)	
	Skagit/Marblemount Winter Steelhead	Marblemount Winter Steelhead (2005)	
	Skagit (Cascade)/Marblemount Coho Salmon	Marblemount Coho (2003)	
	Skagit/Oak Harbor Net Pen Coho Salmon	Oak Harbor Coho Net Pens (2003)	
	Skagit (Cascade)/San Juan Net Pen Coho Salmon	San Juan Coho Net Pens (2003)	
Barnaby Slough	Skagit/Barnaby Slough Winter Steelhead	Barnaby Slough Winter Steelhead (2005)	WDFW
Baker Lake Trout Pond Complex	Skagit (Baker)/Baker Lake Coho Salmon	Baker Lake Coho (2003)	WDFW
Baker Lake Sockeye Spawning Beach Facilities	Baker Lake/Baker Lake Sockeye Salmon	Baker Lake Sockeye (2003)	WDFW
Whitehorse Pond	North Fork Stillaguamish/Whitehorse Springs Hatchery NF Stillaguamish Summer Chinook Salmon	Whitehorse Pond Summer Chinook (2005)	WDFW
	Skamania lineage (out-of-DPS)/Whitehorse Pond Summer Steelhead	Whitehorse Pond Summer Steelhead (2005)	
	Chambers Creek lineage/(out-of-DPS)/Whitehorse Pond Winter Steelhead	Whitehorse Pond Winter Steelhead (2005)	
Harvey Creek	North Fork Stillaguamish/North Fork Stillaguamish Summer Chinook Salmon	Stillaguamish Summer/Fall Chinook (2003)	Stillaguamish Tribe
	South Fork Stillaguamish/South Fork Stillaguamish Fall Chinook Salmon	South Fork Stillaguamish Chinook (2007)	
	Stillaguamish/Stillaguamish Coho Salmon	Stillaguamish Coho (2004)	
	Stillaguamish/Stillaguamish Chum Salmon	Stillaguamish Chum (2003)	

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	**Fish Population/Program Name**	**Draft HGMP Name and Year**	**Operator**
Bernie Kai-Kai Gobin	Cascade/Tulalip Spring Chinook Salmon	Tulalip Spring Chinook (2004)	Tulalip Tribe
	Skykomish/Tulalip Summer Chinook Salmon	Bernie Kai-Kai Gobin Tulalip Summer Chinook (2005)	
	Skykomish/Tulalip Coho Salmon	Tulalip Coho (2004)	
	Walcott Slough/Tulalip Chum Salmon	Tulalip Bay Chum (2004)	
Wallace River	Skykomish/Wallace River Summer Chinook Salmon Fingerling	Wallace River Summer Chinook (fingerlings) (2005)	WDFW
	Skykomish/Wallace River Summer Chinook Salmon Yearling	Wallace River Summer Chinook (yearlings) (2005)	
	Chambers Creek (out-of-DPS) lineage/Wallace River Winter Steelhead	Wallace River Winter Steelhead (2005)	
	Skykomish/Wallace River Coho Salmon	Wallace River Coho (2003)	
	Skykomish/Mukilteo Coho Salmon Net Pen	Mukilteo Coho Net Pens (2003)	
	Skykomish/Possession Point Coho (net pen)	Possession Point Coho (2003)	
Reiter Pond	Skamania lineage (out-of-DPS)/Reiter Pond Summer Steelhead	Reiter Pond Summer Steelhead (2005)	WDFW
	Chambers Creek (out-of-DPS) lineage/Reiter Pond Winter Steelhead	Reiter Pond Winter Steelhead (2005)	
Tokul Creek	Chambers Creek (out-of-DPS) lineage/Tokul Creek Winter Steelhead	Tokul Creek Winter Steelhead (2005)	WDFW
Issaquah	Sammamish/Issaquah Fall Chinook Salmon	Issaquah Fall Chinook (2005)	WDFW
	Issaquah Creek and Green River/Issaquah Coho Salmon	Issaquah Coho (2003)	
	Issaquah Creek and Green River/Laebugton Coho Salmon Net Pen	Laebugton Coho Net Pens (2003)	
	Issaquah Creek and Green River/Ballard Coho Salmon Net Pen	Ballard Coho Net Pen (2005)	
Portage Bay	Green River (out-of-ESU) lineage/Portage Bay Fall Chinook Salmon	Portage Bay Fall Chinook (2005)	University of Washington
	Portage Bay Coho Salmon	Portage Bay Coho Salmon (2003)	WDFW/UW
Cedar River	Lake Washington (localized Baker River)/Cedar River Sockeye Salmon	Cedar River Sockeye (2005)	WDFW

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	Fish Population/Program Name	Draft HGMP Name and Year	Operator
Soos Creek	Green/Soos Creek Fall Chinook Salmon	Soos Creek Fall Chinook (fingerlings) (2005)	WDFW
	Green/Soos Creek/Icy Creek Fall Chinook Salmon Yearling	Soos Creek/Icy Creek Fall Chinook (yearlings) (2005)	
	Chambers Creek (out-of-DPS) lineage/Palmer Ponds Winter Steelhead	Palmer Ponds Winter Steelhead (2005)	
	Skamania lineage (out-of-DPS)/Palmer Ponds Summer Steelhead	Palmer Ponds Summer Steelhead (2005)	
	Green/Green River Wild Winter Steelhead	Green River Wild Stock Winter Steelhead (2010)	
	Green/Soos Creek Coho Salmon	Soos Creek Coho (2003)	
	Green/Marine Technology Center Coho Salmon	Marine Technology Center Coho (net pen) (2003)	
	Green/Des Moines Coho Salmon Net Pen	Des Moines Coho Net Pens (2003)	
	Green/Elliot Bay Coho Salmon Net Pens	Elliott Bay Coho Net Pens (2004)	Muckleshoot Indian Tribe and Suquamish Tribe
Icy Creek	Chambers Creek (out-of-DPS) lineage/Palmer Ponds Winter Steelhead	Palmer Ponds Winter Steelhead[2] (2005)	WDFW
	Skamania lineage (out-of-DPS)/Palmer Ponds Summer Steelhead	Palmer Ponds Summer Steelhead[3] (2005)	
Palmer Ponds	Chambers Creek (out-of-DPS) lineage/Palmer Ponds Winter Steelhead	Palmer Ponds Winter Steelhead (2005)	WDFW
	Skamania lineage (out-of-DPS)/Palmer Ponds Summer Steelhead	Palmer Ponds Summer Steelhead (2005)	
Keta Creek	Green/Keta Creek Fall Chinook Salmon	Keta Creek Chinook (2003)	Muckleshoot Indian Tribe
	East Kitsap (localized)/Keta Creek Fall Chum Salmon	Keta Creek Chum (2004)	
Crisp Creek Rearing Ponds	Green/Crisp Creek Ponds Coho Salmon	Crisp Creek Ponds Coho (2004)	Muckleshoot Indian Tribe
Grovers Creek	Green River (out-of-ESU) lineage/Grovers Creek Fall Chinook Salmon Subyearling	Suquamish Fall Chinook (2000)	Suquamish Tribe
Gorst Creek	Green River (out-of-ESU) lineage/Gorst Creek Fall Chinook Salmon Yearling	Suquamish Fall Chinook[4] (2000)	Suquamish Tribe
Agate Pass Net Pens	Minter Creek/Agate Pass Coho Salmon Sea Pens	Suquamish Agate Pass Coho Sea Pens (2003)	Suquamish Tribe
Cowling Creek	Chico Creek (East Kitsap)/Cowling Creek Fall Chum Salmon	Suquamish Cowling Creek Chum (2003)	Suquamish Tribe
Garrison Springs	Green River (out-of-ESU) lineage/Garrison Springs Fall Chinook Salmon	Garrison Springs Fall Chinook (fingerlings) (2005)	WDFW

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	Fish Population/Program Name	Draft HGMP Name and Year	Operator
Minter Creek	Green River (out-of-ESU) lineage/Minter Creek Fall Chinook Salmon	Minter Creek Fall Chinook (fingerlings) (2005)	WDFW
	Minter Creek/Minter Creek Coho Salmon	Minter Creek/Coulter Creek Coho (2003)	
	Elson Creek (localized)/Minter Creek Chum Salmon	Minter Creek Chum (2004)	
Hupp Springs	White/White River Spring Chinook Salmon	White River Spring Chinook (2002)	WDFW
Chambers Creek	Green River (out-of-ESU) lineage/Chambers Creek Fall Chinook Salmon	Chambers Creek Chinook (yearlings) (2005)	WDFW
Voights Creek	Puyallup/Voights Creek Fall Chinook Salmon	Voights Creek Fall Chinook (fingerlings) (2005)	WDFW
	Chambers Creek (out-of-DPS) lineage/Voights Creek Winter Steelhead	Voights Creek Winter Steelhead (2005)	
	Puyallup/Voights Creek Coho Salmon	Voights Creek Coho Salmon (2003)	
	Puyallup/Puyallup Coho Salmon Acclimation Sites	Diru Creek Fall Coho (Puyallup Acclimation Sites) (2003)	Puyallup Indian Tribe
Clarks Creek	Puyallup/Clarks Creek Fall Chinook Salmon	Clarks Creek Fall Chinook (2005)	Puyallup Indian Tribe
Diru Creek	White/White River Winter Steelhead Supplementation	White River Winter Steelhead Supplementation (2006)	WDFW, Puyallup Indian Tribe, Muckleshoot Indian Tribe
	Chambers Creek (localized)/Diru Creek Late Fall Chum Salmon	Diru Creek Winter (Late Fall) Chum (2003)	Puyallup Indian Tribe
White River	White/White River Spring Chinook Salmon	White River Spring Chinook (2003)	Muckleshoot Indian Tribe
White River Acclimation Facility	White/Puyallup White River Spring Chinook Salmon	Puyallup White River Acclimation (2002)	Puyallup Indian Tribe
Clear Creek	Nisqually/Nisqually (Clear Creek) Fall Chinook Salmon	Nisqually (Clear Creek) Fall Chinook (2000)	Nisqually Indian Tribe
	Central-South Sound/Clear Creek Fall Coho Salmon	Nisqually Clear Creek Coho (2003)	
Kalama Creek	Nisqually/Nisqually (Kalama Creek) Fall Chinook Salmon	Nisqually (Kalama Creek) Fall Chinook (2000)	Nisqually Indian Tribe
	Central-South Sound/Kalama Creek Fall Coho Salmon	Nisqually Kalama Creek Fall Coho (2003)	
Tumwater Falls	Green River (out-of-ESU) lineage/Tumwater Falls Fall Chinook Salmon Subyearling	Tumwater Falls Fall Chinook (fingerlings) (2005)	WDFW
	Green River (out-of-ESU) lineage/Tumwater Falls Fall Chinook Salmon Yearling	Tumwater Falls Fall Chinook (yearlings) (2005)	
South Sound Net Pens	Central-South Sound/Squaxin Island/South Sound Coho Salmon Net Pens	Squaxin Island/South Sound Coho Net Pens (2003)	Squaxin Island Tribes and WDFW

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	Fish Population/Program Name	Draft HGMP Name and Year	Operator
McKernan	Skokomish/Hood Canal Winter Steelhead Supplementation	Hood Canal Steelhead Supplementation Project (2009)	WDFW and Long Live the Kings
	Finch Creek/McKernan Fall Chum Salmon	McKernan Fall Chum (fingerlings) (2003)	WDFW
Enetai	Walcott Slough-Quilcene (localized to release site)/Skokomish Fall Chum Salmon	Skokomish Hatchery (Enetai Creek) Fall Chum (2003)	Skokomish Tribe
George Adams	Skokomish/George Adams Fall Chinook Salmon Subyearling	George Adams Fall Chinook (fingerlings) (2005)	WDFW
	Skokomish/Ricks Pond Fall Chinook Salmon	Ricks Pond Fall Chinook (2005)	
	Mixed (localized to release site) Skokomish River/George Adams Coho Salmon Yearling	George Adams Coho Yearlings (2003)	
Hoodsport	Green River (out-of-ESU) lineage/Hoodsport Fall Chinook Salmon Subyearling	Hoodsport Fall Chinook (fingerlings) (2005)	WDFW
	Green River (out-of-ESU) lineage/Hoodsport Fall Chinook Salmon Yearling	Hoodsport Fall Chinook (yearlings) (2005)	
	Finch Creek/Hoodsport Fall Chum Salmon	Hoodsport Fall Chum (fingerlings) (2003)	
	Dungeness-Dosewallips (localized to Finch Creek)/Hoodsport Pink Salmon	Hoodsport Pink Salmon (fingerlings) (2003)	
Hamma Hamma	Mid-Hood Canal/Hamma Hamma Fall Chinook Salmon	Hamma Hamma Chinook (2005)	WDFW and Long Live the Kings
Lilliwaup	Westside and Eastside Hood Canal/Hood Canal Winter Steelhead Supplementation	Hood Canal Steelhead Supplementation Project[7] (2009)	WDFW and Long Live the Kings
Quilcene NFH	Big Quilcene/Quilcene National Fish Hatchery Coho Salmon	Quilcene NFH Coho (2010)	USFWS
Quilcene Net Pens	Big Quilcene/Quilcene Coho Salmon	Quilcene Coho Net Pens (2003)	Skokomish Tribe and USFWS
Hurd Creek	Snow Creek/Snow Creek Coho Salmon	Snow Creek Coho Supplementation (2005)	WDFW
Dungeness	Dungeness/Dungeness Spring Chinook Salmon	Dungeness River Chinook (2005)	WDFW
	Dungeness/Dungeness Winter Steelhead	Dungeness River Steelhead (2005)	
	Dungeness mixed/Dungeness River Coho Salmon	Dungeness River Coho (2003)	
Elwha Channel	Elwha/Elwha River Summer/Fall Chinook Salmon	Elwha River Summer/Fall Chinook (2012)	WDFW

Table 1.5-1. Puget Sound salmon and steelhead hatchery facilities, programs, draft HGMPs, and operators reviewed in the EIS, continued.

Primary Hatchery Facility[1]	Fish Population/Program Name	Draft HGMP Name and Year	Operator
Lower Elwha	Elwha/Lower Elwha Winter Steelhead	Lower Elwha Steelhead (Wild Steelhead Recovery Program Addendum) (2012)	Lower Elwha Klallam Tribe
	Elwha/Lower Elwha Coho Salmon	Lower Elwha Coho (2012)	
	Elwha/Lower Elwha Chum Salmon	Lower Elwha Chum (2012)	
	Elwha/Lower Elwha Pink Salmon	Elwha River Pink (2012)	
Port Gamble Net Pens	Big Quilcene/Port Gamble Coho Salmon	Port Gamble Coho Net Pens (2003)	Port Gamble S'Klallam Tribe
Little Boston	Walcott Slough (localized to release site)/Port Gamble Fall Chum Salmon	Port Gamble Hatchery Fall Chum (2003)	Port Gamble S'Klallam Tribe

[1] The facilities are main facilities listed geographically from north to south and then west. Many of the programs have associated incubation and final rearing facilities (i.e., acclimation sites). Multiple hatchery facilities may be addressed in individual HGMPs (e.g., the Lummi Nation Coho HGMP included operations at the Lummi Bay Hatchery and Skookum Creek Hatchery). Programs for listed summer-run chum salmon in Hood Canal and the Strait of Juan de Fuca are not shown.

[2] Same HGMP as Palmer Ponds winter steelhead (Soos Creek).

[3] Same HGMP as Palmer Ponds summer steelhead (Soos Creek).

[4] Same HGMP as Grovers Creek.

[5] Same HGMP as McKernan (this is a component of the Hood Canal steelhead supplementation project).

Box 1-6. What are the physical components of a hatchery and how does it operate?

Each hatchery is unique, but most share common components. Differences between individual hatcheries depend on the species reared and the age of release into the natural environment. A hatchery that operates from collection and spawning of adults, to rearing and release of juveniles, typically has water intake and supply systems, adult collection, egg incubation, early rearing vessels, raceways, and ponds.

Artificial propagation starts with the collection of adults to serve as broodstock. Adults are either collected at the hatcheries or are captured outside the hatchery environment using nets or other methods. Once at the hatchery, adults are typically held in raceways until they are ready for spawning. After adults are spawned, eggs are placed in incubators. Upon hatching, the very small fish live off their attached yolk sack, which provides a food source as the young fish learn to feed on their own. At that point the fish are transferred to tanks. As they grow, the fish are transferred to raceways and then, in some cases, to rearing ponds for a final stage of rearing prior to release.

Depending on the species, hatchery-origin fish can be released from hatcheries as very young and small fry, or older and increasingly larger fingerlings, sub-yearlings, or yearlings.

1.5.2 History of Hatcheries in Puget Sound

The policies, purposes, and practices associated with hatchery production in Puget Sound have evolved since fish culture began in the late 1800s. Hatchery facilities and practices have become more sophisticated and efficient over time as new technologies were applied. Changes in policies of the hatchery operators have led to hatchery improvements, including the development of hatchery broodstocks, limits on the extent to which hatchery-origin fish can be transferred from one basin to another, improvements in fish disease management, marking for fish management and for evaluation purposes, and limitations on natural spawning and straying by hatchery-origin fish. More recently, hatcheries have been used for conservation and recovery purposes using locally adapted within-basin broodstocks, and to simultaneously provide harvest benefits. For a detailed discussion of the history of hatcheries in Puget Sound, including improvements in hatchery technology, development of hatchery broodstocks, and a summary of institutional and operational changes, refer to the co-managers' RMPs (WDFW and PSTT 2004; PSTT and WDFW 2004).

1.5.3 Other Reviews of Puget Sound Hatchery Programs

Because of the potential negative effects of hatchery programs on natural-origin salmon and steelhead populations, Puget Sound hatchery programs have undergone other reviews designed to address risks. In 2000, the United States Congress established the Puget Sound and Coastal Washington Hatchery Reform Project. The Hatchery Scientific Review Group (HSRG), funded by the Hatchery Reform Project, was the independent scientific panel established by Congress to ensure that hatchery reform programs in Puget Sound and Coastal Washington are scientifically sound. The HSRG assembled, organized, and applied the best available scientific information and provided specific guidance to policy makers implementing hatchery reform in 2004 (HSRG 2004). HSRG products informed development of the co-managers' RMPs and HGMPs, and informed identification of potential mitigation measures in this EIS. Conclusions and reports of the HSRG for Puget Sound hatchery programs can be found at http://hatcheryreform.us/hrp/reviews/puget/welcome_show.action.

1.6 Scoping and Relevant Issues

The first step in preparing an EIS is to conduct scoping of the issues that may be associated with the Proposed Action. This occurs through public and internal agency scoping processes. The purpose of public and internal scoping is to identify the relevant human environmental issues, to eliminate insignificant issues from detailed study, and to identify the alternatives to be analyzed in the EIS. Scoping can also help determine the level of analysis and the types of data required for analysis.

1.6.1 Scoping Process

This EIS involved activities that included both public and internal scoping that are described in the following paragraphs.

1.6.2 Notices of Public Scoping

Public scoping for the Puget Sound Hatchery EIS commenced with publication of a Notice of Intent on May 12, 2004 (69 Fed. Reg. 26363, May 12, 2004). That notice started a 60-day public comment period (May 12 to July 12, 2004) to gather information on the scope of the issues and the range of alternatives to be analyzed in the EIS. A project scoping brochure was sent to addresses on a mailing list developed for the project by NMFS, WDFW, and the Northwest Indian Fisheries Commission (NWIFC). NMFS developed a website for the EIS at http://www.westcoast.fisheries.noaa.gov/hatcheries/ps_deis/ps_deis.html. The website was available during the scoping period and will be updated and available throughout the project duration. For interested parties whose e-mail addresses were available, an electronic message was sent that contained the link to the EIS website and on-line scoping brochure. For those without email addresses, a scoping brochure was sent via fax or through the United States mail. The mailing lists consisted of agencies, private individuals, private businesses, and non-governmental organizations. Invitations to attend public meetings were also advertised on appropriate organization and agency websites and in local newspapers.

During 2004, NMFS held four public scoping meetings in the project area, including Mount Vernon (June 7), Seattle (June 8), Belfair (June 14), and Port Hadlock (June 15), Washington. Presentations were provided by NMFS and WDFW staff, and a question and answer session was also included. At these meetings, NMFS requested public comment on project alternatives.

A second public scoping period for the EIS commenced with publication of a Notice of Intent on July 29, 2011 (76 Fed. Reg. 45515, June 29, 2011). That notice provided an additional 30-day comment period (July 29 to August 29, 2011) to gather new information that may have become available since the 2004 scoping period. Building from e-mail addresses that were available from the initial scoping, an electronic notification was sent to agencies, private individuals, businesses, and non-governmental organizations that contained a link to the NMFS Puget Sound Hatcheries EIS website, and the address to the NMFS project electronic mailbox.

1.6.3 Internal Scoping

NMFS conducted internal project scoping in late 2003 to early 2004, and in 2011. A Technical Work Group was formed representing NMFS, WDFW (applicant), State of Washington State Environmental Policy Act (SEPA) staff, and the NWIFC (representing applicant Puget Sound treaty tribes) to identify the technical feasibilities and the related environmental parameters considered relevant to the Puget Sound hatcheries. The Technical Work Group identified resource elements both likely and unlikely to be affected by the Proposed Action as a result of technical activities. Those elements that were identified to be potentially affected by the Proposed Action were then included in Chapter 3, Affected Environment, and Chapter 4, Environmental Consequences, of the EIS. Resource impacts to fish, socioeconomics resources, tribal rights and Federal treaty trust responsibilities, wildlife, water quality and quantity, and human health were identified because of the potential for adverse effects to these resources from the Proposed Action. In addition, internal-only NMFS meetings were held to develop the EIS outline and review public issues received during scoping that could be used for developing alternatives and those that should be addressed in other sections of the EIS.

Further internal-only meetings were held to develop a full and reasonable range of alternatives, define the rationale for selecting specific alternatives for detailed EIS consideration, and identify those alternatives that should be eliminated from detailed consideration. Information from the internal scoping process was presented to the public for assessment and comment during the public scoping process.

1.6.4 Written Comments

A total of 3 letters, 10 email comment responses (some with attached letters), and 1written public meeting response were received during the initial scoping period in 2004. Two emails with attached letters were received during the second scoping period in 2011. A total of 16 comment responses (emails and letters) were received during the two public scoping periods, including 1 from a governmental agency, 2 from tribal organizations, 5 from non-governmental organizations and businesses, and 8 from individual citizens.

1.6.5 Issues Identified During Scoping

Based on all input received during the scoping process, the purpose and need for Federal action, and discussions with co-managers regarding technical feasibilities, issues relevant to development of EIS alternatives are summarized as follows:

- Modify hatchery programs, including eliminating some programs altogether, to help conserve natural-origin salmon and steelhead, particularly ESA-listed species.
- Modify hatchery programs to provide more fishing opportunities.
- Change hatchery production, release methods, and locations to minimize undesired effects on listed species.

1.6.6 Future Public Review and Comment

Under NEPA, this draft EIS has been issued for a 90-day public review period, which was announced in newspapers, through letters to interested parties, and by publication in the Federal Register. Following this public review period, responses to public comments will be prepared and included in the final EIS. Responses will include any changes to the EIS resulting from public comments, as warranted. Following public review and comment on the final EIS, the ROD (Subsection 1.3.2, Record of Decision) will be signed and made publicly available.

Under the ESA 4(d) rule Limit 6, NMFS will prepare Evaluation and Recommended Determination (ERD) documents for each proposed RMP (Subsection 1.3.3, NMFS' Determination as to Compliance with the 4(d) Rule). The ERD documents will be made available for public review and comment.

To the extent that RMPs and appended HGMPs reviewed in this EIS substantively change over time in response to adaptive management, new information, actions, or changes in existing or baseline conditions and are submitted to NMFS for approval, additional NEPA and ESA compliance may be warranted (Subsection 1.1, Introduction; Subsection 1.1.2, Take of a Listed Species, The Puget Sound Hatchery RMPs and HGMPs). The nature and extent of changes to plans or new information will determine the type of additional NEPA and ESA compliance that may be needed. Subsequent public review opportunities may be warranted as part of these additional NEPA and ESA reviews.

1.7 Relationship to Other Plans, Regulations, and Laws

In addition to NEPA and ESA, other plans, regulations, agreements, treaties, laws, and Secretarial and Executive Orders also affect hatchery operations in Puget Sound. They are summarized below to provide additional context for Puget Sound hatchery programs. It is the intention of this EIS that all action alternatives would comply with applicable plans, guidelines, regulations, and laws. However, additional permitting may be required for compliance with specific regulations and laws following implementation of the selected alternative. Thus, hatchery program changes that may occur as a result of the decision described within the ROD for this EIS would include further project-specific reviews as necessary to ensure compliance with all applicable plans, guidelines, regulations, and laws.

1.7.1 Federal and International Guidance, Regulations, and Treaties

1.7.1.1 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) (Public Law 94-265) is the principal law governing marine fisheries in the United States. The act was first enacted in 1976, amended in 1996, and reauthorized in 2006 with some updates. It was adopted to extend control of United States marine waters to 200 nautical miles beyond the United States coastline, to phase out foreign fishing within this zone, to prevent over-fishing, to allow over-fished stocks to recover, and to conserve and manage fishery resources. Under the Magnuson-Stevens Act, conservation and management measures are intended to prevent over-fishing while achieving optimum yield. In addition, the importance of fishery resources to fishing communities mandates that this be taken into account in fishery management decisions. These decisions should provide for the sustained participation of, and minimization of adverse impacts to, such communities (consistent with conservation requirements). Puget Sound hatchery programs are consistent with the Magnuson-Stevens Act because the hatcheries help provide fishing opportunities that would otherwise not be available to many fishing communities. In addition to their importance to fishing communities, some of the hatchery programs are necessary for reducing extinction risk and for reintroducing salmon and steelhead into areas where they have been extirpated.

1.7.1.2 Sustainable Fisheries Act

The Sustainable Fisheries Act of 1996 (Public Law 104-297) is an amendment to the Magnuson-Stevens Act. There were two major changes to the purpose of the law: adding the promotion of catch and release programs to conservation and management principles, and adding the promotion of essential fish habitat (EFH) protection. The Sustainable Fisheries Act establishes requirements for EFH descriptions in Federal

Fishery Management Plans (50 CFR 600). EFH was designated for groundfish, coastal pelagic species, highly migratory species, and salmon. In 1997, NMFS subsequently issued an interim final rule (62 Fed. Reg. 66531, December 19, 1997) to implement the EFH provisions of the Magnuson-Stevens Act. This rule established guidelines to assist the Regional Fishery Management Councils and the Secretary of Commerce (Secretary) in the description and identification of EFH in fishery management plans, including identification of adverse impacts from both fishing and non-fishing activities on EFH, and identification of actions required to conserve and enhance EFH. The intended effect of the rule is to promote the protection, conservation, and enhancement of EFH. The interim rule was then finalized in 2002 (67 Fed. Reg. 2343, January 17, 2002). In estuaries and marine areas, salmon EFH extends from the shoreline to the 200-mile limit of the economic exclusion zone and beyond. In fresh water, salmon EFH includes all the lakes, streams, ponds, rivers, wetlands, and other bodies of water that have been historically accessible to salmon. The description of EFH also includes areas above artificial barriers, except for certain barriers and dams that fish cannot pass. Although changes in hatchery production as described in this EIS would not affect EFH for fish species, it is possible that improvements recommended in this EIS to hatchery weirs and other barriers for containment of returning hatchery-origin adults would directly improve EFH for salmon. Changes in hatchery-origin fish production also indirectly affect EFH through changes in the potential for predation, competition, and available prey.

1.7.1.3 Pacific Salmon Treaty

The Pacific Salmon Treaty between Canada and the United States was finalized March 17, 1985 (Pacific Salmon Commission 1985). The treaty established a framework for managing salmon stocks either originating from one country and intercepted by the other, or affecting the management or the biology of the stocks of the other country. The treaty commits the United States and Canada to equitable cross-border sharing of harvest and conservation of United States and Canadian stocks. The objective of the original treaty and subsequently negotiated agreements (annexes) is to constrain harvest on both sides of the border and to rebuild depressed salmon stocks. The Pacific Salmon Commission oversees implementation of the treaty and negotiates periodic revisions of the annex fishing regimes. The current agreement governs Chinook salmon and several other species from 2009 through 2018. The agreement was finalized by exchange of diplomatic notes on December 23, 2008. Some hatchery programs included in the RMPs (i.e., indicator stock programs that enable estimation of harvest exploitation rates) are operated for the sole purpose of providing information to support the Pacific Salmon Treaty mandate.

1.7.1.4 Clean Water Act

The Clean Water Act (33 USC 1251, 1977, as amended in 1987), administered by the U.S. Environmental Protection Agency and state water quality agencies, is the principal Federal legislation directed at protecting water quality. Each state implements and carries forth Federal provisions, as well as approves and reviews National Pollutant Discharge Elimination System applications, and establishes total maximum daily loads for rivers, lakes, and streams. The states are responsible for setting the water quality standards needed to support all beneficial uses, including protection of public health, recreational activities, aquatic life, and water supplies.

The Washington State Water Pollution Control Act, codified as Revised Code of Washington Chapter 90.48, designates the Washington Department of Ecology (Ecology) as the agency responsible for carrying out the provisions of the Federal Clean Water Act within Washington State. The agency is responsible for establishing water quality standards, making and enforcing water quality rules, and operating waste discharge permit programs. These regulations are described in Washington Administrative Code (WAC) 173. Hatchery operations are required to comply with the Clean Water Act.

1.7.1.5 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 USC 1361) as amended, establishes a national policy designated to protect and conserve wild marine mammals and their habitats. This policy was established so as not to diminish such species or populations beyond the point at which they cease to be a significant functioning element in the ecosystem, nor to diminish such species below their optimum sustainable population. All marine mammals are protected under the MMPA. The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. The term ‘take,’ as defined by the MMPA, means to “harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” The MMPA further defines harassment as “any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing a disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.” Changes in fish production can indirectly affect marine mammals by altering the amount of available prey (salmon and steelhead).

1.7.1.6 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 USC. 668-668c), enacted in 1940 and amended several times since then, prohibits the take of bald eagles, including their parts, nests, or eggs. The act defines ‘take’ as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb.” The USFWS, who is responsible for carrying out provisions of this act, define ‘disturb’ to include a “decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.” Changes in hatchery production have the potential to affect eagle productivity through changes in its prey source (salmon and steelhead).

1.7.1.7 Executive Order 12898

In 1994, the President issued Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority and Low-income Populations*. The objectives of the EO include developing Federal agency implementation strategies, identifying minority and low-income populations where proposed Federal actions could have disproportionately high and adverse human health and environmental effects, and encouraging the participation of minority and low-income populations in the NEPA process. Changes in hatchery production have the potential to affect the extent of harvest available for minority and low-income populations.

1.7.2 Tribal Treaty Rights and Related Federal Policies and Laws

1.7.2.1 Treaties of Point Elliot, Medicine Creek, and Point No Point

Beginning in the mid-1850s, the United States entered into a series of treaties with tribes in Puget Sound. The treaties were completed to secure the rights of the tribes to land and the use of natural resources in their historically inhabited areas in exchange for the ceding of land to the United States for settlement by its citizens. The first treaty bearing upon the actions evaluated in this EIS is the Treaty of Medicine Creek (signed in 1854), followed by two treaties signed in 1855—the Point Elliot Treaty and the Point No Point Treaty. These treaties secured the rights of tribes for taking fish at usual and accustomed grounds and stations in common with all citizens of the United States. Marine and freshwater areas of Puget Sound were affirmed as the usual and accustomed fishing areas for treaty tribes under *United States v. Washington* (1974).

1.7.2.2 *United States v. Washington*

Salmon fisheries within the project area are jointly managed by the WDFW and the Puget Sound treaty tribes (co-managers) under the continuing jurisdiction of *United States v. Washington* (1974). *United States v. Washington* is the Federal court proceeding that enforces and allocates harvest between the State and tribes while addressing reserved treaty fishing rights with regard to salmon and steelhead returning to Puget Sound. Hatchery fish are subject to this allocation under *United States v. Washington.* Without many of these hatcheries, there would be limited opportunity for tribal harvest. These fishing rights and attendant access were established by treaties that the Federal government signed with the tribes in the 1850s. In those treaties, the tribes agreed to allow the peaceful settlement of Indian lands in western Washington in exchange for their continued right to fish, gather shellfish, hunt, and exercise other sovereign rights.

1.7.2.3 Puget Sound Salmon Management Plan

The Puget Sound Salmon Management Plan (PSSMP) (PSSMP 1985) (as described in *United States v. Washington* [1974]) is the implementation framework for the allocation, conservation, and equitable sharing principles defined in *United States v. Washington* that governs the joint management of salmon resources in Puget Sound between the Puget Sound treaty tribes and State of Washington. It defines the basis for deriving artificial production levels, management objectives and allocation of harvest, information exchange, and dispute resolution among the co-managers, and includes provisions for annual review and modification. Puget Sound harvest management RMPs (e.g., Puget Sound Chinook harvest RMP [Puget Sound Indian Tribes and WDFW 2010]) are consistent with the PSSMP, as are the hatchery RMPs reviewed in this draft EIS. The PSSMP envisioned the adaptive management process that motivated the hatchery program review and modification approach proposed in the hatchery RMPs (i.e., that improved understanding of the productivity of populations, and assessment of the actual performance of management regimes in relation to management objectives and the status of stocks, would result in continuing program modifications that improve prospects for meeting hatchery program objectives).

1.7.2.4 Secretarial Order 3206

Secretarial Order 3206 (American Indian Tribal Rights, Federal–Tribal Trust Responsibilities and the ESA, http://www.nmfs.noaa.gov/sfa/reg_svcs/Councils/Webinar/secretarial_order.pdf) issued by the secretaries of the Departments of the Interior and Commerce, clarifies the responsibilities of the agencies, bureaus, and offices of the departments when actions taken under the ESA and its implementing regulations affect, or may affect, Indian lands, tribal trust resources, or the exercise of American Indian tribal rights. The Secretarial Order acknowledges the United States' trust responsibility to, as well as its government-to-government relationship with, Indian tribes. Under the Order, the Services "will carry out their responsibilities under the [ESA] in a manner that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the [Services], and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to avoid or minimize the potential for conflict and confrontation."

More specifically, the Services shall, among other things, do the following:

- Work directly with Indian tribes on a government-to-government basis to promote healthy ecosystems (Section 5, Principle 1).
- Recognize that Indian lands are not subject to the same controls as Federal public lands (Section 5, Principle 2).
- Assist Indian tribes in developing and expanding tribal programs so that healthy ecosystems are promoted and conservation restrictions are unnecessary (Section 5, Principle 3).
- Be sensitive to Indian culture, religion, and spirituality (Section 5, Principle 4).

Additionally, the Department of Commerce has issued a Departmental Administrative Order (DAO) addressing *Consultation and Coordination with Indian Tribal Governments* (DAO 218-8, April 26, 2012; http://www.osec.doc.gov/opog/dmp/daos/dao218_8.html), which implements relevant Executive Orders, Presidential Memoranda, and Office of Management and Budget Guidance. The DAO describes actions to be "followed by all Department of Commerce operating units … and outlines the principles governing Departmental interactions with Indian tribal governments." The DAO affirms that the "Department works with Tribes on a government-to-government basis to address issues concerning … tribal trust resources, tribal treaty, and other rights."

1.7.2.5 The Federal Trust Responsibility

The United States government has a trust or special relationship with Indian tribes. The unique and distinctive political relationship between the United States and Indian tribes is defined by statutes, executive orders, judicial decisions, and agreements and differentiates tribes from other entities that deal with, or are affected by, the Federal government. Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments,* states that the United States has recognized Indian tribes as domestic dependent nations under its protection. The Federal government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian tribes. The relationship has been compared to one existing under common law trust, with the United States as trustee, the Indian tribes or individuals as beneficiaries, and the property and natural resources of the United States as the trust corpus (Cohen 2005). The trust responsibility has been interpreted to require Federal agencies to carry out their activities in a manner that is protective of Indian treaty rights. This policy is also reflected in the March 30, 1995 document, *Department of Commerce – American Indian and Alaska Native Policy* (U.S. Department of Commerce 1995). The Ninth Circuit Court of Appeals has held, however, that "unless there is a specific duty that has been placed on the government with respect to Indians, [the government's general trust obligation] is discharged by [the government's] compliance with general regulations and statutes not specifically aimed at protecting Indian tribes" (*Gros Ventre Tribe v. United States*, 2006, citing Morongo Band of *Mission Indians v. FAA*, 1998; *United States v. Jicarilla Apache Nation*, U.S., 131 S.Ct. 2313, 180 L.Ed.2nd 187, 2011).

1.7.3 State Guidance and Regulations

1.7.3.1 Washington State Environmental Policy Act

Washington State has environmental rules governing facilities it owns, manages, and/or funds as described in Revised Code of Washington Chapter 43.21C, SEPA Rules, WAC Chapter 197-11 (implementing rules); and the SEPA Handbook (guidance provided by Ecology). Under SEPA, implemented state actions require SEPA review, such as approvals, permits, and authorizations. As such, RMPs and WDFW HGMPs will require compliance with SEPA prior to implementation.

1.7.3.2 State Endangered, Threatened, and Sensitive Species Act

This EIS will consider the effects of hatchery programs on state endangered, threatened, and sensitive species. The State of Washington has species of concern listings (Washington Administrative Code Chapters 232-12-014 and 232-12-011) that include all state endangered, threatened, sensitive, and candidate species. These species are managed by WDFW, as needed, to prevent them from becoming endangered, threatened, or sensitive. The state-listed species are identified on WDFW's website (http://wdfw.wa.gov/conservation/endangered/); the most recent update occurred in June 2008. The criteria for listing and de-listing, and the requirements for recovery and management plans for these species, are provided in Washington Administrative Code Chapter 232-12-297. The state list is separate from the Federal ESA list; the state list includes species status relative to Washington state jurisdiction only. Critical wildlife habitats associated with state or federally listed species are identified in

Washington Administrative Code Chapter 222-16-080. Species listed under the state endangered, threatened, and sensitive species list are reviewed in this EIS if EIS actions could affect these species.

1.7.3.3 Hatchery and Fishery Reform Policy

The Washington Department of Fish and Wildlife Hatchery and Fishery Reform Policy (Policy C-3619) was adopted by the Washington Fish and Wildlife Commission in 2009 (WFWC 2009). Its purpose is to advance the conservation and recovery of wild salmon and steelhead by promoting and guiding the implementation of hatchery reform. The policy applies to state hatcheries and its intent is to improve hatchery effectiveness, ensure compatibility between hatchery production and salmon recovery plans and rebuilding programs, and support sustainable fisheries.

1.7.3.4 Washington State Growth Management Act

The Growth Management Act (RCW 36.70A) was enacted by the Washington Legislature in 1990 in response to rapid population growth and concerns with suburban sprawl, environmental protection, quality of life, shoreline management, and other issues. Under the Growth Management Act; all cities and counties in Washington are required to adopt critical areas regulations to designate and classify ecologically sensitive and hazardous areas and to protect these areas and their functions and values, while also allowing for reasonable use of private property. Critical areas include the following areas and ecosystems: (a) wetlands; (b) areas with a critical recharging effect on aquifers used for potable water; (c) fish and wildlife habitat conservation areas; (d) frequently flooded areas; (e) and geologically hazardous areas. Counties and cities are required to include the best available science in developing policies and development regulations to protect the functions and values of critical areas. Critical areas ordinances and shoreline management associated with the Growth Management Act help to protect fish and wildlife habitat in Puget Sound.

1.7.4 Other Applicable Multi-agency Guidelines

1.7.4.1 Recovery Plans for Puget Sound Salmon

Federal recovery plans are in place for the ESA-listed Puget Sound Chinook Salmon (72 Fed. Reg. January 19, 2007) and Hood Canal Summer-run Chum Salmon ESUs (72 Fed. Reg. 29121, May 24, 2007). Broad partnerships of Federal, state, local, and tribal governments and community organizations collaborated in the development of the two recovery plans under Washington’s Salmon Recovery Act. Although listed in 2007, a recovery plan for the Puget Sound steelhead DPS has not yet been completed.

The comprehensive recovery plans include conservation goals and proposed habitat, hatchery, and harvest actions needed to achieve the conservation goals for each watershed within the geographic boundaries of the two listed ESUs. The two recovery plans incorporate the RMPs proposed in this EIS (WDFW and PSTT 2004; PSTT and WDFW 2004) for protecting and recovering the Puget Sound Chinook Salmon and Hood Canal Summer-run Chum Salmon ESUs, along with the habitat and harvest management measures of the respective plan.

In 2007, NMFS approved the recovery plans for Puget Sound Chinook salmon (Shared Strategy for Puget Sound 2007) and Hood Canal summer-run chum salmon (Hood Canal Coordinating Council 2005). As part of its approval of the Puget Sound Chinook salmon recovery plan (72 Fed. Reg. 2493, January 19, 2007), NMFS determined that some enhancements were needed to address insufficient recovery actions, including actions related to hatchery activities (NMFS 2006). Several watersheds lacked adequate coverage of on-going and proposed hatchery program plans. In addition, NMFS identified the need to describe all hatchery actions conducted in Puget Sound as part of the suite of recovery measures, and to integrate those hatchery actions with the habitat and harvest-related actions in the plan. In its approval of the Hood Canal summer-run chum salmon recovery plan (72 Fed. Reg. 29121, May 24, 2007), NMFS incorporated the summer-run chum salmon hatchery programs it had approved in 2002 under ESA 4(d) rule Limit 5, and the HGMPs located within the geographic boundaries of the Hood Canal Summer-run Chum Salmon ESU (NMFS 2007).

The hatchery resource management plans for Puget Sound Chinook salmon and other salmon and steelhead that were submitted by the co-managers for ESA review in 2004 were identified by NMFS at that time as the appropriate descriptors of the anadromous salmon and steelhead hatchery programs in the area occupied by listed salmon and steelhead in Puget Sound. These plans and related HGMPs are the subject of this EIS; however, to the extent possible, programs terminated since 2004 are not included in the analyses, and programs developed since 2004 have been analyzed.

1.7.4.2 Wild Salmonid Policy

The Wild Salmonid Policy was adopted in 1997 by the Washington Fish and Wildlife Commission (WDFW and Western Washington Treaty Tribes 1997) to guide WDFW in harvest, hatchery, and habitat protection programs. The policy’s goal was to restore Washington’s wild salmon and steelhead stocks to healthy, harvestable runs by performing the following activities:

- Managing commercial and sport fishing to ensure enough of the wild run returns to spawn while providing fishing opportunities where possible

- Producing and releasing hatchery salmon and steelhead without harming wild fish runs
- Identifying habitat priorities that are essential for the protection and rebuilding of the salmonid resource in Washington State

Not all tribal governments endorsed the Wild Salmonid Policy. Where WDFW and the tribes could not reach a common goal or standard, they deferred further agreement and discussion to a particular watershed or tribal area. This approach reserved the prerogative for WDFW and the tribes to provide additional fishery management guidance, directives, or policies that would better address the needs in specific watersheds.

1.8 Related NEPA Analyses

Several NEPA documents pertaining to disclosure of the environmental effects of NMFS ESA determinations for related salmon and steelhead hatchery and harvest actions within the project area have been previously prepared (Table 1.8-1). These include NEPA analyses that were used to help determine if proposed management, evaluation, implementation, harvest, and/or recovery plans and specific HGMPs meet NMFS' proposed ESA 4(d) rule Limits 5 and 6. However, this draft EIS is the first NEPA analysis that comprehensively addresses the effects of all Chinook salmon, fall-run chum salmon, coho salmon, sockeye salmon, pink salmon, and steelhead hatchery programs operating within the geographic boundaries of the Puget Sound Chinook Salmon ESU and Puget Sound Steelhead DPS.

1.9 Roles and Responsibilities of NMFS, State of Washington, and Puget Sound Treaty Tribes

1.9.1 NMFS

Within Puget Sound, NMFS has ESA regulatory authority for salmon, steelhead, and marine mammals; and MMPA regulatory authority for marine mammals. NMFS also has regulatory authority for the Magnuson-Stevens Act, which includes coastal salmon fishery management responsibilities for the Pacific Fisheries Management Council and North Pacific Fisheries Management Council forums, and habitat protection and regulatory authority for waters designated as EFH for salmon. NMFS' role in fisheries management extends to United States and Canadian salmon fisheries included within the Pacific Salmon Treaty. Stewardship of tribal fishing rights ensured under treaties made between the tribes and the United States Government is an additional NMFS responsibility. With regard to these responsibilities, NMFS works with hatchery operators to develop HGMPs that are consistent with these mandates.

Table 1.8-1. ESA section 4(d) rule NEPA reviews related to the Proposed Action

Document	Completion or Federal Register Notice Date
Environmental Assessment (EA) of a NMFS Action to Determine Whether the Summer Chum Salmon Conservation Initiative - An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region (Harvest Management) – Meets the Criteria in the ESA Section 4(d) Rule Limit 6	66 Fed. Reg. 31600, June 12, 2001
EA of a NMFS Action to Determine Whether a Chinook Salmon Fisheries Management and Evaluation Plan for 2001-2002 Fisheries Provided by the WDFW and the Puget Sound Treaty Tribes Meets the Criteria in the ESA Section 4(d) Rule Limit 6	66 Fed. Reg. 31603, June 12, 2001
EA/Finding of No Significant Impact (FONSI) for a NMFS Action to Determine Whether Eight HGMPs Provided by the WDFW and USFWS Meet the Criteria in the ESA Section 4(d) Rule Limit 5 – Hood Canal Summer Chum	March 2002
EA for a NMFS Action to Determine Whether a Chinook Salmon Fisheries Management and Evaluation Plan for Salmon Fisheries and Steelhead Net Fisheries Affecting Puget Sound Chinook Salmon in 2003 Provided by the WDFW and the Puget Sound Treaty Tribes Meets the Criteria in the ESA Section 4(d) Rule Limit 6	May 2003
Draft EIS of a NMFS Action to Determine Whether a Chinook Salmon Fisheries Management and Evaluation Plan for 2004 Fisheries Provided by the WDFW and the Puget Sound treaty Tribes Meets the Criteria in the ESA Section 4(d) Rule Limit 6	April 2004
Supplement to the EA Prepared for a NMFS Action to Determine Whether Eight HGMPs Provided by the Washington Department of Fish and Wildlife and the USFWS Meet the Criteria in the ESA Section 4(d) Rule Limit 5 - Tahuya River Reintroduction Component	November 2004
Puget Sound Chinook Harvest Resource Management Plan Final EIS	December, 2004
Record of Decision for Puget Sound Chinook Harvest Resource Management Plan	March 2005
Final EA to Analyze Impacts of NOAA's NMFS Determination that Five Hatchery Programs for Elwha River Salmon and Steelhead as Described in Joint State-Tribal Hatchery and Genetic Management Plans and One Tribal Harvest Plan Satisfy the Endangered Species Act Section 4(d) Rule	December 10, 2012

1.9.2 State of Washington (Washington Department of Fish and Wildlife)

The State of Washington has management responsibilities for non-tribal salmon fisheries occurring in waters within 3 miles of the coast and in all inshore and freshwater areas. The State of Washington participates directly in the management of salmon fisheries through its representation on the North Pacific Fisheries Management Council, the Pacific Fisheries Management Council, Pacific Salmon Commission, and other regional technical and policy committees that guide salmon management decisions. State fishery agencies, along with NMFS and tribal fishery agencies, provide much of the technical information and research used in managing state fishery resources. The State of Washington co-manages Washington's salmon and steelhead fisheries with the Washington treaty tribes.

State fishery management policies are set by commissions appointed by the Washington administrative branch, and are defined in state administrative codes. The Washington Fish and Wildlife Commission consists of nine members appointed by the governor for 6-year terms. The commission is the supervising authority for the WDFW. With the 1994 merger of the former Washington Department of Fisheries and Washington Department of Wildlife, the commission has comprehensive species authority, as well. Through formal public meetings and informal hearings held around the state, the commission provides an opportunity for citizens to actively participate in management of Washington's fish and wildlife. Along with the Puget Sound treaty tribes, the state is responsible for co-managing Puget Sound salmon and steelhead hatchery production.

The WDFW participated in the development of this EIS by providing representation on the NMFS NEPA Technical Work Group and through review of the team's work products.

1.9.3 Puget Sound Treaty Tribes

Five treaties ratified by the United States and various Washington tribes between 1854 and 1856 guaranteed tribes fishing rights in common with citizens of the Territory. These are the treaties of Medicine Creek, Quinault, Neah Bay, Point Elliott, and Point-No-Point. Findings of *United States v. Washington* (1974), commonly referred to as the Boldt Decision, clarified these treaties with regard to allocation of salmon harvests between tribal and non-tribal fishers, affirming that the tribes are entitled to a 50 percent share of the harvestable run of fish. In addition, *Hoh v. Baldrige* (1981) established principles governing co-management of shared salmon resources whereby tribes are equal co-managers with the state and have the authority to represent themselves in the regional and international management forums. Along with the State of Washington, the Puget Sound treaty tribes (both individually and through the NWIFC) are responsible for co-managing Puget Sound salmon and steelhead hatchery production.

The Puget Sound treaty tribes also participated in the NEPA Technical Work Group via the NWIFC (representing the tribal applicants), and provided technical information and reviews of work products.

1.10 Organization of this Draft EIS

This EIS has been prepared in accordance with NEPA (40 CFR 1500 to 1508) and with the NEPA implementing regulations adopted by NMFS (NOAA 1999). The EIS should be reviewed in conjunction with the co-managers' RMPs and appended HGMPs, which contain more detailed information and explanations of hatchery programs affecting Puget Sound resources. Links to online sources of information used in the EIS are active at the time of publication; however, NMFS cannot guarantee that they will remain active over time. The contents of this draft EIS are described briefly below:

- **Introductory Materials**. Prior to Chapter 1 are a cover sheet, executive summary, list of acronyms, glossary of key terms, and table of contents.

- **Chapter 1**. This chapter provides the background and context leading to the development of the Proposed Action. It describes the purpose and need for the action; background and decisions to be made; scoping and relevant issues; and the relationship of this action to other plans, regulations, and laws.

- **Chapter 2**. This chapter describes each of the alternatives and lists their major components. The No-action Alternative is included, along with three action alternatives, including the Proposed Action, and alternatives considered but not analyzed in detail.

- **Chapter 3**. This chapter describes the existing environmental setting that would be affected by the alternatives (i.e., baseline conditions). It includes sections on fish, socioeconomics, environmental justice, wildlife, water quality and quantity, and human health resources.

- **Chapter 4**. This chapter contains a description and analyses of the potential direct and indirect effects of each alternative on the resources identified in Chapter 3. It also compares the action alternatives to the No-action Alternative.

- **Chapter 5**. This chapter addresses cumulative impacts, which are the incremental effects of an action when added to other past, present, and reasonably foreseeable actions, regardless of what agency or person undertakes such actions. Climate change is addressed in this chapter.

- **Remaining Material**. After Chapter 5 are a list of references, distribution list, list of preparers, and appendices.

Chapter 2

Alternatives

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2.0 ALTERNATIVES

2.1 Introduction

This chapter describes the Proposed Action and the four alternatives evaluated in this environmental impact statement (EIS). The alternatives are fully described in this chapter and their environmental effects are presented in Chapter 4, Environmental Consequences. A table summarizing the key components of each alternative is provided at the end of this chapter (Table 2.6-1). Specifically, this chapter describes the following:

- The Proposed Action
- How the alternatives were developed
- Alternatives that were analyzed in detail
- Alternatives that were considered but eliminated from detailed analysis
- The process for developing a preferred alternative (Box 2-1)

Box 2-1. Is there a preferred alternative or environmentally preferred alternative identified in this draft EIS?

This draft EIS does not contain a preferred alternative. NMFS anticipates identifying the preferred alternative in the final EIS after considering the comments received on this document. The preferred alternative may be a blend of more than one of the alternatives evaluated in this EIS. The preferred alternative may or may not be the environmentally preferred alternative, which will be identified in the Record of Decision (ROD). The environmental effects of the preferred alternative will be explained in the final EIS and summarized in the ROD.

Reviewers are not constrained to comment solely on the specific alternatives in this EIS but may recommend a preferred alternative that combines elements of several alternatives presented in this draft EIS.

NMFS encourages reviewers to perform the following activities:

1. Review the draft EIS to gain an understanding of how it is organized and how the alternatives are framed and analyzed.
2. Carefully consider the information provided in Chapters 4 and 5, Environmental Consequences and Cumulative Effects, respectively.
3. After considering the effects, comment on how NMFS should formulate a preferred alternative for publication in the final EIS and ROD.

2.2 Proposed Action

Under the Proposed Action, the National Marine Fisheries Service (NMFS) would evaluate the two proposed Puget Sound hatchery resource management plans (RMPs) and appended hatchery genetic and management plans (HGMPs) discussed in Chapter 1, Purpose of and Need for the Proposed Action, for Endangered Species Act (ESA) compliance. Upon concurrence by NMFS, the RMPs and HGMPs would achieve the conservation standards of the ESA as set forth in Limit 6 of the 4(d) rule for listed Puget Sound Chinook salmon (65 Fed. Reg. 42422, July 10, 2000), and steelhead (73 Fed. Reg. 55451, September 25, 2008). NMFS would conduct an ESA section 7 consultation to determine whether the action would likely jeopardize the continued existence of any listed species. The two RMPs and appended HGMPs for Puget Sound hatcheries would be implemented by the Washington Department of Fish and Wildlife (WDFW) and the Puget Sound treaty tribes (hereafter referred to as the co-managers).

As discussed in Subsection 1.1, Introduction, the EIS does not have a specific term or duration. The term of the EIS will continue until such time as new information, actions, or changes in baseline conditions warrant additional NEPA review.

In March 2004, NMFS received two RMPs from the Puget Sound hatchery co-managers:

- Puget Sound Chinook Salmon Hatcheries—A Component of the Comprehensive Chinook Salmon Management Plan (WDFW and PSTT 2004)
- Resource Management Plan—Puget Sound Hatchery Strategies for Steelhead, Coho Salmon, Chum Salmon, Sockeye Salmon & Pink Salmon (PSTT and WDFW 2004)

2.2.1 Context for the Alternatives

The submitted RMPs describe the overall role of hatcheries in achieving the co-managers' resource management goals, and include proposed conservation measures for listed Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*), and Hood Canal summer-run chum salmon (*O. keta*). Appended to the RMPs are 117 HGMPs that describe in greater detail 133 individual hatchery programs that are operated at 49 hatchery facilities and 13 net pens (Table 1.5-1). In addition, there are several facilities where the co-managers rear fish for a short time just prior to release.

Hatchery programs in the project area are described in Subsection 1.4, Project and Analysis Areas. These include programs for steelhead and Chinook salmon, coho salmon (*O. kisutch*), fall-run chum salmon

(*O. keta)*, sockeye salmon (*O. nerka*), and pink salmon (*O. gorbuscha*) from throughout the range of the listed Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU) and Puget Sound steelhead Distinct Population Segment (DPS). The RMPs do not include Hood Canal summer-run chum salmon programs because those programs were previously evaluated and approved (NMFS 2001a; 2001b). Summer-run chum salmon hatchery programs are part of the comprehensive Summer Chum Management Plan (WDFW and Point No Point Treaty Tribes [PNPTT] 2000) that has been reviewed and adopted by NMFS as part of the recovery plan for Hood Canal summer-run chum salmon (72 Fed. Reg. 29121, May 24, 2007).

This EIS discloses the impacts of HGMPs that have been submitted to NMFS under the RMPs (Box 2-2). Although the RMPs were submitted in March of 2004, some HGMPs have changed over time in response to changes in resource goals, budget considerations, and adaptive management. The oldest HGMP is from 2000, whereas the most recent HGMP that is analyzed in the EIS was submitted in 2012 (Table 1.5-1). Environmental analyses of substantially changed or new HGMPs submitted since that time (e.g., Chambers Creek winter-run steelhead programs) will be analyzed in the final EIS, or in a draft supplemental EIS (Box 2-2), as warranted.

Box 2-2. How will new or changed HGMPs relate to this EIS?

The two hatchery RMPs reviewed in this EIS were submitted to NMFS in 2004. The HGMPs reviewed in this EIS are shown in Table 1.5-1. Under the RMPs, changes to hatchery programs (and new programs) resulting from adaptive management, new information, or actions may occur over time. If new or changed HGMPs are submitted while this EIS is being developed, they will be addressed in the final EIS, or publication of a draft supplemental EIS may be required per Council on Environmental Quality regulations for supplemental reviews.

In addition, several circumstances have changed since 2004. For example, in 2007, Puget Sound steelhead were listed as threatened under the ESA. In addition, several new programs have begun operations since 2004 with the intent of conserving and recovering listed salmon and steelhead populations. These include new programs for South Fork Nooksack Chinook salmon, White River steelhead, Hood Canal steelhead, Elwha River steelhead (79 Fed. Reg. 20801, April 14, 2014), and Elwha River pink salmon. Under the RMPs and HGMPs, changes will continue to occur to hatchery programs over time in response to adaptive management (Subsection 2.2.4, Adaptive Management). To accommodate changes, the RMPs and HGMPs include performance monitoring, research, and adaptive management provisions, and the action alternatives in this EIS identify potential adaptive management measures, as appropriate. In some cases, measures have already been incorporated in hatchery program plans. In other cases, the co-managers will consider potential adaptive management measures and to the extent substantial changes are proposed, will submit changed plans to NMFS. The plans, which will be evaluated by NMFS under Limit 6 of the 4(d) rule [50 CFR 223.203(b)(6)], will explicitly address the impacts of the co-managers' proposed programs on listed Puget Sound steelhead.

Adaptive management will be considered in this chapter and in Chapter 4, Environmental Consequences. For the purposes of the EIS, it is not assumed that physical improvements to facilities will be made. However, such improvements would be expected as funds become available. All facility improvements would be evaluated under Federal and/or state NEPA/SEPA requirements (as applicable) at the time proposals are submitted to NMFS or to a state agency.

2.2.2 Hatchery Management Goal and Strategies

As stated in the RMPs, the co-managers' overall hatchery management goal is to protect, restore, and enhance the productivity, abundance, and diversity of salmon and steelhead and their ecosystems to sustain treaty ceremonial, treaty subsistence, treaty and non-treaty commercial and recreational fisheries, non-consumptive fish benefits, and other cultural and ecological values using the following multi-part strategy:

1. Protect and recover indigenous populations of salmon in watersheds where they still occur.

2. Implement management actions that use the most locally adapted stock to re-establish and sustain natural production in watersheds that no longer have indigenous populations, but where natural production is possible given the existence of suitable or productive habitat.

3. Manage watersheds that historically may not have supported self-sustaining, naturally spawning populations for hatchery production, when desired, while maintaining habitat for other fish species that are supported by these watersheds.

4. Protect treaty rights by providing fish for tribal harvest.

Under the Proposed Action, the co-managers would employ three watershed management strategies related to how Chinook salmon recovery categories achieve their goal of protecting, restoring, and enhancing salmon and steelhead productivity, as described in Table 2.2-1 (and see Box 2-3).

Table 2.2-1. Chinook salmon populations and associated co-manager-assigned recovery categories and watershed management strategies.

Chinook Salmon Population	Recovery Category	Watershed Management Strategy
Elwha Dungeness NF Nooksack SF Nooksack Upper Sauk Suiattle Cascade Upper Skagit Lower Skagit Lower Sauk SF Stillaguamish NF Stillaguamish Skykomish Snoqualmie Cedar Duwamish/Green White	1	Protect and recover indigenous populations in watersheds where they still occur.
Sammamish Puyallup Nisqually Mid-Hood Canal Skokomish	2	Implement management actions that use the most locally adapted stock to re-establish and sustain natural production in watersheds that no longer have indigenous populations, but where natural production is possible given the existence of suitable or productive habitat.
Samish East Kitsap Tributaries Deep South Sound Tributaries Deschutes Eastside Tributaries of Hood Canal	3	Manage watersheds that historically may have not supported self-sustaining natural populations for hatchery production, when desired, while maintaining habitat for other species that are supported in these watersheds.

Box 2-3. What do recovery categories 1, 2, and 3 mean?

The co-managers developed three recovery categories and watershed management strategies based on the current and historical distribution of Chinook salmon populations (Table 2.2-1). At this time, such categories have only been identified for Puget Sound Chinook salmon.

Recovery category 1 – Includes Chinook salmon populations that are genetically unique and indigenous to Puget Sound. Maintaining genetic diversity and integrity, and achieving abundance levels for long-term sustainability are the highest priorities for populations in this category.

Recovery category 2 – Includes Chinook salmon populations that were sustainable historically but are not likely to be indigenous currently. These populations are primarily found in southern Puget Sound and Hood Canal where hatchery production has been used extensively to mitigate for natural production that has been lost to habitat degradation. Historically, these areas were managed for hatchery production. Consequently, in many of these systems, hatchery-origin and natural-origin Chinook salmon are currently indistinguishable on the spawning grounds.

Recovery category 3 – Includes Chinook salmon populations that are generally found in small tributaries that may now have some natural spawning, but never historically had independent, self-sustaining populations. Salmon in these watersheds are probably hatchery strays or progeny from hatchery strays. The small tributary spawning aggregations characteristic of this category do not meet the current definition of independent populations. There are no populations of Chinook salmon in recovery category 3 that are part of the Puget Sound Chinook Salmon ESU.

Recovery categories for associating populations with watershed management strategies and actions have not been developed by the co-managers for species other than Chinook salmon.

Specific goals, objectives, and strategies for each hatchery program are contained in individual HGMPs. The specific goals consider current habitat conditions, the potential for and likely pace of recovering needed habitat, and harvest needs in each watershed.

2.2.2.1 Artificial Production Strategies

As described in Subsection 1.5.2, History of Hatcheries in Puget Sound, and Subsection 2.2.2, Hatchery Management Goals and Strategies, the two main benefits of hatcheries are increased abundance of salmon for harvest (i.e., harvest hatchery programs) and conservation and recovery of depressed natural-origin populations (i.e., conservation and recovery hatchery programs) (Table 2.2-2). The co-managers' hatchery strategies vary based on the specific goals of the hatchery program. For example, a program designed to help recover a species would be managed differently than a program designed to augment harvest. Each strategy has its own risks and benefits. To provide a systematic approach to addressing the different risks and benefits of hatcheries, the co-managers have classified their hatchery programs based on 1) the intended benefit of the hatchery program, and 2) whether the hatchery-origin fish are intended to spawn in the wild with natural-origin fish.

Table 2.2-2. Uses of hatchery program strategies by management objective.

Primary Management Objective	Hatchery Program Strategy	
	Integrated	**Isolated**
Conservation and Recovery[1]	• Prevent extinction • Increase natural-origin recruits • Reintroduction • Research • Harvest	• Prevent extinction • Create reserve populations in case other recovery options fail • Gene banking until reintroduction • Research • Harvest
Harvest	• When isolated production approach is not feasible • While developing locally adapted stocks • During rebuilding • Mitigation • Research • Harvest	• Create new or enhance existing fishing opportunities • Mitigation • Research • Harvest

Source: WDFW and PSTT (2004).
[1] Many natural-origin and hatchery-origin populations would have some level of incidental harvest even if the primary objective is not for harvest.

The RMPs describe two strategies related to the degree of interaction and similarity between hatchery-origin and natural-origin populations: integrated production strategies and isolated production[1] strategies. Integrated and isolated strategies can apply to either harvest or conservation hatchery programs, or both. Research hatchery programs are designed to improve salmon management practices associated with hatchery reform.

[1] Isolated production strategies are also commonly referred to as segregated production strategies.

Integrated hatchery programs are designed so that differences between hatchery-origin and natural-origin fish are minimized, and that hatchery-origin fish are integrated with the local populations included in ESUs or DPSs. Integrated hatchery programs may be used to support conservation and harvest.

Isolated hatchery programs produce fish that are different from local populations, and are designed to prevent hatchery-origin fish from spawning in the wild or to avoid interbreeding and ecological interactions between hatchery-origin and natural-origin populations. Isolated hatchery programs support harvest and generally do not contribute to recovery or conservation of populations in ESUs or DPSs.

As shown in Table 2.2-3, of the total number (133) of co-managers' hatchery programs, 60 percent are isolated hatchery programs, and 40 percent are integrated hatchery programs. Seventy-seven percent are harvest programs, 20 percent are conservation programs, and the remaining 3 percent are research programs.

Table 2.2-3. Number of programs by species and hatchery program strategy.

	Hatchery Program Strategy						
	Integrated			Isolated			
Species	Harvest	Conservation	Research	Harvest	Conservation	Research	Total
Chinook salmon	11	13	2	19	2	1	48
Coho salmon	9	4	0	30	0	0	43
Chum salmon[1]	6	1	0	7	0	0	14
Pink salmon	0	1	0	2	0	0	3
Sockeye salmon	1	1	0	0	0	0	2
Steelhead	0	4	0	19	0	0	23
Totals (Percent)	**27 (20)**	**24 (18)**	**2 (2)**	**77 (57)**	**2 (2)**	**1 (1)**	**133 (100)**

[1] Programs producing Hood Canal summer-run chum salmon are not included. Those programs are not included in the RMP.

2.2.3 Guidelines for Each Artificial Production Strategy

The co-managers developed strategy-specific guidelines for desired operating conditions for each artificial production strategy (Appendix A in WDFW and PSTT 2004). Each HGMP describes in more detail the operating procedures and guidelines applied to specific hatchery programs.

2.2.4 Adaptive Management

The RMPs include guidelines and operating procedures for addressing changes over time through an adaptive management process that would be used under the Proposed Action. Adaptive management is a deliberate process of using research, monitoring, and scientific evaluation in making decisions in the face of uncertainty (Hollings 1978; Walters 1986).

As described in the RMPs, adaptive management can be active or passive. Active adaptive management is often associated with large-scale experiments where decisions can only be informed upon completion of the experiment. Passive adaptive management uses the best available scientific information to make decisions initially, but also specifies multiple, future decision points where new information is analyzed and incorporated into decisions. Evolutionary problem solving encourages managers to experiment with innovation independently and share results (Anderson et al. 2003). Change depends largely on the extent of participation, communication, and commitment among those participating in the adaptive management process.

Under the Proposed Action, the RMPs' adaptive management framework would combine passive adaptive management and evolutionary problem solving. The framework has several key elements:

- Monitoring and research
- Scientific tools for evaluating hatchery operations, including statistical analysis, risk-benefit assessments, and independent scientific review
- A decision-making framework for considering in-season, annual, and long-term changes in hatchery program objectives and resolving disputes
- Implementation of hatchery program actions using available resources

Each of these key elements is described in more detail in the following subsections.

2.2.4.1 Monitoring, Research, and Evaluation

Monitoring and research would provide new information for evaluating hatchery programs under the passive adaptive management strategy. The co-managers currently monitor fish culture at all state and tribal facilities, and would continue with this monitoring under the Proposed Action. However, funding limitations constrain implementation of comprehensive hatchery program monitoring. Thus, as described in the RMPs, the co-managers would continue to place highest priority on: 1) marking and sampling hatchery-origin fish, 2) developing genetic baselines of hatchery-origin and natural-origin populations, 3) selecting hatchery broodstock, 4) controlling for disease, 5) providing fish screening and passage, and 6) abating hatchery pollution (Monitoring Oversight Committee 2002). A summary of monitoring activities for these activities is contained in Appendix B of WDFW and PSTT (2004).

Research and evaluation would continue to help explain trends in monitoring outcomes, provide information for developing better risk assessments, and test new ideas and practices for improving hatcheries. Although funding for research is also limited, the co-managers would continue to actively work with NMFS and independent scientists[2] to identify and conduct critical research in Puget Sound on the genetic, ecological, and demographic effects of salmon and steelhead hatchery programs on the survival and productivity of listed and non-listed salmon and steelhead populations. Summaries of research are contained in Appendix C of WDFW and PSTT (2004).

2.2.4.2 Scientific Tools for Evaluating Hatchery Operations

Scientific tools for adaptive management evaluations of hatchery programs include benefit-risk assessments and independent scientific reviews, which would continue under the Proposed Action.

2.2.4.2.1 Benefit-Risk Assessments

The co-managers developed the Benefit-Risk Assessment Procedure tool to evaluate the benefits and risks of hatchery programs in the ecological context of each watershed (WDFW 2001). This tool has been used to systematically analyze benefits and risks of hatchery programs for Chinook salmon and identify needed changes in hatchery program plans.

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[2] For example, the Hatchery Scientific Review Group.

2.2.4.2.2 Independent Scientific Review

Independent scientific review is an important way to obtain new insights and maintain scientific credibility. The RMPs state there are at least two major mechanisms available to obtain independent scientific reviews in support of the adaptive management provisions of the RMPs and HGMPs. First, from 2001 to 2003, the Hatchery Scientific Review Group (HSRG) served as an independent scientific panel that worked with the co-managers to produce guidelines and recommended actions to help ensure that the goals of hatchery reform are met while reducing adverse effects of hatchery operations (Subsection 1.5.3, Other Reviews of Puget Sound Hatchery Programs). The HSRG reviewed all hatchery programs in western Washington and developed recommendations for changes to those programs based on dual goals of recovering natural-origin salmon and steelhead populations and providing for sustainable fisheries. The work of the HSRG informed development of draft HGMPs and has continued on a limited basis. Second, the co-managers may use ad hoc independent scientific review panels to address specific issues on a case-by-case basis. The key to such reviews is identifying appropriate experts with the willingness and time to participate. The American Fisheries Society is an example of a professional organization that can help coordinate and organize independent scientific review panels.

Scientific tools, such as these for evaluating hatchery operations, are important for informing policy decisions. However, scientific tools do not create or dictate policy changes for implementing hatchery reform. Under the RMPs, political, social, and legal goals would be considered and incorporated through co-manager policy review. Under the RMPs, the process for policy review, implementation, or modification of technical recommendations resulting from monitoring, research, evaluations, benefit-risk assessments, or independent scientific review would be reached through the legal and policy decision-making framework described below.

2.2.4.3 Decision-making Framework

As described in Subsection 1.7.2.3, Puget Sound Salmon Management Plan, the Puget Sound Salmon Management Plan is the implementation framework for the allocation, conservation, and equitable sharing principles that govern the joint management of salmon resources in Puget Sound between the Puget Sound treaty tribes and the State as defined under *United States v. Washington* (1974). The RMPs in turn provide the tools and processes for making changes in hatchery plans and operations in Puget Sound to meet the noted principles. These tools and processes are 1) descriptions of standard modes of operating hatchery programs developed by the co-managers (i.e., via Equilibrium Brood Documents), 2) annual descriptions and review of the operating objectives and changes from the standard program that can be used for annual planning (i.e., via Future Brood Documents[3] [http://wdfw.wa.gov/hatcheries/future_brood.html], and co-managers' Fish Disease Policy [NWIFC and WDFW 2006]), 3) management plans to coordinate co-manager activities and priorities, 4) exchange of technical information and analyses through coordinated information systems, and 5) dispute resolution.

The co-management decision-making framework described in the RMPs would be implemented using policy review, decisions, and allocation of resources to improve the performance of hatchery programs in meeting their objectives. Attention would be focused at regular intervals in a three-tiered process (Table 2.2-4). This approach is consistent with a passive adaptive management and evolutionary problem solving strategy. The most important review and decision-making steps would occur in tier 1, wherein every 3 to 5 years hatchery programs and monitoring data would be reviewed, which may lead to recommendations for changing programs, equilibrium brood documents, practices, and HGMPs (Table 2.2-4).

Table 2.2-4. Components of the adaptive management decision-making framework.

Tier	Time Interval	Implementation Documents	Evaluation Tools	Dispute Resolution
Tier 1	3 to 5 years	• Equilibrium Brood Documents • HGMPs	• Monitoring and evaluation • Independent scientific review • Benefit-risk assessment	• Co-management meetings • Annual state/tribal co-managers' meeting
Ter 2	Annual	• Future Brood Documents • Hatchery reform recommendations	• Risk assessment • Co-manager review	• Co-management meetings • Annual state/tribal co-managers' meeting
Tier 3	Within-year	• Fish transfer requests • Co-managers' Fish Disease Policy	• Risk assessment • Co-manager review	• Co-management meetings

[3] The Equilibrium Brood Document (EBD) and Future Brood Document (FBD) annually describe production goals and plans for hatcheries agreed upon by WDFW, Puget Sound treaty tribes, the Northwest Indian Fisheries Commission, and the U.S. Fish and Wildlife Service. The documents are compiled annually by WDFW for review by the co-managers. The documents include goals and operational details such as stock source, egg-takes, transfers, release timing, and numbers to be released. Using the EBDs as a basis, FBDs are pre-season hatchery planning documents for the upcoming broodstock collection and fish rearing season (July 1 to June 30). After agreement among the parties, the FBD becomes the current EBD, and the cycle repeats. For more information see http://wdfw.wa.gov/hatcheries/future_brood.html

In tier 2, individual hatchery programs would be evaluated annually (Table 2.2-4). Future Brood Documents are key implementation documents in this tier. They would describe production objectives and program changes, and identify hatchery reform recommendations developed through independent scientific review. Risk assessment modeling provides a tool for analyzing the changes, should it be necessary. Dispute resolution under the RMPs would occur as described above for tier 1.

In tier 3, the co-managers would evaluate within-year changes from the Future Brood Document (Table 2.2-4). These changes may involve transfers of fish (adults, gametes, or juveniles for growing and release) between watersheds. Failure of the co-managers to agree to the change may lead to dispute resolution as described for the other tiers.

2.2.4.4 Implementation of Changes to Hatchery Program Actions

Under the Proposed Action, the RMPs call for hatchery programs to evolve as needed in response to monitoring, research, and evaluation, conducted through the adaptive management process. Specific hatchery program actions (including best management practices) that may be implemented over time in changes to hatchery program plans as a result of the adaptive management process include:

- Decreases or increases in annual juvenile fish production levels at certain locations
- Changes in juvenile release locations
- Increased use of locally adapted stocks and integrated production strategies
- Changes in marking and tag recovery practices
- Facility improvements designed to limit impacts to natural systems (such as improving water intake screens to comply with current state and Federal guidelines, or construction or improvement of pollution abatement systems to lessen facility impacts from hatchery effluent water)

- Facility improvements that result in more efficient and/or effective operations (such as installation of new predator deterrent systems or repair of rearing containers)[4]
- Improvements that result in better management of adult hatchery-origin fish as they return to and/or reside on the spawning grounds
- Installation of weirs to reduce the number of hatchery-origin fish in natural spawning areas
- Construction of ponds to improve imprinting of juvenile releases so that homing of hatchery-origin adults to desired areas is improved
- Revisions to co-manager fish health policies
- Increases in the proportion of natural-origin fish in hatchery broodstock
- Implementation of other actions consistent with the RMP management guidelines (Appendix A in WDFW and PSTT 2004)

A database, called the Salmon Conservation Reporting Engine (SCoRE), is being developed by WDFW and would help track changes made to their hatchery programs, and how those changes relate to salmon recovery. A SCoRE website and database can be found at https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score. Puget Sound tribes would continue to track hatchery actions at their local levels, and tribal hatchery reform actions funded under the Pacific Coastal Salmon Recovery Fund would be documented in that program's database (https://www.webapps.nwfsc.noaa.gov/apex/f?p=227:1).

2.3 Development of Alternatives

Beginning in August 2004 and continuing through 2011, NMFS solicited and considered public comment on the development of alternatives for this EIS. A series of meetings was convened by NMFS and included the general public, the co-managers, and NMFS staff to identify issues and gather input on possible EIS alternatives. Based on all input received during scoping (Subsection 1.6, Scoping and

[4] Facility improvements would occur as funds become available. All facility improvements would be evaluated under Federal and/or state NEPA/SEPA requirements (whichever is applicable) to determine the appropriate environmental documentation and permitting requirements necessary for the improvements.

Relevant Issues) and discussions with co-managers, issues relevant to development of EIS alternatives are:

- Modify hatchery programs, including eliminating some programs altogether, to help conserve natural-origin salmon and steelhead, particularly ESA-listed species.
- Modify hatchery programs to provide more fishing opportunities.
- Change hatchery production, release methods, and locations to minimize undesired effects on listed species.

The public scoping process identified 12 potential alternatives. Of these 12 alternatives, 3 were found to represent the full range of reasonable alternatives because they met the purpose and need for the Proposed Action and their components differed meaningfully among the other alternatives analyzed. Nine potential alternatives were carefully considered but eliminated from detailed analysis because they would not meet the purpose and need for the action, are already encompassed by other alternatives analyzed in detail and thus would not provide new information for the decision-maker to consider, would likely occur under the Proposed Action's adaptive management plan, and/or would not be technically feasible.

2.4 Alternatives Analyzed in Detail

The four alternatives described in this subsection include a no-action alternative and three action alternatives, one of which is the Proposed Action. A table summarizing the key components of each alternative is provided at the end of this chapter (Table 2.6-1). The alternatives analyzed in detail are:

- **The No-action Alternative (Alternative 1)**

  Under this alternative, NMFS would not evaluate and make take determinations under the ESA section 4(d) rules for the co-managers' Puget Sound hatchery RMPs and appended HGMPs. For analysis purposes, it is assumed that hatchery production would continue at current levels (Subsection 2.4.2, Alternative 1, No Action). It is also assumed that adaptive management provisions would not be applied.

- **The Proposed Action (Alternative 2)**

  This alternative consists of hatchery operations as proposed under the co-managers' RMPs and appended HGMPs. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Hatchery program sizes would meet conservation requirements for listed species, harvest benefits would continue, and conservation measures would be applied to all programs to reduce risks.

- **A Reduced Production Alternative (Alternative 3)**

  Compared to Alternative 2, this alternative would provide greater conservation benefits to salmon and steelhead. Under this alternative, hatchery production for the purpose of harvest would be reduced 50 percent[5] for all Chinook salmon, coho salmon, and steelhead programs in watersheds having Chinook salmon populations in recovery categories 1 and 2 (Table 2.2-1), where watershed management strategies are oriented at protecting and recovering indigenous populations where they still occur, and where management actions use the most locally adapted stock to re-establish natural production in watersheds in which suitable habitat exists but indigenous populations no longer occur. Reductions would not occur in watersheds having recovery category 3 populations that may not have historically supported, self-sustaining natural populations. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Harvest benefits would be reduced but would continue, and conservation measures would be applied to all programs to reduce risks to listed species.

- **An Increased Production Alternative (Alternative 4)**

  Compared to Alternative 2, this alternative would provide more harvest benefits. Under this alternative, hatchery production would increase for programs where existing facility and funding capacity exists to do so. No new facilities or water sources would be developed. The additional production would depend on the match of available hatchery capacity with the broodstock collection, spawning, incubation, and rearing needs of the fish species produced. Increases could occur for programs whose purposes include harvest and/or conservation.

[5] During scoping some commenters proposed an alternative with increased hatchery production, whereas others proposed decreased hatchery production. Therefore, the 50 percent value was chosen to reflect a balance. This percentage was deemed robust for analysis and likely to provide useful information for the decision maker.

Increases in production would need to be in compliance with the ESA. NMFS would evaluate and make take determinations under the ESA section 4(d) rules, and adaptive management provisions in the RMPs would be applied. Program size and harvest benefits would increase, and conservation measures would be applied to all programs to reduce risks to listed species.

More detail on each alternative is presented in the subsections below.

2.4.1 Actions Common to All Alternatives

Actions associated with hatchery management that do not vary across the alternatives include:

- Rearing and release timing of juveniles (e.g., the locations and times hatchery-origin juveniles are released)
- Broodstock choice (e.g., local, natural-origin stock, or out-of-ESU hatchery-origin stock)
- Hatchery funding (e.g., for operation and maintenance or structures)
- Management of fish to reduce risk of disease (e.g., testing, isolation, and prophylactic treatments)
- Fish passage at hatcheries (e.g., operation of fishways or weirs)
- Screens on water intake structures (e.g., placement and use of diversion screens)
- Water supplies (e.g., consistent with water rights)
- Marking and detection of tagged fish (e.g., fin-marking and coded-wire tagging)
- Harvest production (e.g., consistent with the Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes [PSIT] and WDFW 2010), and other ESA-approved harvest plans)

2.4.2 Alternative 1 (No Action)

2.4.2.1 Description of Alternative

As summarized in Table 2.6-1, under Alternative 1, the co-managers' RMPs and HGMPs would not be evaluated and approved by NMFS, and NMFS would not make a take determination under Limit 6 of the ESA 4(d) rule for Puget Sound salmon or Puget Sound steelhead. Section 9 take prohibitions would continue to apply to the co-managers' hatchery activities (65 Fed. Reg. 42422, July 10, 2000 and 73 Fed. Reg. 55451, September 25, 2008). In addition, under Alternative 1, the hatchery adaptive management processes may not be similar to what is described in the RMPs and HGMPs. Thus, it is assumed that the watershed management strategies by recovery category (Subsection 2.2.2, Hatchery Management Goals and Strategies) and the formal adaptive management process (Subsection 2.2.4, Adaptive Management), would not be in place under Alternative 1. NMFS cannot make any assumptions about alternative permitting processes, potential litigation, or possible enforcement actions that could occur if NMFS fails to approve the RMPs under Limit 6 of the ESA 4(d) rule.

Under Alternative 1, no new facilities would be constructed, no existing facilities would be expanded, and no modifications of existing water supplies would be made. In addition, the alternative does not presume that harvest regulations would change to accommodate changes in hatchery production. Harvest regimes for Chinook salmon and other fish species would continue to be consistent with the co-managers' 2010 ESA-approved Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (PSIT and WDFW 2010), and other ESA-approved harvest plans.

2.4.2.2 Juvenile Fish Production Levels

The annual production levels under Alternative 1 would total 147 million juvenile fish (Table 2.4-1). This production level is based on draft HGMPs identified in Table 1.5-1. All HGMPs are consistent with the proposed RMPs.

Under Alternative 1, Chinook salmon and chum salmon would be the most commonly produced species, and steelhead and pink salmon would be the least commonly produced species (Table 2.4-1). Production levels for individual hatchery programs can be found in Appendix A, Puget Sound Hatchery Programs and Facilities.

Table 2.4-1. Annual juvenile production levels (in thousands) for all alternatives and percent changes relative to Alternative 1.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
Species	**Number**	**Number**	**Percent Change from Alt. 1**	**Number**	**Percent Reduction from Alt. 1**	**Number**	**Percent Increase from Alt. 1**
Chinook Salmon	45,317	45,317	0	37,182	18	51,307	13
Coho Salmon	14,592	14,592	0	11,391	22	18,478	27
Steelhead	2,468	2,468	0	1,409	43	2,561	4
Chum Salmon	44,995	44,995	0	44,475	1	57,495	28
Pink Salmon	4,500	4,500	0	4,500	0	5,000	11
Sockeye Salmon	35,125	35,125	0	35,125	0	35,125	0
Total	**146,997**	**146,997**	**0**	**135,082**	**8**	**169,967**	**16**

Source: Draft HGMPs.

2.4.3 Alternative 2 (Proposed Action)

2.4.3.1 Description of Alternative

As summarized in Table 2.6-1, under Alternative 2, NMFS would evaluate and make determinations on whether the proposed RMPs and HGMPs addressed criteria under Limit 6 of the ESA 4(d) rule for Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and Puget Sound steelhead. If the hatchery programs were determined to meet the Limit 6 criteria, ESA section 9 take prohibitions would not apply to hatchery activities that are undertaken in compliance with the co-manager RMPs.

Under Alternative 2, the co-managers would implement watershed management strategies associated with recovery categories (Subsection 2.2.2, Hatchery Management Goals and Strategies), and the three-tiered adaptive management process described in the RMPs and HGMPs (Subsection 2.2.4, Adaptive Management), which includes monitoring, research, and evaluation to determine if the programs are meeting stated objectives and are adequately protective of listed fish. Hatchery production levels could change over time based on results from the adaptive management process.

As under the No-action Alternative, no new facilities would be constructed under Alternative 2, no existing facilities would be expanded, and no modifications of existing water supplies would be made. In addition, the alternative does not presume that harvest regulations would change to accommodate changes in hatchery production. Harvest regimes for Chinook salmon and other fish species would continue to be consistent with the co-managers' 2010 ESA-approved Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (PSIT and WDFW 2010), and other ESA-approved harvest plans, respectively.

2.4.3.2 Juvenile Fish Production Levels

Under Alternative 2, the annual production levels for hatchery programs would be the same as under Alternative 1 (Table 2.4-1).

2.4.4 Alternative 3 (Reduced Production)

2.4.4.1 Description of Alternative

As summarized in Table 2.6-1, under Alternative 3, as under Alternative 2, NMFS would evaluate and make take determinations under Limit 6 of the 4(d) rule for Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and Puget Sound steelhead. If the programs described under Alternative 3 were determined to meet the Limit 6 criteria, ESA section 9 take prohibitions would not apply to hatchery activities that are undertaken in compliance with the RMPs.

Under Alternative 3, the co-managers would implement watershed management strategies associated with recovery categories (Subsection 2.2.2, Hatchery Management Goals and Strategies), and the three-tiered adaptive management process described in the RMPs and HGMPs (Subsection 2.2.4, Adaptive Management), which includes monitoring, research, and evaluation to determine if the programs are meeting stated objectives and are adequately protective of listed fish.

Alternative 3 would increase protection of natural-origin Puget Sound Chinook salmon populations by reducing production of hatchery-origin fish. The implied assumption of this alternative is that compared to Alternative 1, release of fewer hatchery fish would reduce the risks of genetic degradation and ecological interactions between hatchery-origin and natural-origin fish. All other components of the co-managers' RMPs and HGMPs as described under Alternative 2 would be applied under Alternative 3.

Under Alternative 3, hatchery programs designed to increase harvest opportunities for Chinook salmon, steelhead, and coho salmon would decrease 50 percent in watersheds that support Chinook salmon populations in recovery categories 1 and 2 (see Subsection 2.2.2, Hatchery Management Goals and Strategies, for descriptions of recovery categories 1 and 2). There would be no changes to production levels in hatchery programs designed to aid in the recovery of Chinook salmon (Table 2.4-2). In addition, chum salmon, pink salmon, and sockeye salmon are not known to prey on, or significantly compete with, Chinook salmon (Subsection 3.2.5.4.1, Hatchery Program Risks and Benefits; and Appendix B, Hatchery Effects and Evaluation Methods for Fish). Thus, production levels for chum salmon, pink salmon, and sockeye salmon programs would remain at current levels in watersheds that support recovery category 1 and 2 Chinook salmon populations. There would be no changes to production levels in watersheds with recovery category 3 Chinook salmon populations because Chinook salmon in those watersheds do not need to reach viable status to recover the Puget Sound Chinook Salmon ESU (Ruckelshaus et al. 2002).

As under Alternative 1, no new facilities would be constructed, no existing facilities would be expanded, and no modifications of existing water supplies would be made under Alternative 3. In addition, this alternative does not assume that harvest regulations would change to accommodate changes in hatchery production. Harvest regimes for Chinook salmon and other species would continue to be consistent with the co-managers’ 2010 ESA-approved Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (PSIT and WDFW 2010), and other ESA-approved harvest plans.

2.4.4.2 Juvenile Fish Production Levels

The annual production levels under Alternative 3 would be about 135 million fish, or 12.0 million fish (8 percent) less than under Alternative 1 (Table 2.4-1). Compared to Alternative 1, steelhead production would be reduced 43 percent, Chinook salmon production would be reduced 18 percent, coho salmon production would be reduced 22 percent, and chum salmon production would be reduced 1 percent. There would be no reductions in pink salmon and sockeye salmon production compared to Alternative 1. Production levels for individual hatchery programs can be found in Appendix A, Puget Sound Hatchery Programs and Facilities.

Table 2.4-2. Alternative 3 reductions in hatchery production by species and program type relative to Alternative 1 by Chinook salmon recovery category.

Recovery Category of Chinook Salmon Populations	**Chinook Salmon Hatchery Programs**			**Coho Salmon Hatchery Programs**			**Steelhead Hatchery Programs**		**Chum Salmon Hatchery Programs**	**Pink Salmon Hatchery Programs**	**Sockeye Salmon Hatchery Programs**
	Conservation	**Harvest**	**Research**	**Conservation**	**Harvest (in fresh water)**	**Net Pens in Marine Waters**	**Conservation**	**Harvest**			
Category 1	No Change	50% Reduction	No Change	No Change	50% Reduction	No Change	No Change	50% Reduction	No Change	No Change	No Change
Category 2	No Change	50% Reduction	No Change	No Change	50% Reduction	No Change	No Change	50% Reduction	No Change	No Change	No Change
Category 3	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

2.4.5 Alternative 4 (Increased Production)

2.4.5.1 Description of Alternative

As summarized in Table 2.6-1, under Alternative 4, as under Alternative 2, NMFS would evaluate and make take determinations under Limit 6 of the 4(d) rule for Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and Puget Sound steelhead. If the hatchery programs described under Alternative 4 were determined to meet the Limit 6 criteria, then ESA section 9 take prohibitions would not apply to hatchery activities that are undertaken consistent with this alternative.

Under Alternative 4, the co-managers would implement the watershed management strategies associated with all recovery categories (Subsection 2.2.2, Hatchery Management Goals and Strategies) and the three-tiered adaptive management process described in the RMPs and HGMPs (Subsection 2.2.4, Adaptive Management), which includes monitoring, research, and evaluation to determine if the programs are meeting stated objectives and are adequately protective of listed fish.

Alternative 4 would increase production of hatchery-origin fish to provide additional fishing opportunities for Indian tribes, commercial fishers, and recreational anglers. As described for the other action alternatives, all other components of the co-managers' RMPs and HGMPs would be applied under Alternative 4.

Production would be increased at all Puget Sound hatcheries where additional existing capacity exists (Table 2.4-3). Different species of salmon and steelhead have different hatchery facility requirements for water quantity, water quality, water temperature, rearing time, and the density under which they can be held. Unused capacity would be used to produce the species in quantities that would be most suitable for the individual hatchery facility at which capacity exists.

As under Alternative 2, no new facilities would be constructed, no existing facilities would be expanded, and no modifications to existing water supplies would be made under Alternative 4. In addition, the alternative does not presume that harvest regulations would change to accommodate increased hatchery production. Harvest regimes for Chinook salmon and other species would continue to be consistent with the co-managers' 2010 ESA-approved Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (PSIT and WDFW 2010), and other ESA-approved harvest plans.

2.4.5.2 Juvenile Fish Production Levels

The annual production levels under Alternative 4 would total about 170 million fish, or about 23 million fish (16 percent) more than under Alternative 1 (Table 2.4-1). Coho salmon production would increase 27 percent compared to Alternative 1, chum salmon production would increase 28 percent, Chinook salmon production would increase 13 percent, pink salmon production would increase 11 percent, and steelhead production would increase 4 percent (Table 2.4-1). Production levels for individual hatchery programs can be found in Appendix A, Puget Sound Hatchery Programs and Facilities.

2.5 Alternatives Considered but Eliminated from Detailed Analysis

Nine additional alternatives identified during scoping (Subsection 1.6, Scoping and Relevant Issues), were carefully considered but eliminated from detailed analysis for one or more of the following reasons:

- Alternative(s) would not meet the purpose and need for action.
- Alternative(s) would be encompassed by other alternatives analyzed in detail and thus would not provide new information for the decision-maker.
- Alternative(s) would not be feasible or practicable.

2.5.1 Eliminating All Hatchery Production Proposed in the Co-managers' RMPs

This potential alternative would result in the elimination of production at 133 hatchery programs in Puget Sound managed by the WDFW and/or the Puget Sound treaty tribes. This alternative is not analyzed in detail because it would not meet the purpose and need for the Proposed Action; eliminating all hatchery production would not meet ESA requirements of conserving listed species supported by conservation hatcheries, may not meet Federal treaty trust responsibilities to tribes, and would not be technically feasible.

Table 2.4-3. Alternative 4 increases in hatchery production[1] by species and program type relative to Alternative 1 by Chinook salmon recovery category.

Recovery Category of Chinook Salmon Populations	Chinook Salmon Hatchery Programs			Coho Salmon Hatchery Programs			Steelhead Hatchery Programs		Chum Salmon Hatchery Programs	Pink Salmon Hatchery Programs	Sockeye Salmon Hatchery Programs
	Conservation	**Harvest**	**Research**	**Conservation**	**Harvest (in fresh water)**	**Net Pens in Marine Waters**	**Conservation**	**Harvest**			
Category 1	No Change	4% Increase	No Change	No Change	36% Increase	No Change	No Change	4% Increase	No Change	No Change	No Change
Category 2	No Change	37% Increase	No Change	No Change	9% Increase	No Change	No Change	No Change	50% Increase	No Change	No Change
Category 3	No Change	10% Increase	No Change	No Change	48% Increase	No Change	No Change	12% Increase	35% Increase	33% Increase	No Change

[1] Increases are where existing capacity exists that can support rearing needs of the species.

When the Puget Sound Chinook Salmon ESU was listed as threatened in 1999, NMFS determined that eight conservation hatchery programs were essential for the recovery of the ESU. Chinook salmon produced in those hatchery programs were, therefore, listed along with natural-origin Chinook salmon (64 Fed. Reg. 14308, March 24, 1999). In subsequent updated status reviews for the Puget Sound Chinook Salmon ESU, NMFS concluded that fish produced in an additional 20 hatchery programs should be listed because they contained a substantial portion of the genetic diversity remaining in the ESU (NMFS 2011; 70 Fed. Reg. 37204, June 28, 2005; 76 Fed. Reg. 50448, August 15, 2011). Two new Chinook salmon conservation hatchery programs are included in the ESU (Skookum Creek Hatchery and Harvey Creek Hatchery) (79 Fed. Reg. 20802, April 14, 2014). At this time, Chinook salmon produced in 26 Puget Sound hatchery programs are listed under the ESA, and eliminating these programs would not meet the underlying need for the Proposed Action. In addition, Puget Sound steelhead were listed in 2007. Five new steelhead conservation hatchery programs are now included in the DPS (White River winter-run, Hood Canal winter-run [Dewatto, Duckabush, North Fork Skokomish River], and Elwha River native winter-run) (79 Fed. Reg. 20802, April 14, 2014). Eliminating these programs would not meet the purpose and need for the Proposed Action.

The potential alternative may not meet treaty trust responsibilities. Eliminating all hatchery production would greatly reduce, and in some cases eliminate, the opportunity for tribal harvest of salmon in Puget Sound. It would also eliminate hatchery programs producing indicator stocks under the Pacific Salmon Treaty (Subsection 1.7.1.3, Pacific Salmon Treaty).

Finally, this potential alternative would not be reasonable or practicable. Even if hatchery programs were discontinued, adult hatchery-origin fish would return for about 5 years after the last juveniles were released and it would take about three generations of salmon or steelhead (or 15 years), for the fish to respond to changes in management actions. The effects from the hatchery production prior to that time, such as changes in genetic diversity resulting from past and recent gene flow from hatchery-origin to natural-origin fish and the loss of marine-derived nutrients from hatchery-origin fish spawning naturally, would be expected to remain for the long term. Thus, the potential alternative would not represent a landscape without influences from hatchery fish, and analysis of the alternative would not provide the information necessary to address the reasons for the request for this alternative. In addition, the alternative is infeasible to assess because it is not possible to distinguish hatchery-origin from natural-origin adults for many populations of listed Puget Sound salmon and steelhead species with currently applied tools and available data.

2.5.2 Incorporation of All Hatchery Scientific Review Group Recommendations

This potential alternative would implement all recommendations made by the HSRG from 2002 to 2004 as an action alternative. This alternative is not analyzed in detail because the co-managers are already implementing HSRG recommendations. For example, RCO (2012) indicates progress has been made in increasing the percentage of WDFW's Puget Sound hatchery programs that meet HSRG standards. In addition, HSRG recommendations are already being incorporated into HGMPs, and the co-managers intend to continue to implement them over time within the adaptive management framework of the RMPs (Subsection 2.2.4, Adaptive Management). Thus, this potential alternative would not be substantially different from the action alternatives.

2.5.3 Close Hatchery Programs when Natural-origin Chinook Salmon Populations Improve

This potential alternative would result in the closure of individual Chinook salmon hatchery programs once the naturally producing Chinook salmon populations that the hatcheries support are acceptably self-sustaining. This alternative is not analyzed in detail because it would be expected to occur within the adaptive management framework of the co-managers' proposed RMPs. Thus, this potential alternative is not substantially different from the action alternatives.

2.5.4 Eliminate Chinook Salmon Hatchery Programs in Watersheds with Recovery Categories 1 and 2 Chinook Salmon Populations

This potential alternative would eliminate production of Chinook salmon from hatcheries in watersheds having natural-origin Chinook salmon populations in recovery categories 1 and 2. All of the Chinook salmon populations comprising the ESU reside in watersheds harboring in recovery categories 1 and 2. This alternative is not analyzed in detail because it would not meet the purpose and need for the Proposed Action as it would not meet ESA requirements of conserving listed Chinook salmon supported by conservation hatcheries. In addition, it may not meet treaty trust responsibilities. Eliminating Chinook salmon hatchery production in watersheds with recovery category 1 and 2 populations would greatly reduce the opportunity for tribal and non-tribal harvest of Chinook salmon in Puget Sound.

2.5.5 Strict Adherence to the State's Wild Salmonid Policy

This potential alternative would implement the Wild Salmonid Policy (WDFW and Western Washington Treaty Tribes 1997) that was adopted in 1997 by WDFW. Since then, WDFW's Wild Salmonid Policy has been superseded by the hatchery reform policy (see Subsection 2.5.6, Strict Adherence to Current

State Wild Salmon and Steelhead Policies). This hatchery reform policy would be applied by the State through the adaptive management process under the RMPs. Thus, this potential alternative is not analyzed because it is not substantially different from the action alternatives.

2.5.6 Strict Adherence to Current State Wild Salmon and Steelhead Policy

This potential alternative would implement the hatchery reform policy adopted by the Washington Fish and Wildlife Commission in 2009 (WFWC 2009). The hatchery reform policy is internal to WDFW. The hatchery reform policy already guides state hatchery programs, and would be used by the State through the adaptive management framework of the co-managers' proposed RMPs. Thus, this potential alternative is not analyzed because it is not substantially different from the action alternatives.

2.5.7 Develop an Alternative that is More Protective of ESA-listed Steelhead

Puget Sound steelhead were listed as threatened under the ESA in 2007 (72 Fed. Reg. 26722, May 11, 2007). This potential alternative would specifically address the conservation needs of Puget Sound steelhead. Hard et al. (2007) and Ford (2011) identify releases of out-of-DPS hatchery-origin steelhead as a major concern for DPS diversity and viability. NMFS is in the process of formally identifying individual populations (Myers et al. 2014) and associated viability criteria (Hard et al. 2014) for recovery of Puget Sound steelhead. In addition, a recovery plan for this listed species has not been developed that would inform planning for individual steelhead hatchery programs. However, under the action alternatives, effects of hatchery programs for salmon and steelhead on listed Puget Sound steelhead are evaluated, including the effects from steelhead releases that are not part of the DPS. Thus, this potential alternative is not analyzed in detail because it is not substantially different from the action alternatives and would be addressed within the adaptive management framework of the co-managers' proposed RMPs.

2.5.8 Develop an Alternative that is More Protective of ESA-listed Summer-run Chum Salmon

Hood Canal summer-run chum salmon were listed as threatened under the ESA in 1999 (64 Fed. Reg. 14507, March 25, 1999). The hatchery programs described by the co-managers in the RMPs and HGMPs are not expected to have substantive impacts on Hood Canal summer-run chum salmon in fresh water. This is because the distribution of the Hood Canal Summer-run Chum Salmon ESU is limited to Hood Canal, and only two hatchery programs produce summer-run chum salmon. Furthermore, releases from other salmon and steelhead hatchery programs in watersheds containing summer-run chum salmon would not occur until the majority of the natural-origin chum salmon juveniles have out-migrated from the systems, thus minimizing potential ecological risks. However, there could be some impacts to summer-run chum salmon in nearshore marine habitats to the extent that natural-origin juveniles co-exist and compete with hatchery-origin fish. Under the action alternatives, risks to all listed salmon and steelhead species, including Hood Canal summer-run chum salmon, are evaluated, and adaptive management would occur. Thus, this potential alternative is not analyzed in detail because it is not substantially different from the action alternatives and would be addressed within the adaptive management framework of the co-managers' proposed RMPs.

2.5.9 Develop an Alternative Focusing on Protection of ESA-listed Southern Resident Killer Whales

This potential alternative would focus on the conservation needs of Southern Resident killer whales in Puget Sound, which were listed as endangered under the ESA in 2005 (70 Fed. Reg.69903, November 18, 2005). The status of Southern Resident killer whales is influenced by the availability of important food sources, including adult Chinook salmon (Hanson et al. 2010). Partial compensation by hatcheries for declines in natural-origin salmon populations may have benefitted Southern Resident killer whales (Myers 2011). Under Alternative 4, Increased Production, hatchery production for salmon and steelhead would be increased consistent with existing surplus hatchery capacity. Production of juvenile Chinook salmon would increase to the extent that suitable surplus hatchery capacity exists for that species. Thus, this potential alternative is not substantially different from Alternative 4, Increased Production.

2.6 Selection of a Preferred Alternative and an Environmentally Preferred Alternative

As explained in Subsection 1.6.6, Future Public Review and Comment, NMFS will review public comment received on the draft EIS and prepare a final EIS. A preferred alternative will be identified in the final EIS. The preferred alternative may be one of the alternatives or a combination of components of more than one alternative. Information from the public review process will be used in choosing a preferred alternative. In addition, the preferred alternative will be informed by the concurrent and complex authorities that currently exist for the Puget Sound area, including *United States v. Washington* (Subsection 1.7.2.2, *United States v. Washington*) and ESA recovery planning (Subsection 1.1.1, The Endangered Species Act, and Subsection 1.7.4.1, Recovery Plans for Puget Sound Salmon).

Finally, NMFS will identify an environmentally preferred alternative in the ROD. This alternative may or may not be the same as the preferred alternative.

Table 2.6-1. Summary of key components among alternatives.

Alternative	NMFS Review, Evaluation, and Approval of Plans under 4(d) Rules	Number of Hatchery-origin Fish Released	Adaptive Management and Mitigation Measures[1]	Changes in Hatchery Programs	Conservation Benefit to Salmon and Steelhead
Alternative 1 (No Action)	No evaluation and determination under the 4(d) rules	146,997,000	Unknown	Unknown	Unknown
Alternative 2 (Proposed Action)	Evaluation and determination under the 4(d) rules	146,997,000	Adaptive management provisions of plans would apply, and mitigation measures would reduce risks	Conservation measures would be applied to all programs to reduce risks and increase benefits while meeting conservation requirements	Conservation requirements for listed salmon and steelhead would be met
Alternative 3 (Reduced Production)	Same as Alternative 2	135,082,000	Same suite of measures as Alternative 2, but potentially fewer measures applied than under Alternative 2	Same as Alternative 2 Hatchery production for harvest purposes would be reduced 50 percent in watersheds with Chinook salmon populations in recovery categories 1 and 2	Greater than Alternative 2
Alternative 4 (Increased Production)	Same as Alternative 2	169,967,000	Same suite of measures as Alternative 2, but potentially more measures applied than under Alternative 2	Same as Alternative 2 Hatchery production would increase to the extent there is capacity at existing facilities	Less than Alternative 2

[1] The purpose of adaptive management mitigation measures is to reduce risks to salmon and steelhead from hatchery programs. The suite of potential mitigation measures to apply is the same for each action alternative, but implementation of the measures may vary depending on the specific risk being addressed.

Chapter 3

Affected Environment

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3.0 AFFECTED ENVIRONMENT

3.1 Introduction

Chapter 3 describes the affected environment for six resources that may be affected by implementation of the alternatives: fish, socioeconomics, environmental justice, wildlife, water quality and quantity, and human health. No other resources were identified during scoping that could potentially be impacted by the proposed action or alternatives. Chapter 4, Environmental Consequences, analyzes potential effects on these resources under the alternatives. The sequence of subsections in this chapter is:

- Introduction (Subsection 3.1)
- Fish (Subsection 3.2)
- Socioeconomics (Subsection 3.3)
- Environmental Justice (Subsection 3.4)
- Wildlife (Subsection 3.5)
- Water Quality and Quantity (Subsection 3.6)
- Human Health (Subsection 3.7)

3.2 Fish

3.2.1 Introduction

This subsection describes existing conditions for fish within the analysis area (Subsection 4.2.2, Analysis Area) that may be affected by the alternatives, specifically, changes in hatchery production. Fish species are presented in the following order: 1) listed salmon, steelhead, and trout; 2) non-listed salmon; and 3) other fish species with a relationship to salmon and steelhead (i.e., predators and prey of salmon and steelhead). These fish species and groups are:

- Listed salmon, steelhead, and trout
  - Chinook salmon
  - Hood Canal summer-run chum salmon
  - Steelhead
  - Bull trout
- Non-listed salmon
  - Coho salmon
  - Fall-run chum salmon
  - Odd- and even-year pink salmon
  - Sockeye salmon
- Other fish species
  - Rainbow trout
  - Coastal cutthroat trout
  - Sturgeon and lamprey
  - Forage fish
  - Groundfish
  - Resident freshwater fish

The order of the above species and species groups is organized according to the extent of information available and evaluation approaches used (Appendix B, Hatchery Effects and Evaluation Methods for Fish; and Subsection 4.2.3, Overall Methods for Analyzing Effects), with listed salmon, steelhead, and trout first.

Listed Salmon, Steelhead, and Trout. Because of their listed status, species in the listed salmon, steelhead, and trout group are the primary focus of this EIS. Compared to the other fish groups, substantial published literature is available on natural-origin fish of this group, and includes the effects on these fish associated with hatchery production. Information provided in Subsection 3.2, Fish, for each of the listed species in this group includes life history, distribution, and abundance of the natural-origin fish; description of the hatchery-origin fish released; and risks (i.e., competition, predation, genetics, hatchery facilities and operation) and benefits (i.e., total return, viability, and marine-derived nutrients) of hatchery programs.

For this fish group, risks and benefits to the affected environment are described in terms of rating categories (i.e., using the terms negligible, low, moderate, and high) based on defined criteria associated with methods described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. These methods, effects, rating categories, and terms are carried forth in the analysis in Subsection 4.2, Fish, to determine how each risk and benefit would be affected under the alternatives.

Non-listed Salmon. The information available for non-listed salmon is considerable, but is not as comprehensive as for the listed salmon, steelhead, and trout species group. Similar to the listed salmon, steelhead, and trout group, descriptions for each non-listed salmon species include the life history, distribution, and abundance of the natural-origin fish; description of the hatchery-origin fish; and risks and benefits of hatchery programs. Information on methods used to evaluate risks and benefits for non-listed salmon is described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Because there is less information available for the non-listed salmon species concerning the magnitude of the risks and benefits from hatchery releases, qualitative evaluations are used to describe the magnitude of the risks and benefits rather than the four rating categories and terms as used for listed salmon, steelhead, and trout (with the exception of hatchery facilities and operation risk). For non-listed salmon, the extent of risk and benefit is generally described using relative qualitative terms (i.e., likely, substantial, unsubstantial, minimal). These methods, effects, and terms are carried forth in the analysis in Subsection 4.2, Fish, to determine how each risk and benefit would be affected under the alternatives. If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

Other Fish Species. Less information is available for species in the other fish species group than for the non-listed salmon group. There is no hatchery production for species in this fish group. Similar to the other two fish groups, descriptions of the species or groups of species include their listing status, life history, distribution, and abundance of natural-origin fish to the extent information is available. Information on methods used to evaluate risks and benefits for other fish species is described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risks and benefits are described in terms of each species' relationship to salmon and steelhead (e.g., as competitors and/or predators). Some risks (e.g., hatchery facilities and operation) and benefits (e.g., total return) are not discussed because they are not applicable to this group of other fish species. Also, as described above for non-listed salmon, the extent of risk is generally described using relative qualitative terms (i.e., likely, substantial, unsubstantial, minimal). These methods, effects, and terms are carried forth in the analysis in Subsection 4.2, Fish, to determine how each risk and benefit would be affected under the alternatives. If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

The ESA provides for listing species, subspecies, or distinct population segments of vertebrate species. NMFS and the U.S. Fish and Wildlife Service (USFWS) review biological species under each agency's jurisdiction and determine the species' status and structure. Evolutionarily significant units (ESUs) and distinct population segments (DPSs) are designated when populations identified for the species are 1) substantially reproductively isolated from conspecific populations, and 2) represent an important component of the evolutionary legacy of the biological species (Subsection 1.1.1, The Endangered Species Act). The ESU policy (56 Fed. Reg. 58612, November 20, 1991) for Pacific salmon defines the criteria for identifying a Pacific salmon population as a distinct population segment (DPS), which can be listed under the ESA. A DPS is a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species (61 Fed. Reg. 4722, February 7, 1996). Fish species under NMFS' jurisdiction are anadromous, and those under USFWS' jurisdiction are resident to fresh water. Fish species under NMFS' jurisdiction that are analyzed in this EIS include all salmon and steelhead, some sturgeon and lamprey, forage fish, and groundfish; those under USFWS' jurisdiction that are analyzed are bull trout, rainbow trout, coastal cutthroat trout, some sturgeon and lamprey, and other resident freshwater fish.

This subsection begins with a summary of the general factors that affect the presence and abundance of the natural-origin salmon and steelhead in the project area followed by the general risks of hatchery programs to natural-origin fish. This subsection is then followed by the hatchery-origin fish species and hatchery programs reviewed for this EIS, including characteristics of hatchery-origin fish that are different from natural-origin fish.

For each fish species analyzed in this EIS, the listing status, life history characteristics, distribution, and abundance of the natural-origin fish are provided, along with descriptions of hatchery-origin fish of the species, if applicable. More detailed background information on the risks and benefits of hatchery programs relative to salmon and steelhead in general, and methods and criteria used in this EIS, are contained in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

3.2.2 General Factors that Affect the Presence and Abundance of Salmon and Steelhead

Although this EIS is focused on the effects of hatchery programs on listed and non-listed salmon and steelhead and other fish species in Puget Sound, it is important to recognize that hatchery programs are but one of a variety of natural and human-caused changes that have and will continue to affect these species as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. These changes have affected the abundance, productivity, diversity, and distribution of salmon and steelhead in Puget Sound. In addition to hatchery programs, previous NMFS salmon status reviews (Myers et al. 1998; Good et al. 2005; Ford 2011), recovery plans (72 Fed. Reg. 2493, January 19, 2007; 72 Fed. Reg. 29121, May 24, 2007), and other documents (WSCC 2005), describe a range of past and current factors that have contributed to the decline of salmon and steelhead in Puget Sound, including:

- **Hatcheries.** Production from hatcheries helps increase the number of salmon and steelhead available for harvest and, depending on the management intent and type of program, can help improve population status. However, hatchery production also generally results in increased risk of competition, predation, and loss of genetic diversity in natural-origin fish. Hatchery facilities can increase the potential for disease transfer from hatchery-origin fish to natural-origin fish, as well as affect water quality and quantity in the hatchery vicinity.

- **Habitat.** Freshwater habitat modified from development and land use practices related to agriculture, forestry, industry, and residential uses can alter stream hydrology and natural stream channels, reduce riparian cover and large woody debris in streams, and increase sedimentation and flooding.

- **Water Quality and Quantity.** Water quality in streams used by salmon and steelhead can be affected by channel modification, sediment input, increases in stream temperature and surface water run-off, and releases of toxic pollutants. Withdrawals of surface and groundwater can affect the amount and timing of water in streams available to support salmon and steelhead.

- **Dams and Diversions.** Construction of dams, water diversion structures, and hydroelectric operations can block salmon and steelhead migration routes, entrain migrating juveniles, change stream flow patterns, and alter natural water temperature regimes.

- **Culverts.** Road construction and installation of culverts can block and/or limit fish access to spawning and rearing areas.

- **Shoreline Modifications.** Armoring, bulk-heading, dredging, filling, dock and pier construction, riparian vegetation and pocket estuary removal, and urbanization and industrialization can alter shorelines of importance to juvenile salmon and steelhead freshwater migration in estuaries and marine waters. Loss of shoreline aquatic vegetation can impact salmon and steelhead foraging, resting, and spawning opportunities.

- **Fish Harvest.** Harvest can impact natural-origin salmon and steelhead abundance and diversity over time, and use of fishing gear can result in incidental losses of fish.

- **Predation**. Direct predation by aquatic, terrestrial, and avian species result in salmon and steelhead mortality, including that from introduced species or predators whose abundance has increased because of man-made changes.

- **Oceanic Conditions.** Broad-scale, cyclic changes in climatic and oceanic conditions drive salmon productivity (e.g., El Niño events), and are important to how and where populations of salmon are sustained over the short and long term.

- **Climate Change.** Changes in climate can alter the abundance, productivity, and distribution of salmon and steelhead through changes in water temperatures and seasonal stream flow regimes, which then affect the type and extent of aquatic habitat that is suitable for viable salmon and steelhead.

In a review of these factors, NMFS concluded that the impacts to salmon and steelhead habitat continue to suppress prospects for recovery of listed natural-origin salmon and steelhead, including current and continuing degradation and loss of habitat essential for their survival and productivity (NMFS 2011a). However, all of the past and current factors as described above have affected salmon and steelhead populations, distribution, and overall survival.

3.2.3 General Risks and Benefits of Hatchery Programs to Fish

This subsection provides brief general overviews of hatchery-origin fish and their associated hatchery programs relative to natural-origin salmon and steelhead, and other fish, in terms of risks and benefits. Findings are based on watershed-specific studies in Puget Sound, and where those are lacking, on inferences from the best available and reliable information and literature. A risk is defined as the possibility of a loss or injury to natural-origin salmon and steelhead from the development and use of hatchery facilities, hatchery programs, and hatchery-origin fish. A benefit is defined as a contribution by hatchery-origin fish and associated hatchery programs that enhances natural-origin fish populations or social values (fishing opportunities). Risks and benefits are summarized below, and more detailed information is provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish.[1]

- **Risks** – may occur in fresh water and estuarine/marine waters, and include juveniles and adults
  - **Competition** – occurs where hatchery-origin fish compete with natural-origin fish for food and space
  - **Predation** – occurs when large hatchery-origin fish prey on small, natural-origin fish
  - **Genetics** – occurs when hatchery-origin fish interbreed with natural-origin fish
  - **Hatchery facilities and operation** – occurs when hatchery facilities and operation may affect the survival of natural-origin fish
- **Benefits** – occur primarily from adult salmon and steelhead
  - **Total return** – occurs when hatchery-origin fish provide fishing opportunities
  - **Viability** – occurs where the production of hatchery-origin fish reduces extinction risk in the short term
  - **Marine-derived nutrients** – occurs where hatchery-origin fish carcasses provide nutrients to aquatic habitat

[1] Appendix B, Hatchery Effects and Evaluation Methods for Fish, provides more detailed information on each risk and benefit, including available information and references used.

For non-listed salmon and trout, and other fish species (i.e., sturgeon, lamprey, forage fish, groundfish, and resident freshwater fish) reviewed in this EIS (Subsection 3.2.1, Introduction [Fish]), risks and benefits are considered in terms of the species' general relationships with salmon and steelhead. These general relationships are considered either risks to the other fish species (e.g., salmon and steelhead compete for food with rockfish) or benefits to the other fish species (e.g., groundfish and rockfish prey on salmon and steelhead). General relationships between these fish species and salmon and steelhead are described using the best available information. Most available studies do not address whether the general relationships between a species and natural-origin salmon and steelhead are different from the relationships between a species and hatchery-origin salmon and steelhead. Because characteristics such as behavior, size, and distribution of natural-origin and hatchery-origin fish are similar, the general relationships between the other fish species and natural-origin salmon and steelhead are assumed to be the same as the general relationships between the species and hatchery-origin salmon and steelhead.

Harvest of hatchery-origin fish has both negative and beneficial impacts on natural-origin fish and has beneficial effects to people. Harvest can remove hatchery-origin fish that compete with, prey upon, and interbreed with fish from natural-origin populations, and harvest regulations or the use of fishing gear can affect the long-term survival of natural-origin fish. Harvest management benefits may occur when hatchery-origin fish abundance increases commercial, tribal, and recreational fishing opportunities. These benefits are described in Subsection 3.3, Socioeconomics, and Subsection 4.3, Socioeconomics. Because of the importance of harvest management and its associated risks to salmon and steelhead, harvest in the project area is evaluated in detail in a related EIS, *Puget Sound Chinook Harvest Resource Management Plan Final Environmental Impact Statement* (NMFS 2004a), and *Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation National Marine Fisheries Service (NMFS) Evaluation of the 2010-2014 Puget Sound Chinook Harvest Resource Management Plan under Limit 6 of the 4(d) Rule* (NMFS 2011b). The NMFS 2004 final EIS is herein incorporated by reference. In that EIS, the proposed resource managemen plan (RMP) and other alternatives are described and evaluated. Based upon the review of the alternatives and their environmental consequences described in the EIS, and satisfaction of requirements under the ESA, NMFS approved conservation measures and harvest management objectives for Puget Sound Chinook salmon as defined in the Puget Sound Chinook Harvest RMP jointly developed by the Puget Sound treaty tribes and WDFW (NMFS 2005a). The Chinook salmon harvest RMP approved by NMFS represents conservation measures and harvest management objectives for Puget Sound Chinook salmon that ensure productivity, abundance, and diversity of populations within the Puget Sound Chinook Salmon ESU such that harvest does not appreciably reduce the likelihood of survival and recovery of the

ESU. That RMP also provides for equitable sharing of harvest opportunity among tribes and treaty and non-treaty fishers, protects Indian treaty fishing rights, and meets Federal treaty trust responsibilities.

3.2.3.1 Risks - Competition

Described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized in this subsection are competition risks between hatchery-origin and natural-origin fish species. Competition risks between hatchery-origin and natural-origin salmon and steelhead may occur in both freshwater and marine areas, as well as between juveniles and adults. Freshwater competition generally occurs when hatchery-origin juvenile fish are of the same size as natural-origin fish and/or feed on similar prey, when hatchery-origin fish are released in large quantities compared to natural-origin fish, and when hatchery-origin fish occur in the same locations as natural-origin fish and for a longer time period (such as releases high in a watershed that result in a longer time for overlap between hatchery-origin and natural-origin fish).

Estuarine and marine competition between hatchery-origin fish and natural-origin fish occurs when both types of fish occur in small estuaries where food supplies are limited (competition from hatchery-origin fish can occur within the same species or among different species of salmon and steelhead). Competition can also occur between adult hatchery-origin and natural-origin fish, particularly when females compete for spawning sites (also known as redds), and spawn on gravels where natural-origin fish had spawned previously (called redd superimposition).

Although hatchery programs and the release of hatchery-origin fish can magnify these competition risks based on release timing, fish size, and release location, there are hatchery practices that can decrease these risks by:

- Releasing hatchery-origin fish of a different size than the natural-origin fish that occur in the release area
- Avoiding releases of large numbers of hatchery-origin fish that can outnumber natural-origin fish
- Releasing hatchery-origin fish that out-migrate rapidly to minimize the amount of time that hatchery-origin fish occur in freshwater streams where natural-origin fish are also present
- Trapping and catching returning adult hatchery-origin fish that may compete with natural-origin fish for spawning sites

3.2.3.2 Risks - Predation

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, predation risks generally occur when larger hatchery-origin salmon and steelhead species prey on the smaller natural-origin salmon species. Predation opportunities increase when large numbers of hatchery-origin fish are released compared to natural-origin fish present in the release area, when older larger juveniles (yearlings) are released, when hatchery-origin fish are released high in a watershed, and when salmon and steelhead residualize[2] in fresh water (residualism occurs when anadromous fish delay migration out to the ocean). The latter two circumstances result in a longer time period when hatchery-origin predators are exposed to natural-origin salmon and steelhead. Predation can occur in both fresh water and in estuary/marine areas.

Approaches that hatchery programs can implement to decrease these predation risks include not releasing larger fish in areas where these fish would have the opportunity to feed on smaller natural-origin salmon and steelhead, and avoiding the release of hatchery-origin fish that are likely to residualize in fresh water.

3.2.3.3 Risks - Genetics

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, the ability of natural-origin salmon and steelhead to home to streams of their birth with great accuracy and fidelity has helped these species develop genetic characteristics that are locally adapted and has resulted in different salmon and steelhead species using unique aquatic habitats for food, cover, and spawning. However, production of hatchery-origin fish can result in genetic risks to natural-origin fish through reductions or changes in genetic diversity among and within populations, which erodes the ability of natural-origin fish to adapt to local conditions. Genetic effects on natural-origin salmon and steelhead are the loss of within-population diversity, hatchery-induced selection (also known as domestication), loss of among-population diversity, and outbreeding depression. These effects can contribute to a loss of fitness in natural-origin fish. In most cases, genetic change is caused by the hatchery environment or by management of the hatchery program, and does not become an issue until mating occurs between hatchery-origin and natural-origin fish, either of the same or different populations. See Appendix B, Hatchery Effects and Evaluation Methods for Fish, for a detailed discussion of genetic risks and effects.

[2] Residualism pertains to hatchery-origin fish that out-migrate slowly, if at all, after they are released. Such fish are called residuals that residualize rather than out-migrate as most of the counterparts do.

Methods to reduce these genetic risks caused by hatchery programs include:

- Using local natural-origin broodstock and releasing subyearling fish rather than yearlings (subyearling fish are more likely to acquire traits similar to natural-origin fish)
- Decreasing the proportion of hatchery-origin fish over natural-origin fish in local areas
- Developing more efficient fisheries and trapping of hatchery-origin fish to avoid their spawning naturally
- Releasing hatchery-origin fish in areas where natural-origin fish are not spawning
- Reducing the overall hatchery program size

The intent of these measures is to decrease the potential for hatchery-origin fish to spawn in natural areas and to release hatchery-origin fish that are genetically similar to the locally adapted natural-origin fish. Thus, if these hatchery-origin fish do return to spawn naturally, these fish are similar to the natural-origin fish that occur in the local area.

3.2.3.4 Risks - Hatchery Facilities and Operation

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, hatchery programs pose risks to salmon and steelhead and the environment from both the physical existence of the hatchery facilities and their operation. Guidelines and recommendations for successful hatchery practices to meet identified management objectives are useful to describe hatchery facilities and operation risk factors. Subsection 2.2.2.1, Artificial Production Strategies, describes how different hatchery strategies (isolated or integrated hatchery programs) can be used to meet different management objectives (harvest and/or conservation). Hatchery facility and operation risks to salmon and steelhead occur when programs do not follow guidance and best management practices (BMPs) for broodstock choice and collection, adult holding, spawning and incubation, rearing and release, disease avoidance, water withdrawals, protection of water quality, and barriers used at hatcheries. For detailed explanations of these terms and their relationships to hatchery programs, refer to Appendix B, Hatchery Effects and Evaluation Methods for Fish. Also important is the development of adaptive management plans for hatchery programs to minimize risks to natural-origin fish from the release of hatchery-origin fish from that specific program over time.

Hatchery programs can decrease hatchery facilities and operation risk by ensuring that the programs meet all recent hatchery guidance and applicable BMPs and by implementing monitoring and adaptive management plans.

3.2.3.5 Benefits - Total Return

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, production of hatchery-origin salmon and steelhead provides a benefit to society when fish return as adults and are available for ceremonial, subsistence, commercial, and recreational harvest. As described in Subsection 2.2.2.1, Artificial Production Strategies, depending on the type of hatchery program, hatchery-origin fish can provide a benefit by producing more fish for harvest, and for integrated conservation hatchery programs producing listed fish, can contribute to species conservation and recovery. This total return benefit helps compensate, in part, for loss and degradation of fish habitat and associated declines in natural productivity and lower returns of natural-origin fish that have occurred over time. Total return benefits are determined differently among species, as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

As shown in Table 3.2-1, adults from hatchery production generally contribute from 1 to 74 percent of the average total return (hatchery-origin and natural-origin) by species. Total return is defined as the total number of returning adult hatchery-origin and natural-origin fish that are harvested plus those that spawn.

Table 3.2-1. Estimated average total return of adult salmon and steelhead and percentage of total return from hatchery production in Puget Sound.

Species	Average Total Return of Adults[1]	Average Return of Hatchery-origin Adults[1]	Average Percent of Total Adult Return that are Hatchery-origin Adults
Chinook salmon[2]	221,649	163,496	74
Coho salmon[3]	960,006	447,285	47
Chum salmon[4]	1,866,594	534,145	29
Sockeye salmon[5]	337,767	101,330	30
Pink salmon[6]	1,755,989	24,255	1
Steelhead[7]	Unavailable	Unavailable	Unavailable

[1] Return is catch plus spawning escapement.
[2] Chinook salmon data for 2000-2004 are from B. Sanford, pers. comm., WDFW, Resource Program Manager, June 21, 2005.
[3] Coho salmon data for 1999-2003 are from J. Haymes, pers. comm., WDFW, Resource Program Manager, July 2005.
[4] Data for Puget Sound summer-run, fall-run, and winter-run chum salmon for 1998-2002 are from WDFW chum salmon website: http://wdfw.wa.gov/fishing/salmon/chum/pugetsound/data.html.
[5] Data on Cedar River and Baker River are from K. Adicks, pers. comm., WDFW, Resource Program Manager, July 17, 2006. Total adult return data from Baker Lake sockeye salmon trap counts and Ballard Locks fish counts for 2000-2004 accessed from the WDFW sockeye salmon website: http://wdfw.wa.gov/fishing/counts/sockeye/index.html.
[6] Puget Sound pink salmon data for 1989-2003 are from K. Adicks, pers. comm., WDFW, Resource Program Manager, October 31, 2008.
[7] Complete data for Puget Sound steelhead populations are unavailable, particularly for summer-run steelhead and most hatchery-origin populations that contribute to natural spawning.

3.2.3.6 Benefits - Viability

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, hatchery programs may benefit the viability of natural-origin salmon and steelhead. Subsection 2.2.2.1, Artificial Production Strategies, describes how different hatchery strategies (integrated or isolated hatchery programs) can be used to meet different management objectives (conservation and/or harvest). Certain hatchery programs (typically integrated hatchery programs) can benefit the viability of listed natural-origin populations, depending on the extent to which these programs contribute to the four viable salmonid population (VSP) parameters that NMFS uses to assess population status and recovery (abundance, diversity, spatial structure, and productivity) (McElhany et al. 2000). The viability benefit associated with those hatchery programs can contribute to the long-term health and evolutionary potential of fish species because the benefit helps foster resiliency of fish populations to uncertain future environmental conditions. Isolated hatchery programs (Subsection 2.2.2.1, Artificial Production Strategies) are not designed to contribute to population viability and do not contribute to viability benefits. For more information on the VSP parameters and types of hatchery programs that relate to those parameters, refer to Appendix B, Hatchery Effects and Evaluation Methods for Fish.

3.2.3.7 Benefits - Marine-derived Nutrients

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarized below, during the time that anadromous salmon and steelhead live in marine environments, the fish consume food that contains nutrients that only occur in marine water (marine-derived nutrients). After spawning and dying in freshwater streams, the fish carcasses provide marine-derived nutrients as direct food sources for juvenile salmon and steelhead and other fishes, aquatic invertebrates, and terrestrial animals. The total number and carcass biomass of hatchery-origin and natural-origin fish spawning naturally indicates the relative magnitude of marine-derived nutrient contributions. The total contribution of carcass biomass in the analysis area is about 23 million pounds (Table 3.2-2). Chum salmon and pink salmon contribute the largest percentage of the biomass (80 percent combined), whereas coho salmon contribute 10 percent of the biomass, and Chinook salmon contribute 5 percent of the biomass. Chum salmon and pink salmon escapement is generally the least influenced by hatchery production because returns of those species are predominantly of natural-origin fish. The small steelhead escapement and biomass estimates (1 percent) reflect only natural-origin fish because information on numbers of naturally spawning hatchery-origin steelhead is not available.

Table 3.2-2. Average (2002 to 2006) total (hatchery-origin plus natural-origin) spawning escapement (numbers) and biomass (pounds) by species in Puget Sound.

	Chinook Salmon	Coho Salmon	Pink Salmon	Chum Salmon	Sockeye Salmon	Steelhead	Total
Escapement (Percent)	71,381 (2)	398,882 (12)	1,791,749 (53)	952,294 (28)	169,166 (5)	16,011 (1)	3,399,483 (100)
Biomass[1] (Percent)	1,070,709 (5)	2,393,292 (10)	7,166,998 (31)	11,427,525 (49)	1,014,997 (4)	96,066 (1)	23,169,586 (100)

Source: W. Beattie, pers. comm., Northwest Indian Fisheries Commission (NWIFC), Conservation Planning Coordinator, September 2, 2008.
[1] Biomass is the average individual weight at return multiplied by escapement.

Hatchery production contributes marine-derived nutrients to freshwater systems through natural spawning of hatchery-origin fish and when hatchery programs place carcasses into streams. Most carcasses are from hatcheries that produce coho salmon (44 percent), sockeye salmon (25 percent), and Chinook salmon (18 percent). For more information on marine-derived nutrients and numbers of carcasses distributed into watersheds from hatcheries, see Appendix B, Hatchery Effects and Evaluation Methods for Fish.

3.2.4 Hatchery-origin Fish and Hatchery Programs

This subsection identifies characteristics unique to hatchery-origin salmon and steelhead compared to natural-origin fish; thus, it provides context for understanding risks and benefits associated with hatchery-origin fish and hatchery programs to natural-origin fish evaluated in this EIS. Provided below is 1) a general overview of the characteristics of hatchery-origin fish and how these fish differ from their natural-origin counterparts, and 2) an overview of hatchery programs evaluated in this EIS with a guide to where information for each species and hatchery program is contained in this EIS.

3.2.4.1 Characteristics of Hatchery-origin Salmon and Steelhead

Although the origin of salmon and steelhead produced from hatcheries can be traced back to fish from natural-origin populations, hatchery propagation either advertently or inadvertently leads to adaptations or changes to many characteristics of the fish. The resulting general differences between hatchery-origin and natural-origin fish are summarized in this subsection, and are important to note when considering hatchery program risks and benefits to natural-origin fish.

The causes of adaptations and changes to hatchery-origin fish can be genetic and/or environmental (Flagg et al. 2000; Brannon et al. 2004). Conditions in artificial environments affect how salmon and steelhead respond to food, habitat, other fish, and predators in different ways from fish reared in natural environments. Factors contributing to these differences are complex and include the type and number of broodstock used in hatchery programs, spawning methods, incubation methods, juvenile rearing methods, and life stages and conditions into which the fish are released.

After release, hatchery-origin salmon and steelhead are usually exposed to the same environmental conditions as natural-origin fish. Prior to release, however, hatchery-origin and natural-origin fish are exposed to different environmental conditions. In general, the greater the number of generations fish undergo artificial propagation, the greater the likelihood that hatchery-origin fish will differ from the original source stocks. Artificial production typically affects foraging behavior, social behavior (including mate selection), habitat preferences, and responses to predators, as well as morphological and physiological characteristics, reproductive potential, and overall survival (Flagg et al. 2000) (Table 3.2-3). Although there are similarities between hatchery-origin and natural-origin salmon and steelhead, the discussion in this subsection focuses on differences between hatchery-origin and natural-origin salmon and steelhead that would affect risk and benefit factors to the natural-origin fish.

Characteristics of hatchery-origin fish released into natural aquatic ecosystems tend to be more similar to each other compared to the more diversified characteristics of natural-origin fish (Kostow 2004). This is because hatchery-origin fish are generally released as smolts at a targeted size and age to meet management objectives. When released, hatchery-origin fish are generally less variable in age and tend to be larger in size than their natural-origin counterparts (Flagg et al. 2000; Knudsen et al. 2006) (Table 3.2-4). In general, the initial larger mean size of hatchery-origin juveniles compared to their natural-origin counterparts is primarily due to the preponderance of programs that release fish at the smolt stage, and/or from programs that intend to maximize post-release survival (Fuss and Ashbrook 1995). Other contributing factors may include:

- Inadvertent selection for early spawners when hatchery managers collect earlier spawning broodstock over later spawning broodstock to achieve the numbers of broodstock needed
- Use of warmer groundwater for hatchery incubation and timing, which can accelerate growth
- Use of artificial fish feed, which ensures an adequate and nutritious food supply (Flagg et al. 2000)

Table 3.2-3. General comparison of hatchery-origin and natural-origin salmon and steelhead by attribute category.

Attribute Category	Hatchery-origin Fish Compared to Natural-origin Fish	Natural-origin Fish Compared to Hatchery-origin Fish
Survival		
Egg-to-smolt survival	Higher	Lower
Smolt-to-adult survival	Lower	Higher
Behavior[1]		
Foraging ability	Inefficient	Efficient
Aggression	Higher	Lower
Social density	Higher	Lower
Territorial fidelity	Lower	Higher
Migratory behavior	Congregate[2]	Disperse
Habitat preference	Surface	Bottom
Predator response	Approach	Flee
Morphology		
Juvenile shape	Less variable	More variable
Coloration at spawning time	Duller	Brighter
Kype size (jaw length)	Smaller	Larger
Reproductive potential		
Egg size	Larger	Smaller
Egg number	Higher	Lower
Breeding success	Lower	Higher

Source: Flagg et al. (2000).

[1] Behavioral differences between hatchery-origin and natural-origin fish tend to decrease as hatchery-origin fish are exposed and acclimate to post-release natural environments.

[2] Congregate means the fish migrate in groups, not rate of movement.

Table 3.2-4. Relative size and predominant freshwater occurrence or release timing for natural-origin and hatchery-origin salmon and steelhead juveniles by life stage.

Species/Origin	**Life Stage**[1]	**Size (Fork length in inches (mm))**		**Predominant Occurrence or Release Timing**
		Mean	**Range**	
Chinook salmon (natural-origin)	Fry	1.6 (40)	1.3-2.3 (34-59)	December-April
Chinook salmon (natural-origin)	Parr	3.0 (75)	2.2-3.6 (57-92)	late May-July
Chinook salmon (natural-origin)	Yearling	4.7 (120)	3.6-6.1 (92-154)	late March-May
Chinook salmon (hatchery-origin)	Subyearling	3.1 (80)	2.2-3.4 (57-86)	May-June
Chinook salmon (hatchery-origin)	Yearling	6.1 (155)	5.9-7.7 (150-196)	April
Steelhead (natural-origin)	Fry	2.4 (60)	0.9-3.9 (23-100)	June-October
Steelhead (natural-origin)	Parr	3.8 (96)	2.6-5.2 (65-131)	October-mid May
Steelhead (natural-origin)	Smolt	6.5 (165)	4.3-8.5 (109-215)	late April-June
Steelhead (hatchery-origin)	Yearling	8.1 (206)	7.1-9.1 (180-230)	May
Coho salmon (natural-origin)	Fry	1.2 (30)	1.1-1.4 (29-36)	March
Coho salmon (natural-origin)	Parr	2.1 (54)	1.5-2.9 (37-74)	April
Coho salmon (natural-origin)	Yearling	4.2 (107)	2.9-7.5 (74-190)	late April-May
Coho salmon (hatchery-origin)	Fry	1.7 (43)	1.5-2.5 (38-64)	March-April
Coho salmon (hatchery-origin)	Subyearling	4.1 (104)	3.9-4.2 (99-107)	November
Coho salmon (hatchery-origin) [2]	Yearling	5.5 (140)	5.2-6.1 (131-156)	April-June
Summer-run chum salmon (natural-origin)	Fry	1.5 (38)	1.3-2.0 (33-50)	March
Fall-run chum salmon (natural-origin)	Fry	1.5 (38)	1.3-2.0 (33-50)	April

Table 3.2-4. Relative size and predominant freshwater occurrence or release timing for natural-origin and hatchery-origin salmon and steelhead juveniles by life stage, continued.

Species/Origin	**Life Stage**[1]	**Size (Fork length in inches (mm))**		**Predominant Occurrence or Release Timing**
		Mean	**Range**	
Fall-run chum salmon (hatchery-origin)	Fry	2.0 (50)	1.7-2.0 (42-52)	May
Pink salmon (natural-origin)	Fry	1.3 (34)	1.3-1.7 (32-43)	April-May
Pink salmon (hatchery-origin)	Fry	2.0 (50)	1.6-2.0 (40-52)	April
Sockeye salmon (natural-origin)	Fry	1.1 (28)	1.0-1.2 (25-31)	April-May
Sockeye salmon (natural-origin)	Lake phase fry[3]	2.0 (51)	1.3-4.7 (32-119)	June-March
Sockeye salmon (natural-origin)	Smolt	4.9 (125)	4.7-5.1 (120-129)	March-April
Sockeye salmon (hatchery-origin) [4]	Fry	1.2 (30)	0.9-1.2 (24-30)	February-April

Sources:

Natural-origin parr and yearling Chinook salmon data from Beamer et al. (2005) and WDFW juvenile out-migrant trapping reports (Seiler et al 2000, 2003, 2004; Volkhardt et al. 2006a, 2006b; Kinsel et al. 2007, 2008).

Natural-origin steelhead size data and occurrence estimates from Shapovalov and Taft (1954) and WDFW juvenile out-migrant trapping reports (Volkhardt et al. 2006a, 2006b; Kinsel et al. 2007).

Natural-origin coho salmon data for Green River from Topping et al. (2008) (for smolts); Beacham and Murray (1990) and Sandercock (1991) (for fry); parr size range extrapolated from smolt and fry data considering year-round residence.

Natural-origin chum salmon data from Volkhardt et al. (2006a, 2006b) (Green River fall-run), and Tynan (1997) (summer-run).

Natural-origin pink salmon data from Topping et al. (2008) (Dungeness pink salmon).

Natural-origin sockeye salmon data from Burgner (1991) for Lake Washington sockeye (predominantly 3-1 fish); parr size range extrapolated from smolt and fry data considering year-round residence.

Hatchery-origin fish release size and timing data are average individual fish size and standard release timing targets applied for hatchery salmon and steelhead production in Puget Sound (from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT [2000]).

[1] For the purposes of this EIS, the key stages in the life histories of natural-origin and hatchery-origin juvenile salmon and steelhead are as follows: fry are very small, have absorbed their egg sac, are less than 1 year old, and applies to hatchery-origin and natural-origin fish; subyearlings are small, less than 1 year old, and typically applies to hatchery-origin releases; parr are juveniles from 1 to 3 years old depending on the species, and typically refers to natural-origin fish; smolts are larger hatchery-origin and natural-origin juveniles that are undergoing their transformation from living in fresh water to living in the marine environment and are headed downstream to the ocean; yearlings are typically smolts that reared in the hatchery environment for a year prior to being released.

[2] The vast majority of hatchery-origin coho salmon are released as yearlings; 9,000 subyearling coho salmon are released in one location (Snow Creek).

[3] Lake phase refers to juvenile fish rearing in a lake environment rather than a stream environment.

[4] The vast majority of hatchery-origin sockeye salmon are released as fry, except for a release of 120,000 subyearlings in Baker Lake.

Survival of hatchery-origin and natural-origin fish at similar life stages is typically different (Flagg et al. 2000). For example, hatchery-origin fish have higher egg-to-smolt survival and lower smolt-to-adult survival in the natural environment relative to natural-origin fish. Because the survival of hatchery-origin fish during the juvenile freshwater rearing stages is generally much higher than for natural-origin fish, the total survival from egg to adult return for hatchery-origin fish may be higher for hatchery-origin fish than for natural-origin fish. Such differences may be associated with different behavioral, genetic, or physical characteristics between hatchery-origin and natural-origin fish that affect survival at multiple life stages (Bugert et al. 1992; Campton 1995; Reisenbichler and Rubin 1999).

The habitat preferences of hatchery-origin fish can differ from natural-origin fish (Flagg et al. 2000; Weber and Fausch 2003), but such differences are not always observed (Hill et al. 2006). At release, hatchery-origin fish generally forage at the water surface compared to natural-origin fish that feed lower in the water column. As a result, hatchery-origin fish tend to feed more on terrestrial and winged insects, whereas natural-origin fish feed more on benthic organisms. Hatchery-origin fish may forage more within stream pools than natural-origin salmon and steelhead that tend to forage in both riffles and pools (Flagg et al. 2000).

The foraging efficiency of hatchery-origin fish tends to be less than natural-origin fish. This has been attributed to the lack of variable substrate and the lower light levels in hatcheries where they are reared (Flagg et al. 2000). Although hatchery-origin salmon and steelhead may be less efficient predators than natural-origin fish, particularly immediately following their release, the typically larger size of hatchery-origin fish may offset this inefficiency to some extent (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998). Over time, hatchery-origin fish learn to forage more like natural-origin fish; thus, diets of hatchery-origin and natural-origin fish become more similar. Duffy (2003) found the diets of hatchery-origin Chinook salmon and coho salmon were generally similar to natural-origin fish in the marine environment, supporting the notion that hatchery-origin fish adopt natural foraging behaviors over time.

Hatchery-origin fish tend to out-migrate from fresh water to the ocean earlier and within a shorter time period than natural-origin fish (Flagg et al. 2000). As a result, hatchery-origin fish may spend less time in fresh water and estuaries compared to natural-origin fish. However, the length of time that hatchery-origin fish are present in fresh water after their release depends largely on the distance of the release site from marine waters (Appendix D, PCD RISK 1 Assessment), and in part on whether the hatchery release is involuntary (fish are forced from rearing ponds) or volitional (fish are allowed to leave rearing ponds on their own). Volitional releases allow fish to move out of hatchery facilities when they are physiologically ready to migrate, so they out-migrate at a faster rate than fish that are released regardless of their physiological readiness. Levings et al. (1986) found that the length of time natural-origin juvenile Chinook salmon take to emigrate seaward may be twice as long as for hatchery-origin fish.

Differences in social behavior include increased aggression of hatchery-origin fish compared to natural-origin fish, which can result in disruption of the social behaviors of natural-origin fish (Flagg et al. 2000; Weber and Fausch 2003). The hatchery environment rears fish in isolation from complex social hierarchies that determine dominance in natural streams. Hatchery-origin fish tend to tolerate higher rearing densities than natural-origin fish and may drive natural-origin fish out of locations where large releases of hatchery-origin fish occur. Nickelson et al. (1986) attributed reduced density of juvenile natural-origin coho salmon in Oregon coast streams to competition with hatchery-origin fish.

Hatchery-origin salmon and steelhead that escape to spawn naturally may be less successful in reproducing than their natural-origin counterparts (Knudsen et al. 2006; Chilcote et al. 2011, 2013). Adult hatchery-origin fish have been found in some studies to be competitively inferior to natural-origin fish (Fleming and Petersson 2001), while in other studies, competitive outcomes in spawning areas appear to be less clear, and dependent on fish size, age, and sex (Knudsen 2003; Berejikian et al. 2009; Anderson et al. 2013).

A number of studies have examined the relative differences in the reproductive success between hatchery-origin and natural-origin fish in natural conditions (Berejikian and Ford 2004). Lower relative natural reproductive success and fitness of naturally spawning hatchery-origin fish has been documented, especially for steelhead (Reisenbichler and McIntyre 1977; McLean et al. 2003; Araki and Schmid 2010). Chilcote et al. (1986) found naturally spawning steelhead of parents that had been reared for many generations in hatcheries (i.e., isolated hatchery programs) produced fewer offspring in fresh water than their natural-origin counterparts. A similar difference in reproductive success in the same study was found by Leider et al. (1990), who determined that survival differences also extended from the egg-to-smolt (fresh water) to the smolt-to-adult (marine) return life stage.

Reproductive success studies on other species and using different types of hatchery programs (e.g., integrated programs) have found different results. For example, in studies of Hood Canal summer-run chum, Berejikian et al. (2009) and Small et al. (2009) observed lower relative fitness for hatchery-origin than natural-origin fish, but found the differences were not significant statistically. In a study involving Chinook salmon from an integrated hatchery program, Hess et al. (2012) found reproductive success of hatchery-origin and natural-origin spring Chinook salmon was generally similar.

Taken overall, available information suggests the natural reproductive success of hatchery-origin fish may be greatest for hatchery stocks that are locally adapted to their watersheds of release and have not been artificially propagated for multiple generations, and for species that spend only a short time in hatchery environments prior to release and out-migration (e.g., fall-run Chinook salmon, chum salmon) (RIST 2009; California HSRG 2012). Nonetheless, the progeny of naturally spawning hatchery-origin fish can compete with or prey upon the progeny of natural-origin fish, as indicated by studies of hatchery-origin summer-run steelhead in the Clackamas River basin of Oregon (Kostow et al. 2003). Nickelson et al. (1986) attributed reduced density of juvenile natural-origin coho salmon in Oregon coastal streams to competition with hatchery-origin fish.

In summary, there are various differences between hatchery-origin and natural-origin fish. Initially, hatchery-origin fish tend to be physiologically and behaviorally different than natural-origin fish but become more similar to natural-origin fish over time. These initial differences include:

- Larger size and more aggressive behavior by hatchery-origin fish compared to natural-origin fish, and different feeding locations in the water column between the two fish groups
- Better foraging efficiency by natural-origin fish
- Lower survival of hatchery-origin fish

Based on rearing method, age, and timing of release, hatchery-origin fish may out-migrate faster to saltwater than natural-origin fish. Hatcheries tend to produce more precocial males (i.e., exhibiting qualities of sexual maturity at an unusually early age) and younger adults that have less reproductive potential (i.e., eggs and sperm) compared to natural-origin fish. Where hatchery-origin fish spawn naturally, these fish generally have lower reproductive success and fitness compared to their natural-origin counterparts, but differences depend on species, origin of the propagated fish, type of hatchery program, and rearing strategies.

3.2.4.2 Hatchery Programs Reviewed

As described in Subsection 1.8, Related NEPA Analyses, although prior NEPA analyses have occurred (i.e., for Hood Canal summer-run chum salmon, and species in the Elwha River), this draft EIS is the first NEPA analysis that comprehensively addresses the effects of all Chinook salmon, fall-run chum salmon, coho salmon, sockeye salmon, pink salmon, and steelhead hatchery programs operating within the geographic boundaries of the Puget Sound Chinook Salmon ESU, and Puget Sound Steelhead DPS. This subsection, and the summary data it describes, provides information on existing hatchery conditions that are used in Subsection 3.2, Fish, and Chapter 4, Environmental Consequences, to evaluate effects of the alternatives on all resources. As described in Subsection 1.5.1, Hatchery Facilities in Puget Sound, and shown in Table 1.5-1, 133 Puget Sound hatchery programs are encompassed by the RMPs and reviewed in this EIS. These programs are operated by WDFW, tribes, and/or USFWS; produce six different salmon and steelhead species (Chinook salmon, coho salmon, fall-run chum salmon, pink salmon, sockeye salmon, and steelhead); and represent specific hatchery strategies (e.g., isolated or integrated programs, see Subsection 2.2.2.1, Artificial Production Strategies) as described in the hatchery and genetic management plans (HGMPs) to meet management objectives for each program (Table 3.2-5). Approximately 147 million juvenile fish are produced each year by Puget Sound hatcheries (Table 3.2-6).

Table 3.2-5. Number of hatchery programs by species and hatchery production strategy.

	Hatchery Production Strategy						
	Integrated			Isolated			
Species	**Harvest**	**Conservation**	**Research**	**Harvest**	**Conservation[1]**	**Research**	**Total**
Chinook salmon	11	13	2	19	2	1	**48**
Coho salmon	9	4	0	30	0	0	**43**
Chum salmon	6	1	0	7	0	0	**14**
Pink salmon	0	1	0	2	0	0	**3**
Sockeye salmon	1	1	0	0	0	0	**2**
Steelhead	0	4	0	19	0	0	**23**
Total (Percent)	**27 (20)**	**24 (18)**	**2 (2)**	**77 (57)**	**2 (2)**	**1 (1)**	**133 (100)**

[1] Designation is from the submitted HGMPs.

Table 3.2-6. Average annual numbers (in thousands) of hatchery releases by species and life stage.

Life Stage at Release	Chinook Salmon	Steelhead	Coho salmon	Fall-run Chum	Pink Salmon	Sockeye Salmon	Total
Fry	na[1]	na	181	44,995	4,500	35,000	**84,676**
Subyearling	42,802	na	9	na	na	120	**42,931**
Yearling	2,515[2]	2,468	14,402	na	na	5	**19,390**
Total	**45,317**	**2,468**	**14,592**	**44,995**	**4,500**	**35,125**	**146,997**

[1] na = not applicable
[2] Of the total number of yearlings, 1,575,000 are fall-run fish and 940,000 are spring-run fish.

Information on specific hatchery programs is found in the respective HGMP, and Table 3.2-7 provides a guide to information in the EIS and appendices where species-specific data and information are available for salmon and steelhead.

Table 3.2-7. Guide to information in the EIS on hatchery programs and their influence on salmon and steelhead species.

		Salmon and Steelhead Species			
Information Category	**Variable or Parameter**	**Summer-run Chum Salmon**	**Chinook Salmon**	**Steelhead**	**Non-listed Salmon Species (Coho Salmon, Fall-run Chum Salmon, Pink Salmon, Sockeye Salmon)**
Hatchery Programs	Program Name	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Affected ESU/DPS or Natural-origin Population or Stock	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Race or Run	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Program Type	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Program Purpose	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Operator	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Life Stage(s) Released	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Release Time(s)	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Number Currently Released	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Primary Facility(ies)	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		
	Release Location(s)	NA[1]	Appendix A. Puget Sound Hatchery Programs and Facilities		

Table 3.2-7. Guide to information in the EIS on hatchery programs and their influence on salmon and steelhead species, continued.

Information Category	**Variable or Parameter**	**Salmon and Steelhead Species**			
		Summer-run Chum Salmon	**Chinook Salmon**	**Steelhead**	**Non-listed Salmon Species (Coho Salmon, Fall-run Chum Salmon, Pink Salmon, Sockeye Salmon)**
Competition and Predation Risks	Input Parameters for Risk Factors	Appendix A, Puget Sound Hatchery Programs and Facilities; Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population	Appendix D, PCD RISK 1 Assessment	Appendix F, Hatchery Program Viewer (HPV) Analysis; Appendix H, Steelhead Effects Analysis by Basin	Appendix A, Puget Sound Hatchery Programs and Facilities, and inferences drawn from other research and studies
Genetic Risks	Genetics - Broodstock Source and Length of Time Propagated	NA[1]	Appendix A, Puget Sound Hatchery Programs and Facilities		
	Genetics - Straying	NA[1]	Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population	Appendix F, Hatchery Program Viewer (HPV) Analysis; Appendix H, Steelhead Effects Analysis by Basin	Not generally known; inferences drawn from other research and studies
	Hatchery-induced Selection and Introgression	Not generally known; inferences drawn from other research and studies	Appendix E, Overview of the All H Analyzer; Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population	Appendix E, Overview of the All H Analyzer; Appendix H, Steelhead Effects Analysis by Basin	Not generally known; inferences drawn from other research and studies

Table 3.2-7. Guide to information in the EIS on hatchery programs and their influence on salmon and steelhead species, continued.

		Salmon and Steelhead Species			
Information Category	**Variable or Parameter**	**Summer-run Chum Salmon**	**Chinook Salmon**	**Steelhead**	**Non-listed Salmon Species (Coho Salmon, Fall-run Chum Salmon, Pink Salmon, Sockeye Salmon)**
Hatchery Facility and Operation Risks	Hatchery Facility and Operation Compliance	NA[1]	Appendix F, Hatchery Program Viewer (HPV) Analysis; Appendix C, Puget Sound Chinook Salmon Effect Analysis by Population	Appendix F, Hatchery Program Viewer (HPV) Analysis; Appendix H, Steelhead Effects Analysis by Basin	Not generally known; inferences drawn from other research and studies
Total Return Benefits	Total Return - Hatchery Contribution to Total Return		Appendix C, Puget Sound Chinook Salmon Effect Analysis by Population	Appendix H, Steelhead Effects Analysis by Basin	Not generally known; inferences drawn from other research and studies
Viability Benefits	VSP parameters	NA[1]	Appendix C, Puget Sound Chinook Salmon Effect Analysis by Population	Appendix H, Steelhead Effects Analysis by Basin	Not generally known; inferences drawn from other research and studies
Marine-derived Nutrient Benefits	Hatchery-origin Carcasses	Table 3.2-2. Average total spawning escapement and biomass by species in Puget Sound. Appendix B. Hatchery Effects and Evaluation Methods for Fish.			

[1] Although summer-run chum salmon hatchery program effects are not evaluated in this EIS, the effects of other species hatchery programs on natural-origin summer-run chum salmon are evaluated in this EIS.

Although listed summer-run chum salmon are also produced by hatcheries in Puget Sound, the hatchery programs that propagate listed summer-run chum salmon (Lilliwaup Hatchery and Tahuya River summer-run chum salmon programs) are not evaluated in this EIS because these programs are not part of the co-manager hatchery RMPs and HGMPs subject to this EIS. Summer-run chum salmon hatchery programs previously received authorization under the ESA (NMFS 2002a) and environmental review under NEPA (NMFS 2002b, 2004b). Species-specific data and information for fish species reviewed in this EIS other than salmon and steelhead are found in later subsections of Subsection 3.2, Fish.

3.2.5 Puget Sound Chinook Salmon ESU

Chinook salmon in Puget Sound have experienced population declines over the last several decades (see Subsection 3.2.5.2, Distribution and Abundance of Natural-origin Chinook Salmon). Consistent with the general factors affecting salmon and steelhead identified in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, factors have been identified by NMFS that limit ESU recovery (NMFS 2011c). These are habitat degradation (specifically estuarine and marine habitat, floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, and stream substrate), water quality, hatchery-related adverse effects, and predation/competition/disease from non-native species. As a result, the Puget Sound Chinook Salmon ESU was initially listed as threatened under the ESA in 1999 (64 Fed. Reg. 14308, March 24, 1999), and reconfirmed in 2005 (70 Fed. Reg. 37160, June 28, 2005). NMFS designated critical habitat for the ESU in 2005 (70 Fed. Reg. 52630, September 2, 2005). The locally developed recovery plan for the Puget Sound Chinook Salmon ESU (Shared Strategy for Puget Sound 2007) was reviewed and formally adopted by NMFS in 2007 (72 Fed. Reg. 2493, January 19, 2007). The recovery plan addresses the limiting factors and, through its implementation (including hatchery programs), helps to restore, conserve, and protect the ESU and its habitat (72 Fed. Reg. 2493, January 19, 2007). Recovery plan implementation will continue into the future (Chapter 5, Cumulative Effects). A 5-year status review was completed by NMFS in 2011 (NMFS 2011d).

The ESU includes natural-origin populations and hatchery-origin fish produced from a number of hatchery programs (Table 3.2-8). These hatchery programs produce fish that are part of the listed ESU because the fish were determined to be no more than moderately diverged from the local natural-origin populations, and may serve as genetic reserves and broodstock sources for recovery of the ESU (NMFS 2004c; Jones 2011). Background information on effects of hatchery programs on natural-origin fish and the methods used to evaluate existing conditions are provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Information on individual listed natural-origin Puget Sound Chinook salmon populations is contained in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population.

3.2.5.1 Life History of Natural-origin Chinook Salmon

This subsection describes the general life history of Chinook salmon, including incubation, hatching, and fry emergence in fresh water; out-migration to the ocean; and subsequent maturation and return of adults to fresh water for spawning. The diversity (genetic and behavioral) represented by variation in Chinook salmon life histories helps the ESU to be able to adapt to short-term and long-term changes in its environment over time (McElhany et al. 2000). Although the accompanying tables and figures illustrate differences between natural-origin and hatchery-origin Chinook salmon, more detailed information on the life history of natural-origin Chinook salmon is provided in Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead.

Juvenile Chinook salmon can rear in fresh water for very short or prolonged time periods. Additionally, some male Chinook salmon mature in fresh water, thereby foregoing out-migration to the ocean. The timing and duration of each of these stages is related to genetic and environmental factors and their interactions to varying degrees. Salmon, in general, exhibit a high degree of variability in life-history traits; however, there is considerable debate as to what degree this is the result of local genetic adaptation or the general variability of the salmon and steelhead gene pool (Ricker 1972; Healey 1991; Taylor 1991). More detailed descriptions of the key features of Chinook salmon life history can be found in Myers et al. (1998) and Healey (1991).

The two general freshwater life-history types initially described for Chinook salmon by Gilbert (1912) are: 1) stream-type Chinook salmon that reside in fresh water for a year or more after hatching before out-migrating to the ocean as yearlings, and 2) ocean-type Chinook salmon that out-migrate to the ocean within their first year as subyearlings. Most Puget Sound Chinook salmon populations are ocean-type fish that out-migrate primarily as subyearlings. Yearlings compose a small proportion (5 percent or less) of the out-migrants for most populations; however, they represent a substantial portion (30 to 40 percent) of the adult returns for some Puget Sound spring-run and summer-run Chinook salmon populations (Ruckelshaus et al. 2006).

Table 3.2-8. Watersheds, listed natural-origin populations, and associated hatchery programs that compose the Puget Sound Chinook Salmon ESU.

Watershed	Natural-origin Population	Associated Hatchery Programs[1]
Nooksack River	North Fork Nooksack spring-run	Kendall Creek spring-run
	South Fork Nooksack spring-run	Skookum Creek spring-run[2]
Skagit River	Lower Skagit fall-run	Marblemount fall-run
	Upper Skagit summer-run	Marblemount summer-run
	Cascade spring-run	Marblemount spring-run subyearling Marblemount spring-run yearling
	Suiattle spring-run	None
	Lower Sauk summer-run	None
	Upper Sauk spring-run	None
Stillaguamish River	North Fork Stillaguamish summer-run	Harvey Creek/Whitehorse Pond summer-run
	South Fork and mainstem Stillaguamish fall-run	South Fork Stillaguamish summer-run (Harvey Creek)[2]
Snohomish River	Skykomish summer/fall-run	Bernie Kai-Kai Gobin summer/fall-run Wallace River summer-run subyearling Wallace River summer-run yearling
	Snoqualmie summer/fall-run	None
Lake Washington	Sammamish fall-run	Issaquah fall-run
	Cedar fall-run	None
Green River	Green fall-run	Soos Creek fall-run subyearling Soos Creek/Icy Creek fall-run yearling Keta Creek
Puyallup River	Puyallup fall-run	Voights Creek fall-run subyearling Clarks Creek fall-run (Diru)
White River	White spring-run	White River spring-run[3] Puyallup White River acclimation sites spring-run White River/Hupp Springs spring-run[4]
Nisqually River	Nisqually fall-run	Clear Creek fall-run[4] Kalama Creek fall-run [4]
Skokomish River	Skokomish fall-run	George Adams fall-run subyearling Rick's Pond fall-run[5]
Hamma Hamma River, Duckabush River, Dosewallips River	Mid-Hood Canal fall-run	Hamma Hamma fall-run subyearling
Dungeness River	Dungeness spring-run	Dungeness spring-run[3]
Elwha River	Elwha summer/fall-run	Elwha summer/fall-run[3]

Source: Ruckelshaus et al. (2006); NMFS (2011d).

[1] All of these hatchery programs produce fish that are listed because they are no more than moderately diverged from the local natural-origin populations (Jones 2011). If not otherwise stated, individual programs release fish at the subyearling life stage (Appendix A, Puget Sound Hatchery Programs and Facilities).

[2] New hatchery program that warrants consideration for listing as part of the ESU (NMFS 2011d).

[3] Hatchery program produces subyearlings and yearlings.

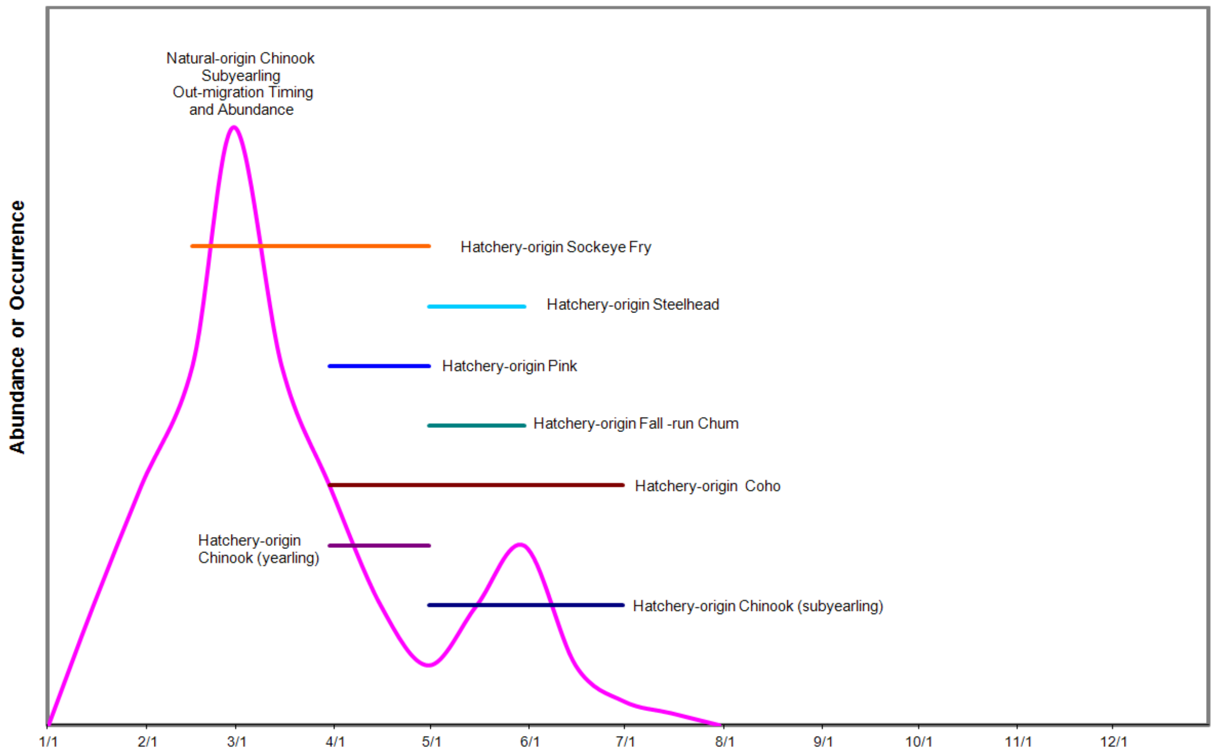
[4] Identified as isolated program in submitted HGMPs.

[5] Hatchery program produces yearlings.

Puget Sound Chinook salmon are typically referred to as summer-run, fall-run, or spring-run, corresponding to the time of year that adults return to fresh water to spawn (Myers et al. 1998; Ruckelshaus et al. 2006). Summer-run and fall-run are often grouped together because their run timing is quite variable and can be hard to distinguish, extending from July through September, with spawning occurring through October in some systems (WDF et al. 1993). However, Puget Sound Chinook salmon populations are predominantly fall runs. Spring or early-timed runs were historically more widely distributed in southern Puget Sound and Hood Canal, but have been reduced to the Nooksack, Skagit, and White River systems. Natural-origin summer-run populations within the project area originate in the Skagit River, Stillaguamish River, and Snohomish River systems (Ruckelshaus et al. 2006). Fall-run populations occur throughout Puget Sound.

The timing of natural-origin juvenile Chinook salmon out-migrations from fresh water are bimodal (Figure 3.2-1), with greater than 70 percent composed of newly emerged fry that average 1.6 inches (40 mm) fork length (i.e., the length of a fish measured from the most anterior part of the head to the deepest point of the notch in the tail fin) (Table 3.2-4). Natural-origin fry out-migrate predominantly between January and April. A second lesser peak occurs between late May and early July, with the majority of these fish being parr or subyearlings (3.0 inches [75 mm] fork length) that move directly to marine waters of Puget Sound. Some natural-origin Puget Sound Chinook salmon populations also include yearling migrants that move downstream predominantly in April and May and average 4.7 inches (120 mm) fork length (Table 3.2-4).

After emerging from the gravel, Chinook salmon fry feed on zooplankton and aquatic invertebrates in drift (Sommer et al. 2001), and parr (sometimes called fingerlings) feed on invertebrates in fresh water (Scott and Crossman 1973). Terrestrial and marine invertebrates are preferred prey during their early marine life phases, with fish (primarily forage fish) becoming the predominant prey item as the Chinook salmon grow to adult size during their marine life phase (Duffy 2003).



Sources: Natural-origin sockeye salmon data from Beamer et al. (2005) and WDFW juvenile out-migrant trapping reports (Seiler et al. 2000, 2003, 2004; Volkhardt et al. 2006a, 2006b; Kinsel et al. 2007, 2008). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-1. Typical duration of natural-origin Chinook salmon juvenile out-migration timing and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

Estuarine residence time for natural-origin Chinook salmon is highly variable, ranging from 1 to 3 weeks for some subyearling and yearling migrants to 1 to 5 months for intermediate-sized (parr) migrants (Simenstad et al. 1982). Juvenile Chinook salmon reside longer in estuaries than other salmon and steelhead, and are present within Puget Sound throughout the year (Reimers 1973; Iwamoto and Salo 1977; Healey 1982; Simenstad et al. 1982; McCabe et al. 1986). They enter Puget Sound in the spring, with peak abundances in nearshore areas in early summer, and typically remain in nearshore areas until early August with timing and abundance varying among different regions. Individual fish have been observed to spend up to 7 weeks in nearshore areas of south Puget Sound and Hood Canal (Simenstad et al. 1982), but may reside longer in areas where they co-occur with rearing and migrating juvenile coho salmon and chum salmon (Rowse and Fresh 2003; Duffy 2003).

Natural-origin Puget Sound Chinook salmon typically reach sexual maturity and return to fresh water to spawn at various ages (2 to 6 years) after 1 to 5 years of ocean residence (Healey 1986, 1991). Adult returns are predominantly 3 or 4 year-old fish (Myers et al. 1998).

Juvenile Chinook salmon may also enter and reside in Puget Sound for rearing until they reach sexual maturity (locally called blackmouth salmon) (Chamberlin et al. 2011). Although these resident Chinook salmon can result from subyearling or yearling out-migrants, historically, most yearling out-migrants are of the stream-type, or spring-run form. Many of these historical spring-run Chinook salmon populations are now extirpated, likely because of habitat loss and over harvest (Ruckelshaus et al. 2006).

The life histories of individual populations reflects adaptations to the variability in habitat conditions unique to each river system, and contribute to the broad genetic and behavioral diversity of the populations composing the ESU (Ruckelshaus et al. 2006). The ability of Chinook salmon to persist and recover in the long term as freshwater and oceanic environmental conditions fluctuate is dependent on avoiding loss of this diversity (Ruckelshaus et al. 2002).

3.2.5.2 Distribution and Abundance of Natural-origin Chinook Salmon

The distribution of Chinook salmon and their abundance helps the ESU to be able to adapt to short-term and long-term changes in its environment over time (McElhany et al. 2000). The geographic area of the Puget Sound Chinook Salmon ESU extends from the Elwha River on the Olympic Peninsula, northeast to the Nooksack River, and to the southern end of Puget Sound and Hood Canal (Figure 3.2-2). The ESU includes 22 naturally reproducing populations (Ruckelshaus et al. 2006), as well as 26 integrated hatchery programs and two isolated hatchery programs that have met NMFS criteria for inclusion in the ESU (e.g., are no more than moderately diverged from the native, natural-origin populations) (Table 3.2-8).

The historic returns of Puget Sound Chinook salmon are not known with certainty. Myers et al. (1998) used early salmon cannery records to estimate a run size of about 690,000 Chinook salmon in Puget Sound at the beginning of the 20th century. Returns declined because of harvest and habitat degradation, and in the 1940s, commercial harvest fell below 100,000 fish per year (Myers et al. 1998). As runs declined and hatchery technology improved in the 1960s and 1970s, hatchery operations using modern rearing methods were implemented, releasing 50 to 70 million subyearling Chinook salmon annually, which bolstered adult returns available for harvest.

In another study, Ruckelshaus at al. (2002) estimated ranges for the sizes of most Puget Sound Chinook salmon populations under historical conditions. Compiling the upper ranges of those estimates as the likely historical adult returns, the total number of fish was 397,000 fish. However, when the populations whose ranges were not estimated by Ruckelshaus et al. (2002) (i.e., Green, White, Skokomish, and Elwha Chinook salmon) are also accounted for (by compiling estimates for those populations based on returns to watersheds of similar size), the total historic Puget Sound Chinook salmon return estimate exceeds 425,000 adults. Thus, for the purposes of this EIS, the 690,000 estimate is assumed to be closer to the historic overall escapement level for natural-origin Puget Sound Chinook salmon.

Total annual adult returns of natural-origin and hatchery-origin Chinook salmon (includes escapement and harvest) have remained well below the number of natural-origin returns produced under historical, pristine habitat conditions (Figure 3.2-3), as well as the restoration spawner abundance[3] for populations (Table 3.2-9). As estimated by WDFW (2011), total returns of Puget Sound Chinook salmon from 2005 to 2009 averaged 239,193 fish, which is about one-third of the historic return (690,000 fish) (Figure 3.2-2). Hatchery-origin Chinook salmon composed the majority (average 79 percent) of Chinook salmon that returned to Puget Sound (Figure 3.2-3) from 2005 to 2009.

In terms of spawner escapement, the most recent estimated 5-year total spawning escapement of Chinook salmon to Puget Sound is only about 37,000 fish, with a population median of about 900 fish (Ford 2011).

The total number of juvenile natural-origin Chinook salmon in Puget Sound marine areas when hatchery-origin Chinook salmon arrive from fresh water is estimated to be approximately 9 million fish, compared to about 177 million historically (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). It is likely that use of the estuary by natural-origin Chinook salmon for rearing and migration is well below historical levels because of the depressed numbers of natural-origin Chinook salmon spawners (Myers et al. 1998) and degradation and loss of freshwater and estuarine Chinook salmon habitat (Pess et al. 2003; 72 Fed. Reg. 2493, January 19, 2007).

[3] Restoration spawner abundance is described in Ford (2011). It refers to the number of spawners needed to achieve population replacement (where one progeny replaces each parent) under Properly Functioning Conditions (historical, pristine habitat conditions).

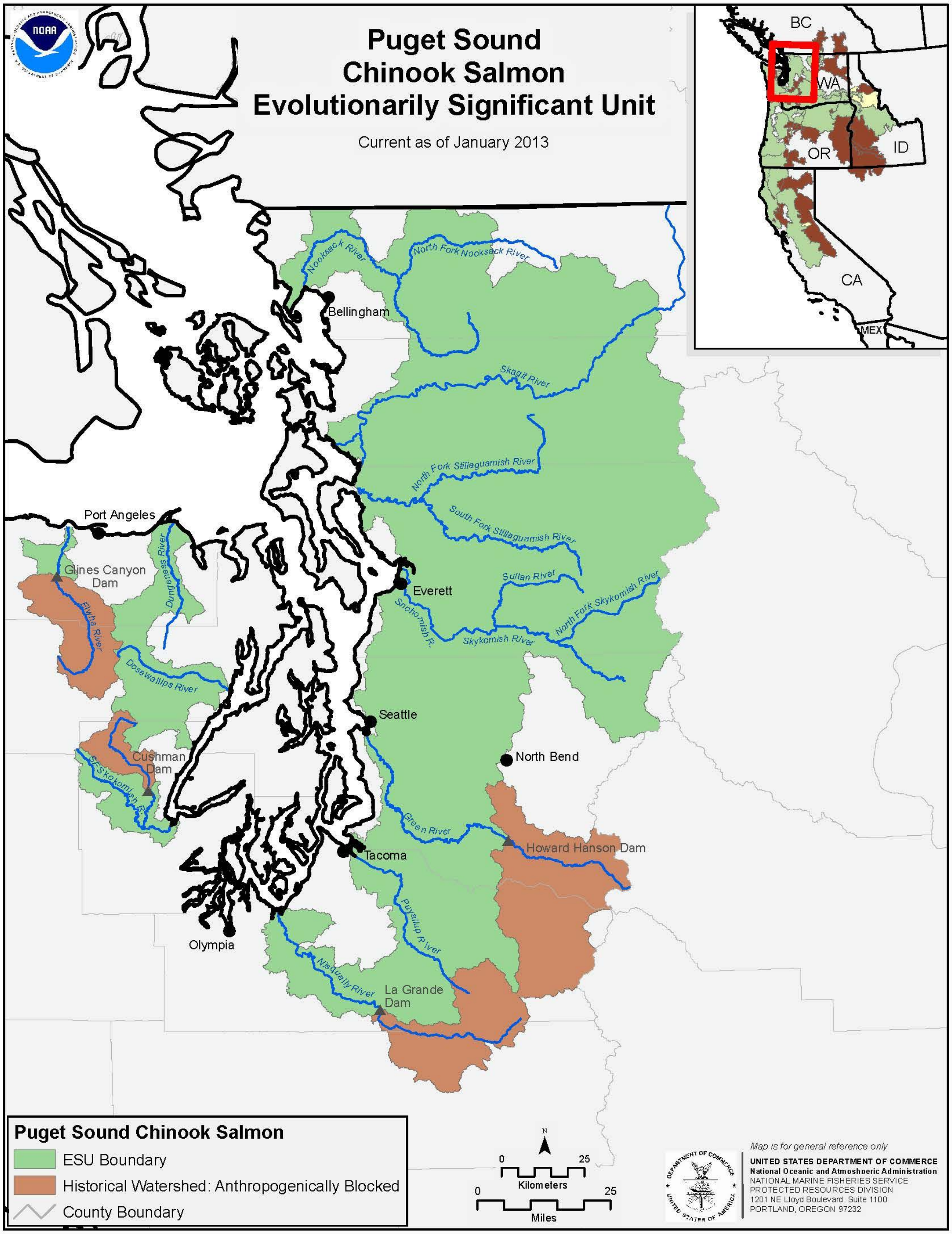
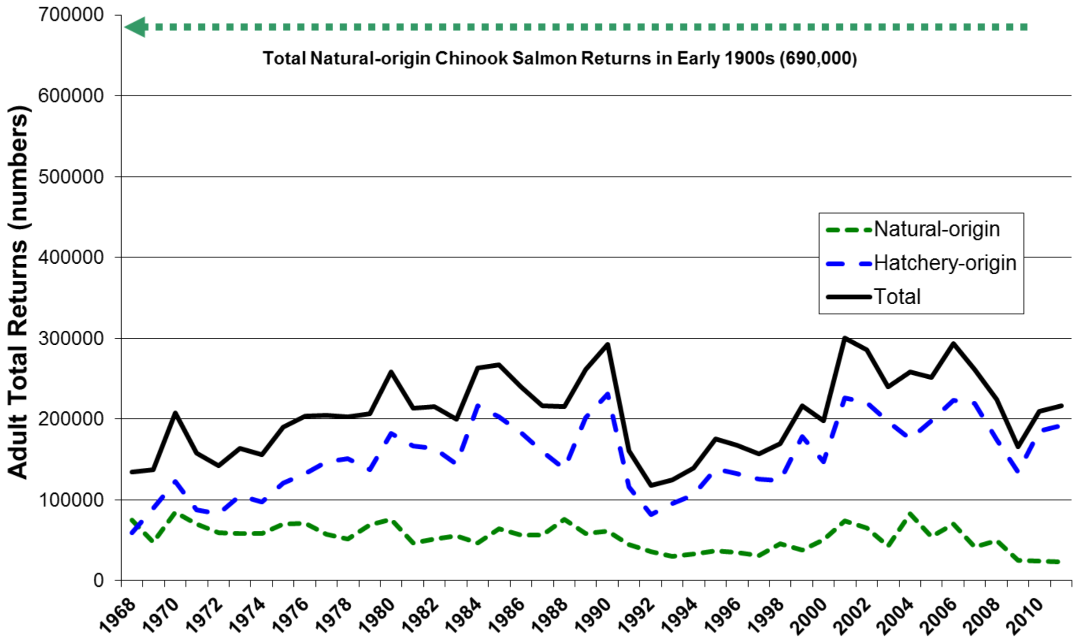


Figure 3.2-2. Geographic area of the Puget Sound Chinook Salmon ESU.



Sources: Estimated annual returns of natural-origin and hatchery-origin Chinook salmon entering Puget Sound is from WDFW (2011). Estimated total natural-origin historic run size is from Myers et al. (1998).

Figure 3.2-3. Total annual adult returns of natural-origin and hatchery-origin Puget Sound Chinook salmon from 1968 to 2011, compared to estimated total historic returns.

Table 3.2-9. Average total returns and total spawner escapements (2005-2009), and restoration spawner abundances for the Puget Sound Chinook Salmon ESU by population.

Population	Average Total Return [1] (Hatchery-origin)	Average Spawner Escapement[2]		Restoration Spawner Abundance[3]
		Total	Hatchery-origin (percent)	
North Fork Nooksack	5,336 (5,025)	1,666	1,390 (82)	16,400
South Fork Nooksack	1,340 (1,261)	388	144 (37)	9,100
Lower Skagit	6,608 (289)	2,163	96 (4)	15,800
Upper Skagit	30,226 (940)	10,345	621 (6)	26,000
Cascade	3,152 (2,630)	336	7 (2)	1,200
Lower Sauk[4]	---	777	35 (5)	5,600

Table 3.2-9. Average total returns and total spawner escapements (2005-2009), and restoration spawner abundances for the Puget Sound Chinook Salmon ESU by population, continued.

Population	Average Total Return [1] (Hatchery-origin)	Average Spawner Escapement[2]		Restoration Spawner Abundance[3]
		Total	Hatchery-origin (percent)	
Upper Sauk[4]	---	504	18 (4)	3,000
Suiattle[4]	---	259	9 (3)	600
North Fork Stillaguamish	2,102 (1,386)	943	465 (46)	18,000
South Fork and mainstem Stillaguamish[4]	---	99	1 (1)	15,000
Skykomish	19,177 (13,605)	3,309	951 (28)	39,000
Snoqualmie[4]	---	1,592	259 (16)	25,000
Sammamish	11,981 (10,000)	249	193 (77)	10,500
Cedar[4]	---	876	160 (18)	11,500
Green	39,657 (18,060)	3,077	1,789 (56)	22,000
Puyallup	13,617 (9,460)	1,960	1,185 (60)	18,000
White	5,130 (3,407)	1,869	563 (30)	14,200
Nisqually	40,170 (31,720)	1,892	1,326 (69)	13,000
Skokomish	17,908 (12,912)	1,109	653 (55)	12,800
Mid-Hood Canal	855 (700)	81	37 (39)	11,000
Dungeness	635 (305)	417	256 (59)	4,700
Elwha	7,195 (3,433)	575	390 (66)	15,100

[1] Total returns include fisheries and escapement of natural-origin and hatchery-origin fish. Average hatchery-origin returns are based on survival rates for programs using coded wire tag and other mark recovery information (WDFW 2007; NWIFC 2007). Natural-origin run sizes are based on expansions using FRAM post-season estimates of exploitation rates from 2002-2009 (from PSIT and WDFW 2008).
[2] Total spawner escapement includes natural-origin and hatchery-origin fish (Ford 2011).
[3] Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).
[4] No hatchery programs are associated with this population and no total returns are calculated.

3.2.5.3 Description of Hatchery-origin Chinook Salmon

Hatchery-origin Chinook salmon in Puget Sound are released as subyearlings or yearlings. Releases for subyearlings occur predominantly in May and June and releases for yearlings occur predominantly in April (Figure 3.2-1, Table 3.2-4). Chinook salmon subyearlings are generally released at an average length of about 3.1 inches (80 mm) fork length, while Chinook salmon yearlings are generally released at an average length of 6.1 inches (155 mm) fork length (Table 3.2-4). Hatchery-origin Chinook salmon smolts migrate to marine waters shortly after release. Residualism in fresh water by hatchery-origin Chinook salmon after release has not been documented in the region. There are no releases of hatchery-origin Chinook salmon fry from hatcheries in Puget Sound.

After release, some hatchery-origin Chinook salmon juveniles may remain in Puget Sound and not leave to rear in the ocean as noted in Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon. These resident fish are locally referred to as blackmouth salmon. By the late 1970s, it was learned that delaying the release timing of fall-run Chinook salmon to the yearling stage would foster the tendency of the fish to remain in Puget Sound, and thus increase numbers of resident Chinook salmon available for harvest (Pressey 1953; Haw et al. 1967). The State then developed hatchery programs to take advantage of this phenomenon, which enhanced recreational salmon fisheries in Puget Sound (Moring 1976) by allowing harvest of the fish when they reached a legal size (22 inches) at about 2 years of age, but prior to reaching sexual maturity. Although successful in meeting program objectives for some time, survival of these delayed-release hatchery-origin fall-run Chinook salmon (to fisheries and escapement) has generally declined, presumably because of degraded habitat and environmental conditions (Washington State Auditor’s Office 2010; WDFW 2012). In addition, for various reasons (including reducing risks to co-occurring listed Chinook salmon) (Washington State Auditor’s Office 2010) the production of these fish is about a third of what it was 10 years ago (S. Theisfeld, pers. comm., WDFW, Resource Program Manager, February 26, 2013).

The average size of hatchery-origin Chinook salmon subyearlings and yearlings is either similar to or larger than other natural-origin salmon out-migrants (Table 3.2-4), with the exception of Chinook salmon that remain in Puget Sound marine waters. Releases of hatchery-origin Chinook salmon occur when other natural-origin salmon and steelhead juveniles out-migrate through fresh water. This results in the potential for hatchery-origin Chinook salmon to compete with or prey on natural-origin salmon and steelhead.

Average returns for hatchery-origin Chinook salmon (Table 3.2-9) range from 289 fish (Lower Skagit fish) to 31,720 fish (Nisqually fish). Hatchery-origin fish compose 1 to 82 percent of the average total (hatchery-origin and natural-origin combined) spawner escapement (Table 3.2-9).

The average total number of hatchery-origin Chinook salmon released from all programs is about 45.3 million fish (Table 3.2-6). Total subyearling production for all Puget Sound Chinook salmon hatchery programs averages approximately 42.8 million fish (94 percent of all hatchery-origin Chinook salmon), while yearling production averages about 2.5 million fish (6 percent of the total). Of this yearling production, approximately 1.6 million (4 percent of the total) are from fall-run Chinook salmon programs operated to support Puget Sound recreational fisheries (Table 3.2-6) (Appendix A, Puget Sound Hatchery Programs and Facilities). Hatchery-origin Chinook salmon are released in all watersheds of Puget Sound with the average number released ranging from a low of 45,000 to a high of 4,000,000 smolts per hatchery program (Appendix A, Puget Sound Hatchery Programs and Facilities). There are a total of 48 hatchery programs that release Chinook salmon, including 22 isolated hatchery programs and 26 integrated hatchery programs (Table 3.2-5).

3.2.5.4 Hatchery Program Risks and Benefits

This subsection summarizes the known risks and benefits of existing hatchery programs to the Puget Sound Chinook Salmon ESU, and is based on the background information, methods, and criteria for evaluation of each risk and benefit category as provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish, specifically for Puget Sound Chinook salmon. This subsection also summarizes evaluations of existing programs and supports the analysis of effects to individual natural-origin Chinook salmon populations that compose the Puget Sound Chinook Salmon ESU (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population).

3.2.5.4.1 Risks - Competition - Fresh Water

Salmon and steelhead hatchery programs can pose competition risks to natural-origin Chinook salmon in freshwater areas. Although results of individual studies vary (e.g., Fresh et al. 1979; Levin et al. 2001; Riley et al. 2004), in a general review of ecological interactions between hatchery-origin and natural-origin salmon and steelhead, SIWG (1984) concluded that hatchery-origin Chinook salmon, coho salmon, and steelhead pose the greatest risks of competition effects to natural-origin Chinook salmon in fresh water, whereas risks from hatchery-origin chum salmon, pink salmon, and sockeye salmon are low. Competition could occur both for food and space when 1) hatchery-origin fish are released at the same time and at the same size as when natural-origin Chinook salmon emerge from gravel and begin their out-migration to marine water, 2) both hatchery-origin fish and natural-origin Chinook salmon spend similar amounts of time in fresh water where food and space are limited, and 3) hatchery-origin fish and natural-origin Chinook salmon co-occur in the same freshwater areas prior to out-migration to marine water (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population).

Considering hatchery programs for all species and all Chinook salmon populations, based on the three elements mentioned above, the average competition risk from hatchery-origin fish to natural-origin Chinook salmon populations in fresh water is estimated to be moderate (average score is 1.7) (Table 3.2-10). This risk is moderate because there are some overlaps in out-migration timing between hatchery-origin steelhead and coho salmon, and natural-origin Chinook salmon, and the release areas for some species (e.g., steelhead) are generally upstream of natural-origin Chinook salmon.

Table 3.2-10. Summary of risks and benefits for the Puget Sound Chinook Salmon ESU from existing hatchery production.

	Risk				Benefit	
	Competition (Fresh Water)	**Predation (Fresh Water)**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Average Overall Score	1.7	2.7	2.1	1.0	1.6	1.1
(Rating)[1]	Moderate	High	Moderate	Low	Moderate	Low

[1] Scores and ratings are averages from the 22 Chinook salmon populations from Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population. Some effects are evaluated at the ESU level only (not at the population level). Those effects are competition risks in estuarine and marine areas (which have an overall low risk rating), predation risks in estuarine and marine areas (which have an overall low risk rating), and marine-derived nutrient benefits (which have an overall negligible risk rating).

3.2.5.4.2 Risks - Competition - Marine

Competition in estuarine and marine areas may occur. In a general review of ecological interactions between hatchery-origin and natural-origin salmon and steelhead, SIWG (1984) concluded that risks of competition effects in marine waters were generally unknown because of lack of data (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, when considering Chinook salmon, they determined that the risk of competition effects from hatchery-origin Chinook salmon to natural-origin Chinook salmon was high.

Natural-origin Chinook salmon are known to rear throughout Puget Sound and beyond for varying periods of time (Duffy 2003; Fresh 2006). The largest releases of hatchery-origin subyearling Chinook salmon occur in south Puget Sound (Appendix A, Puget Sound Hatchery Programs and Facilities), but there are few natural-origin Chinook salmon populations in that area (Table 3.2-8) to be affected by those releases. Because little information is available at the population scale concerning the extent of spatial and temporal overlap between hatchery-origin fish and natural-origin Chinook salmon in marine areas in Puget Sound (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population), an analysis of competition effects in marine areas at the population scale was not undertaken; however, the risk is evaluated in general at the ESU scale. Considering relevant studies described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, and because the location and numbers of hatchery-origin Chinook salmon releases occur in areas with few natural-origin Chinook salmon populations, the overall competition effect to Chinook salmon in marine waters at the ESU scale is likely low, and may primarily occur in estuarine areas adjacent to river mouths where hatchery-origin fish may concentrate on their migration to marine waters.

3.2.5.4.3 Risks - Predation - Fresh Water

Salmon and steelhead hatchery programs can pose predation risks to natural-origin Chinook salmon in freshwater areas. Risks are greatest in habitats adjacent to and downstream from hatchery release sites where hatchery-origin fish are likely to be most concentrated, and where the overlap in space and time with the generally small-sized, natural-origin juvenile Chinook salmon are greatest.

In a general review of ecological interactions between hatchery-origin and natural-origin salmon and steelhead, SIWG (1984) found relatively little data on predation in fresh water, and concluded that predation risks to natural-origin Chinook salmon in fresh water are low from hatchery-origin chum salmon, pink salmon, and sockeye salmon, and unknown for Chinook salmon, coho salmon, and steelhead (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, based on additional studies evaluated in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, predation risks likely occur when released hatchery-origin fish are larger than natural-origin fish, the diet of the hatchery-origin fish includes Chinook salmon juveniles, and when these hatchery-origin fish co-occur at the same time and locations as natural-origin Chinook salmon. Therefore, considering all hatchery programs and Chinook salmon populations, the average predation risk from hatchery-origin fish to natural-origin Chinook salmon populations in fresh water is estimated to be high (average score is 2.7) (Table 3.2-10), primarily because of the larger sizes of hatchery-origin steelhead, coho salmon, and yearling Chinook salmon, compared to smaller-sized natural-origin Chinook salmon, and spatial and temporal overlaps during out-migration.

3.2.5.4.4 Risks - Predation - Marine

This EIS also considers the possibility of hatchery fish predation on natural-origin Chinook salmon in estuarine and marine areas. In a general review of ecological interactions between hatchery-origin and natural-origin salmon and steelhead, SIWG (1984) found relatively little data on predation in nearshore marine areas and concluded that predation risks to natural-origin Chinook salmon in nearshore marine areas are low from hatchery-origin chum salmon, pink salmon, and sockeye salmon, and unknown for Chinook salmon, coho salmon, and steelhead (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, more specific information on predation in Puget Sound marine areas is provided below.

Natural-origin Chinook salmon have been found rearing throughout Puget Sound and beyond (Duffy 2003; Fresh 2006). In Puget Sound, Duffy (2003) found that the temporal distribution, trophic interactions, and factors in marine areas that limit survival of natural-origin Chinook salmon are poorly understood. Because little information is available concerning the extent of spatial and temporal overlap between hatchery-origin fish and natural-origin Chinook salmon in different marine areas in Puget Sound (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population), an analysis of predation effects in marine areas at the population scale was not undertaken in this EIS. However, predation effects in marine areas are more generally evaluated at the ESU scale. Although hatchery-origin Chinook salmon yearlings are large enough to prey on smaller natural-origin Chinook salmon, actual documentation of such predation is lacking. However, in spite of these limitations, it is likely that predation from hatchery-origin fish on natural-origin Chinook salmon occurs in marine waters because of size differences and co-occurrence of these potential predators and prey (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Although the extent of overlap in space and time is limited as the fish migrate through marine waters to the ocean, predation in marine areas is likely to be greatest between the larger hatchery-origin Chinook salmon yearlings and smaller natural-origin subyearlings (with greatest overlap in areas adjacent to river mouths). Thus, overall predation risks at the ESU scale are likely low.

3.2.5.4.5 Risks - Genetics

Hatchery programs for Chinook salmon in Puget Sound have benefits and risks. Genetic risks are addressed in this subsection, whereas benefits are described in Subsection 3.2.5.4.8, Benefits - Viability. All 48 of the hatchery programs producing Chinook salmon (Table 3.2-5) also pose various degrees of genetic risk to natural-origin Chinook salmon populations that compose the Puget Sound Chinook Salmon ESU. However, 28 hatchery programs are designed to help conserve genetic resources within the ESU

(Subsection 3.2.4.2, Hatchery Programs Reviewed), and in some cases, reduce short-term extinction risk as discussed in Subsection 3.2.5.4.8, Benefits - Viability.

Despite the considerable information on genetic effects for various species as summarized in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead (with the exception of assessments of genetic diversity [Ruckelshaus et al. 2006]), empirical studies of genetic risks and hatchery effects for Puget Sound Chinook salmon are limited. Based on recent studies, genetic risks for Chinook salmon hatchery programs primarily arise from hatchery-induced selection risks (sometimes called domestication) at specific hatchery programs, as well as risks of gene flow from hatchery-origin to natural-origin fish in nature (introgression) posed by strays. The genetic considerations below are incorporated in the evaluation of existing genetic risks to natural-origin Chinook salmon (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Relatively little information is available on genetic effects from Chinook salmon hatchery programs on natural-origin Puget Sound Chinook salmon. However, information and analyses are available from other areas on the genetic effects of Chinook salmon hatchery programs. For example, Reisenbichler and Rubin (1999) describe five studies showing that hatchery programs for yearling Chinook salmon genetically change the population and, thereby, reduce fitness over time. The authors report that substantial change in fitness can result from traditional artificial propagation of salmon and steelhead held in captivity for one-quarter or more of their life. In contrast, results from studies of supplementation or integrated programs in the Columbia River basin are mixed. For example, Hess et al. (2012) found reproductive success of natural-origin and hatchery-origin spring Chinook salmon to be generally similar, whereas differences were observed by Hayes et al. (2013). Although any artificial breeding and rearing will result in some degree of genetic change, no studies are available, like those described above, that document declines in fitness of natural-origin Chinook salmon populations associated with the production of hatchery-origin subyearling Chinook salmon in Puget Sound or elsewhere (RIST 2009; California HSRG 2012). Because hatchery-origin subyearling Chinook salmon are subjected to artificial rearing conditions for a shorter time than yearling fish, hatchery-origin subyearlings may be less affected genetically than hatchery-origin yearlings (Berejikian and Ford 2004). In studies of Hood Canal summer-run chum, a species that spend relatively little time in hatcheries (similar to hatchery-origin subyearling Chinook salmon), Berejikian et al. (2009) and Small et al. (2009) observed lower relative fitness for hatchery-origin than natural-origin fish, but found the differences were not significant statistically.

The extent of genetic change is also affected by the number of generations a population has been propagated. RIST (2009) found little evidence of differences in relative fitness of hatchery-origin fish among species for recently developed hatchery programs; however, the number of studies was small and there were differences in the life stages that were evaluated. In contrast, Christie et al. (2012) found that genetic changes in steelhead can occur after one generation of hatchery rearing.

The Puget Sound Chinook Salmon ESU comprises fish from natural-origin populations, fish from hatchery programs that use broodstock that originated from their home watersheds, and programs that use broodstock that originated from areas outside their home watersheds. In the latter case, Chinook salmon originating in the Green River (within the ESU) were used to establish Chinook salmon hatchery programs in a number of watersheds, including the Samish, Puyallup, Nisqually, and Skokomish Rivers, Issaquah Creek, and Mid-Hood Canal watersheds, where locally returning fish are now used for broodstock. Local broodstocks better reflect the range of genetic diversity of the population, reducing risks to genetic diversity of the natural-origin fish. Most Puget Sound Chinook salmon hatchery programs maintain effective spawning population sizes well above 1,000 fish, and in some cases, above 10,000 fish. These levels are large enough that inbreeding depression (inbreeding, or mating between closely related individuals) is not likely.

Straying is a natural occurrence whereby fish spawn in streams or areas that are different from where they were born. When such fish interbreed with the local spawners, straying is thought to serve a useful purpose by reducing loss of genetic diversity that occurs through genetic drift, and by providing opportunities for species to naturally colonize or re-colonize vacant habitat (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, straying that results in introgression can introduce hatchery-adapted traits into the natural-origin population, and potentially negatively affect their genetic diversity, fitness, and viability (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As noted above, straying and gene flow from hatchery-origin to natural-origin Chinook salmon likely occurs in Puget Sound, but has not been comprehensively quantified in genetic studies.

Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, provides analyses and results of the genetic risks for Chinook salmon hatchery programs for each Chinook salmon population. In summary, using the genetic evaluation methods in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and applied in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, for all Chinook salmon hatchery programs and Chinook salmon populations, the overall genetics risk is moderate (average score is 2.1) (Table 3.2-10), primarily because of risks of hatchery-induced selection effects and gene flow from hatchery-origin Chinook salmon.

3.2.5.4.6 Risks - Hatchery Facilities and Operation

Hatchery facilities and the practices used in their operation can pose risks to natural-origin Chinook salmon (Appendix B, Hatchery Effects and Evaluation Methods for Fish), which includes broodstock collection, operations of hatcheries and traps, weirs, water intake screens and extent of withdrawals, and discharges of hatchery effluents. However, most Chinook salmon (94 percent) are reared for a relatively short time prior to release at the subyearling stage, and the remaining fish (6 percent) are released at the yearling stage (Table 3.2-6). Thus, their exposure to hatchery facilities and operation risks are relatively low compared to other species that are released primarily at the yearling life stage (e.g., steelhead, coho salmon).

BMPs consistent with HSRG (2004) can help to minimize hatchery facilities and operation risks and include changes in broodstock collection practices, hatchery water withdrawals, diversion screen criteria, and effluent discharges, as well as implementing practices that decrease the likelihood of fish disease transfers. These BMPs are described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Hatchery facilities and operation risk factors (considering use and/or non-use of these recommended BMPs) were evaluated for Puget Sound Chinook salmon hatchery programs using the Hatchery Program Viewer Tool described in Appendix F, Hatchery Program Viewer (HPV) Analysis. Results are provided in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population.

For Chinook salmon hatchery programs across the ESU, compliance with BMPs is generally good (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). However, compliance with BMPs for a few operational phases in a small number of programs is low. For example, during adult holding (water temperature profiles) and release, management plans with performance indicators are a key component of hatchery operations, but are not in place for all programs. Considering all of the Chinook salmon hatchery programs and Chinook salmon populations, the overall hatchery facilities and operation risk is low (average score is 1.0) (Table 3.2-10) because most programs operate in compliance with BMPs.

3.2.5.4.7 Benefits - Total Return

The total return of hatchery-origin Chinook salmon returning to fisheries and escapement can provide harvest and/or conservation benefits (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

This EIS assesses total return benefits for Chinook salmon based on recent year returns of hatchery-origin and natural-origin Chinook salmon compared to restoration spawner abundance targets associated with individual natural-origin Chinook salmon populations (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). The total return benefit is thus primarily associated with benefits to harvest, and is different from the abundance component used to assess viability benefits, which addresses benefits only to listed natural-origin fish and their recovery (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Total return benefits from Chinook salmon hatchery production vary depending on the hatchery program (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Benefits are lowest for the Mid-Hood Canal, North Fork Stillaguamish, and South Fork Nooksack salmon populations (each under 20 percent), and highest for the Nisqually, Cascade, and Green Chinook salmon populations (each nearly 200 percent or greater). Socioeconomic benefits from harvest are described in Subsection 3.3, Socioeconomics.

Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, provides analyses and results of the total return benefits that individual Chinook salmon hatchery programs contribute to the total return of Puget Sound Chinook salmon. Considering all of the Chinook salmon hatchery programs and populations collectively, the overall total return benefit is moderate (average score is 1.6) (Table 3.2-10), because, for most populations, the total return benefit would be less than 50 percent of the restoration spawner abundance estimate for those populations.

3.2.5.4.8 Benefits - Viability

Benefits can accrue to the viability of the Puget Sound Chinook Salmon ESU when genetic resources important to the ESU reside in fish produced by hatchery programs. Under NMFS' policy for considering hatchery-origin fish in extinction risk evaluations (70 Fed. Reg. 37204, June 28, 2005), hatchery-origin fish can benefit populations to the extent that they positively contribute to the abundance, productivity, diversity, and spatial structure of natural populations, which are the four VSP parameters identified by McElhany et al. (2000). Hatchery programs included in the ESU are presented in Table 3.2-8. These programs can contribute to viability benefits. Most hatchery programs producing listed Chinook salmon are integrated programs, although a few are described by their operators as isolated programs (White River/Hupp Springs spring-run, and Kalama and Clear Creek programs in the Nisqually).

Viability benefits to natural-origin Chinook salmon from hatchery production vary depending on the hatchery program (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Of the 22 total natural-origin Chinook salmon populations, listed hatchery programs are currently associated with 16 populations that potentially contribute to viability (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population).

Many existing listed hatchery programs (Table 3.2-8) benefit the abundance VSP parameter for natural-origin Chinook salmon populations, and most programs benefit the diversity and/or spatial structure parameters. However, benefits to the productivity VSP parameter are generally unknown; thus, no programs are judged as benefitting productivity for any Chinook salmon population. As a result, no programs benefit all four viability parameters; two or three of the abundance, diversity, and spatial structure parameters accrue benefits to 11 of the 16 Chinook salmon populations; 1 parameter (abundance) accrues to 2 populations; and no benefits accrue to 3 populations (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Considering all of the listed Chinook salmon hatchery programs and natural-origin populations collectively, the overall benefit to the viability of the Puget Sound Chinook Salmon ESU is low (average score is 1.1) (Table 3.2-10), primarily because benefits to VSP parameters from listed hatchery programs are limited.

3.2.5.4.9 Benefits - Marine-derived Nutrients

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, natural-origin Chinook salmon and their ecosystems can benefit from marine-derived nutrients that are delivered into fresh water by returning adult hatchery-origin and natural-origin salmon and steelhead that spawn and die. Salmon and steelhead carcasses provide a direct food source for juvenile salmon and steelhead, other fish, aquatic invertebrates, and terrestrial animals. The decomposition of these carcasses supplies nutrients that increase primary and secondary production and benefit the ecosystem. Thus, returning hatchery-origin adults help contribute to marine-derived nutrients in freshwater ecosystems, which benefits natural-origin Chinook salmon.

However, the contributions of marine-derived nutrients from returning Chinook salmon are relatively small. For example, less than 10 percent of the average total escapement and biomass in Puget Sound spawning areas is composed of Chinook salmon (hatchery-origin and natural-origin fish) (Appendix B, Hatchery Effects and Evaluation Methods for Fish). In addition, only 18 percent of the carcasses distributed from WDFW hatcheries into watersheds are hatchery-origin Chinook salmon (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As a result, this benefit is evaluated at the Puget

Sound scale only; it is not evaluated for individual Chinook salmon populations for inclusion in Table 3.2-10.

Considering all Chinook salmon hatchery programs collectively, the overall benefit of marine-derived nutrients from Chinook salmon hatchery programs to the Puget Sound Chinook Salmon ESU is negligible because of the relatively small program contribution to marine-derived nutrients in Puget Sound watersheds.

3.2.6 Hood Canal Summer-run Chum Salmon ESU

Summer-run chum salmon in Hood Canal have experienced population declines over the last several decades (see Subsection 3.2.6.2, Distribution and Abundance of Summer-run Chum Salmon). Consistent with the general factors affecting salmon and steelhead identified in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, factors contributing to these declines are habitat degradation (specifically estuarine and marine habitat, floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream substrate, and stream flow) and predation/competition/disease from non-native species (NMFS 2011c). As a result, the Hood Canal Summer-run Chum Salmon ESU was listed as a threatened species under the ESA in 1999 (64 Fed. Reg. 14508, March 25, 1999) and reconfirmed in 2005 (70 Fed. Reg. 37160, June 28, 2005). A 5-year status review was completed by NMFS in 2011 (NMFS 2011d). The ESU includes all natural-origin summer-run chum salmon in the eastern Strait of Juan de Fuca and Hood Canal of western Washington. NMFS designated critical habitat for the Hood Canal Summer-run Chum Salmon ESU (70 Fed. Reg. 52630, September 2, 2005). As described in Subsection 1.7.4.1, Recovery Plans for Puget Sound Salmon, the recovery plan for the ESU was developed by a local organization (HCCC 2005) and was then reviewed and formally adopted by NMFS in 2007 (72 Fed. Reg. 29121, May 24, 2007). The recovery plan addresses the limiting factors, and through its implementation (including hatchery programs) is helping to restore, conserve, and protect the ESU and its habitat. Recovery plan implementation will continue into the future under all alternatives (Chapter 5, Cumulative Effects). Fall-run chum salmon are not listed, and are described in Subsection 3.2.10, Puget Sound/Strait of Georgia Chum Salmon ESU.

The ESU includes two natural-origin populations and hatchery-origin fish currently produced by two hatchery programs (Table 3.2-11). These hatchery programs are integral components of the recovery plan (70 Fed. Reg. 37160, June 28, 2005). They produce fish that are part of the listed ESU because the fish were determined to be no more than moderately diverged from the local natural-origin populations, and may serve as genetic reserves and broodstock sources for recovery of the ESU (NMFS 2004c; Jones 2011). Background information on effects of hatchery programs on natural-origin fish, and the methods used to evaluate existing conditions are provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Information on individually listed natural-origin Hood Canal summer-run chum salmon populations is contained in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population.

3.2.6.1 Life History of Natural-origin Summer-run Chum Salmon

This subsection describes the general life history of Hood Canal summer-run chum salmon, including incubation and fry emergence in fresh water, out-migration to estuarine areas, and subsequent return of adults to fresh water for spawning. The diversity (genetic and behavioral) represented by summer-run chum salmon life histories helps the ESU adapt to changes in its environment over time (Sands et al. 2009).

Table 3.2-11. Watersheds, listed natural-origin populations, and associated hatchery programs that compose the Hood Canal Summer-run Chum Salmon ESU.

Watershed	Natural-origin Population	Associated Hatchery Programs
Quilcene	Hood Canal	
Dosewallips		
Duckabush		
Hamma Hamma		
Lilliwaup		Lilliwaup
Union		Tahuya
Tahuya [1]		
Big Beef Creek [1]		
Skokomish [2]		
Salmon/Snow	Strait of Juan de Fuca	
Jimmycomelately		
Chimacum [1]		
Dungeness [3]		

Source: Sands et al. (2009)

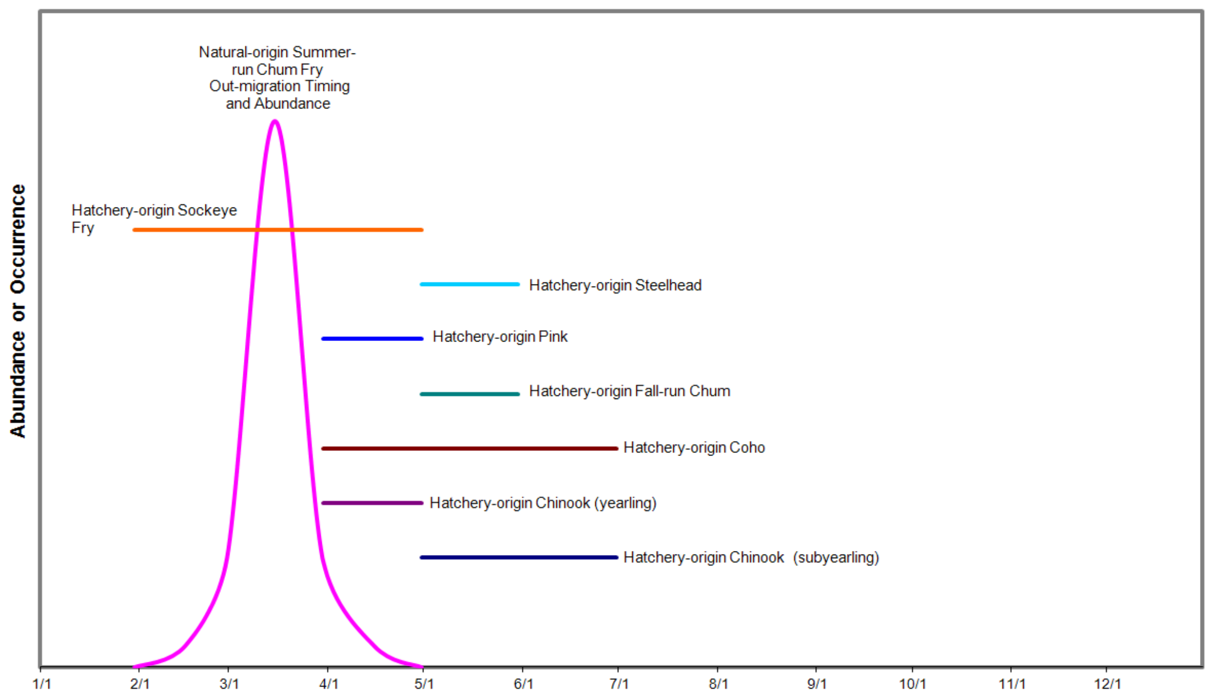
[1] Spawning aggregations in these watersheds are the result of recent conservation hatchery summer-run chum salmon programs where spawning populations were reintroduced where the native stocks were extirpated.

[2] Summer-run chum salmon in the Skokomish River are present at very low levels consistent with straying from other watersheds, and the native population is considered functionally extinct (WDFW and PNPTT 2000).

[3] Dungeness summer-run chum salmon spawning is thought to have occurred historically (WDFW and PNPTT 2000).

The life history of natural-origin summer-run chum salmon is best characterized by the late summer entry of adults into freshwater spawning areas and the late winter/early spring arrival of juveniles in estuaries. Spawning occurs from late August through October, generally in the lowest 1 to 2 miles of streams entering Hood Canal and the Strait of Juan de Fuca (WDFW and PNPTT 2000). Natural-origin summer-run chum salmon fry emerge from stream gravels predominantly in March (Tynan 1997; WDFW and PNPTT 2000) (Figure 3.2-4) and out-migrate immediately to estuarine areas (Schreiner 1977; Koski 1981; Salo 1991).

Natural-origin chum salmon fry arrive in the Hood Canal estuary at an average length of 1.5 inches fork length (38 mm) (Table 3.2-4). They are initially widely dispersed (Bax 1982). They orient to the shoreline for a few days (Schreiner 1977; Bax 1983; Whitmus 1985) where they form schools that may protect them from predation by larger fish (Gerke and Kaczynski 1972; Feller 1974).



Sources: Natural-origin summer-run chum salmon data from Tynan (1997). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

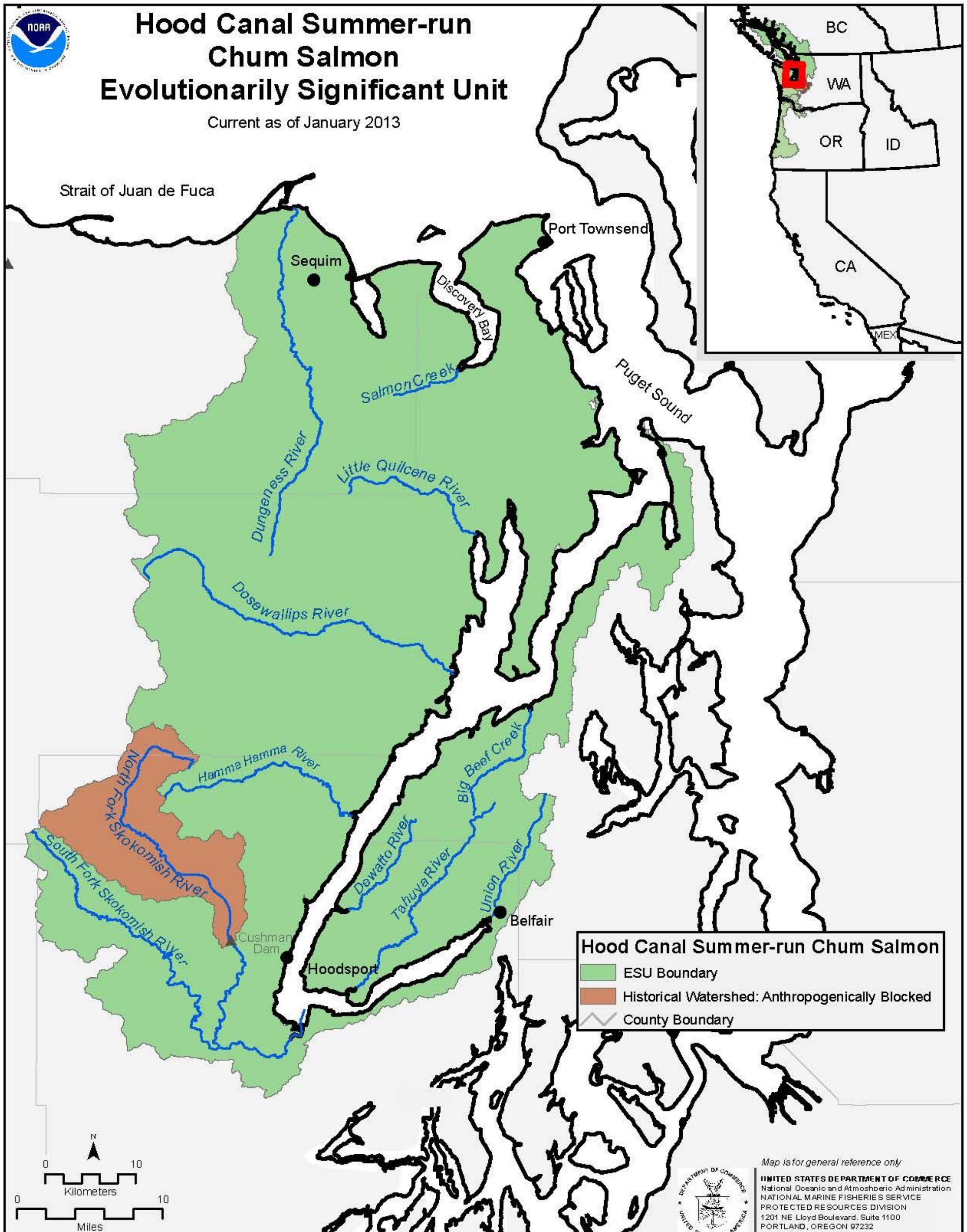
Figure 3.2-4. Typical duration of natural-origin summer-run chum salmon out-migration timing and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

In the nearshore marine habitat, chum salmon fry in Hood Canal prey predominantly on bottom organisms, mainly copepods and amphipods (Bax et al. 1979; Simenstad et al. 1980), but they also feed at the surface on drift insects (Gerke and Kaczynski 1972; Mason 1974; Whitmus 1985). Their diet changes to predominantly pelagic organisms as they grow larger and migrate into offshore areas.

3.2.6.2 Distribution and Abundance of Natural-origin Summer-run Chum Salmon

The Hood Canal Summer-run Chum Salmon ESU consists of natural-origin fish in two populations originating in 1) tributaries to the eastern Strait of Juan de Fuca and 2) Hood Canal (Sands et al. 2009) (Figure 3.2-5). For the eastern Strait of Juan de Fuca population, spawning occurs in Salmon, Snow, and Jimmycomelately Creeks (WDFW and PNPTT 2000). Summer-run chum salmon spawning has also been reestablished in Chimacum Creek (where the native population was previously extirpated) through a conservation hatchery program using Salmon Creek broodstock as the source stock for reintroduction of the species. A small number of summer-run chum salmon also spawn in the Dungeness River. For the Hood Canal population, spawning occurs in most of the major rivers draining the Olympic Mountains on the western shoreline of Hood Canal, including the Big Quilcene, Little Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Lilliwaup Rivers. Until recently, spawning only occurred in the Union River on the eastern side of Hood Canal (WDFW and PNPTT 2000). Spawning currently also occurs in Big Beef Creek and the Tahuya River as a result of conservation hatchery programs using Quilcene and Union River summer-run chum salmon stocks, respectively.

Abundance was high in the late 1970s and low from 1985 to 1999, but has increased substantially in recent years (Table 3.2-12). Conservation hatchery programs in the Big Quilcene, Hamma Hamma, Union, and Tahuya Rivers, and Lilliwaup, Salmon, Jimmycomelately, Big Beef, and Chimacum Creeks have helped listed summer-run chum salmon that were at moderate or high risk of extinction by rebuilding spawner abundance and reintroducing summer-run chum salmon to areas where they were extirpated (HCCC 2005; WDFW and PNPTT 2007). These conservation hatchery programs are consistent with the recovery plan (72 Fed. Reg. 29121, May 24, 2007).



Source: NOAA.

Figure 3.2-5. Geographic area of the Hood Canal Summer-run Chum Salmon ESU.

Table 3.2-12. Annual spawning escapement for summer-run chum salmon populations that compose the Hood Canal Summer-run Chum Salmon ESU, 1999 to 2012.

Return Year	Population		
	Hood Canal	**Strait of Juan de Fuca**	**Total**
1999	4,114	573	**4,687**
2000	8,649	983	**9,632**
2001	12,044	3,955	**15,999**
2002	11,454	6,955	**18,409**
2003	35,696	6,959	**42,655**
2004	69,995	9,341	**79,336**
2005	15,757	9,682	**25,439**
2006	26,404	8,146	**34,650**
2007	10,591	3,295	**13,886**
2008	15,403	3,525	**18,928**
2009	7,423	5,115	**12,538**
2010	12,742	9,261	**22,003**
2011	6,972	5,675	**12,647**
2012	30,123	6,304	**36,427**

Source: WDFW (2014a).

3.2.6.3 Hatchery Programs within the Summer-run Chum Salmon ESU

All hatchery programs in the project area for summer-run chum salmon produce fish that are part of the listed Hood Canal Summer-run Chum Salmon ESU. An ESA biological opinion (NMFS 2002a) and effects review provide authorization for summer-run chum salmon hatchery programs. Past conservation hatchery programs operated in the Big Quilcene, Union, and Tahuya Rivers, and Lilliwaup, Salmon, Jimmycomelately, Big Beef, and Chimacum Creeks. Of these, two conservation programs continue to operate (Table 3.2-11) and release fish in the Hamma Hamma River, Tahuya River, and Lilliwaup Creek. As a result of the authorization under the biological opinion, summer-run chum salmon conservation hatchery programs are not included in the RMP for this Proposed Action that describes hatchery programs for salmon and steelhead (PSTT and WDFW 2004), and thus are not evaluated in this EIS.

The average total number of hatchery-origin fish of all species released into the area of the Hood Canal Summer-run Chum Salmon ESU is 34,564,423 fish, including 25,536,000 fall-run chum salmon, coho salmon, and pink salmon fry; 6,819,000 Chinook salmon and coho salmon subyearlings; 2,208,540 Chinook salmon, coho salmon, and steelhead yearlings; and 883 steelhead adults (Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population). These releases are from

19 hatchery programs, including 6 fall-run chum salmon programs, 4 fall-run Chinook salmon programs, 2 steelhead programs, 1 pink salmon program, and 6 coho salmon programs (Subsection 1.5.1, Hatchery Facilities in Puget Sound; Appendix A, Puget Sound Hatchery Programs and Facilities). Hatchery-origin salmon and steelhead are described in Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead.

3.2.6.4 Hatchery Program Risks

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, and summarizes the risks of hatchery programs to natural-origin summer-run chum salmon. Competition and predation risks are addressed because hatchery programs located within the geographic area bounded by the Hood Canal Summer-run Chum Salmon ESU pose competition and predation risks to listed summer-run chum salmon juveniles and adults (NMFS 2002a). The effects of hatchery programs outside the Hood Canal Summer-run Chum Salmon ESU on natural-origin summer-run chum are unsubstantial because the co-occurrence of fish from those hatchery programs with the natural-origin summer-run chum is minimal. Therefore, those programs are not evaluated further in the EIS. In addition, because summer-run chum salmon hatchery programs are not evaluated in this EIS, genetic and hatchery facility and operations risks, and total return, viability, and marine-derived nutrient benefits from those hatchery programs are not evaluated. For more information on risks and benefits from summer-run chum salmon hatchery programs, refer to NMFS (2002a).

3.2.6.4.1 Risks - Competition

The general effects of competition on natural-origin fish from hatchery-origin fish are summarized in Appendix B, Hatchery Effects and Evaluation Methods for Fish, including juvenile and adult fish in freshwater and marine areas. Johnson et al. (1997) and WDF et al. (1993) found that natural-origin summer-run chum salmon are likely to be at risk from competition with hatchery-origin fall-run chum salmon, pink salmon, coho salmon, and Chinook salmon in streams where they co-occur. These competition risks may be reduced to the extent release times for the hatchery-origin salmon differ from when the natural-origin summer-run chum salmon fry are present. For example, natural-origin summer-run chum salmon fry typically out-migrate from February through April, peaking in March, whereas hatchery-origin salmon are predominantly released after March (Figure 3.2-4).

Some empirical information is available on competition effects on summer-run chum salmon in freshwater or marine areas. For example, Cook-Tabor (1994) and Gallagher (1979) suggested that indirect or direct competition effects from hatchery-origin fall-run chum salmon on natural-origin summer-run chum salmon may occur when higher densities of small-sized hatchery-origin juveniles use the available zooplankton food supply, thus limiting food availability for juvenile natural-origin summer-run chum salmon. Tynan (1997) hypothesized that hatchery-origin salmon may affect natural-origin summer-run chum salmon in several ways, including competition for use of many of the same ecological resources. However, in an evaluation of competition, Ames (1983) found no negative effects based upon correlations using data sets for Hood Canal spanning the 1970s and 1980s. In addition, analysis of hatchery-origin chum salmon production and the carrying capacity of Hood Canal marine waters did not suggest that hatchery-origin juveniles negatively affected natural-origin chum salmon fry in Hood Canal (Fuss and Fuller 1994).

Historically, competition for limited food resources between natural-origin summer-run chum salmon and hatchery-origin fall-run chum salmon may have been minimized because the natural-origin summer-run chum salmon would have emerged and entered marine waters before the hatchery-origin fall-run chum salmon juveniles were present (Koski 1975). Hatchery-origin fall-run chum salmon are released after April 1, and predominantly beginning in May, after natural-origin summer-run chum salmon have out-migrated from the area. Therefore, the risk to juvenile natural-origin summer-run chum salmon from competition with hatchery-origin fish for ecological resources, such as limited food resources in freshwater and marine areas at the ESU scale, is low because of the minimal overlap in timing of hatchery-origin fish releases with natural-origin summer-run chum salmon out-migration (Figure 3.2-4) (average score is 1.0) (Table 3.2-13).

Table 3.2-13. Summary of risks for the Hood Canal Summer-run Chum Salmon ESU.

	Risk		
	Competition (Juveniles)	**Competition (Adults)**	**Predation**
Average Overall Score (Rating)	1.0 Low	0.3 Negligible	0.7 Low

Redd superimposition is a form of adult competition that occurs when fish spawn in gravels that already contain incubating eggs from previous spawners (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Hatchery-origin adults that spawn in places where natural-origin summer-run chum salmon redds already occur can injure or kill incubating summer-run chum salmon eggs. Natural-origin summer-run chum salmon would be at risk from redd superimposition from hatchery-origin fall-run Chinook salmon because that species spawns in similar areas low in streams after summer-run chum salmon have already deposited eggs.

Flows in streams used by natural-origin summer-run chum salmon are typically lowest when the fish spawn (WDFW and PNPTT 2000). Low flows tend to constrain spawning of all species, especially in smaller creeks. In such instances, spawning of hatchery-origin Chinook salmon and coho salmon in areas where natural-origin summer-run chum salmon redds are present may negatively affect summer-run chum salmon eggs and fry. Eggs from natural-origin summer-run chum salmon spawners in streams with large flows (e.g., the Skokomish, Hamma Hamma, and Dungeness Rivers) are at less risk from superimposition impacts from hatchery-origin Chinook salmon spawners. This is because spawners are able to disperse over broader areas, reducing the likelihood that returning hatchery-origin fish will spawn in the same places as natural-origin summer-run chum salmon. However, overall adult competition risks are considered negligible (average score is 0.3) (Table 3.2-13) because hatchery-origin Chinook salmon return to hatchery facilities rather than natural summer-run chum salmon spawning areas, and because hatchery-origin fish returning to streams with the large flows disperse into streams within a broad area in the vicinity of the Hood Canal Summer-run Chum Salmon ESU (Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population).

Combining low competition risks to juvenile summer-run chum salmon (average score is 1.0) with negligible competition risks to adult summer-run chum salmon (average score is 0.3) results in an overall competition risk of low (average score is 0.7) for the ESU.

3.2.6.4.2 Risks - Predation

The general effects of predation on natural-origin fish from hatchery-origin fish are summarized in Appendix B, Hatchery Effects and Evaluation Methods for Fish, including juvenile and adult fish in freshwater and marine areas. In general, SIWG (1984) found that the smaller natural-origin chum salmon are vulnerable to predation from the larger Chinook salmon, coho salmon, and steelhead. The life stages of hatchery-origin species that may prey on natural-origin summer-run chum salmon are Chinook salmon subyearlings and yearlings, coho salmon yearlings, and steelhead yearlings to the extent that the spatial and temporal distributions of the fish overlap.

Natural-origin summer-run chum salmon out-migrate as fry primarily in March at an average length of 1.5 inches (38 mm) fork length (Table 3.2-4). Hatchery-origin Chinook salmon subyearlings are released at an average length of 3.1 inches (80 mm) fork length in May through June, hatchery-origin Chinook salmon yearlings are released at an average length of 6.1 inches (155 mm) fork length in April, coho salmon yearlings are released at an average length of 5.5 inches (140 mm) fork length from April through June, and steelhead yearlings are released at an average length of 8.1 inches (206 mm) fork length in May (Table 3.2-4). The larger size of these hatchery-origin fish compared to natural-origin summer-run chum salmon fry suggests predation can occur. However, the hatchery-origin fish are released after the natural-origin summer-run chum salmon have exited fresh water; thus, the predation effect is low. In addition, chum salmon tend to spawn in lower reaches of rivers and streams, and the resulting fry promptly out-migrate relatively short distances to reach marine water, compared to other species like Chinook salmon and coho salmon that rear in fresh water for longer periods of time. In addition, summer-run chum salmon enter adjacent marine waters at a small size where they are vulnerable to predators (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Thus, although predation risk occurs in fresh water, it may occur to an even larger extent in marine water than in fresh water because natural-origin summer-run chum salmon are exposed to hatchery-origin fish that congregate in adjacent marine areas prior to continuing their migration to the ocean.

In summary, predation risks from hatchery-origin fish occur primarily when release timing and location overlap that of natural-origin summer-run chum salmon, and when hatchery-origin fish are at least 50 percent larger in size than the natural-origin summer-run chum salmon. The overall risk of predation to natural-origin summer-run chum salmon at the ESU scale is low (average score is 0.7) (Table 3.2-13), commensurate with the extent of overlap in space and time between natural-origin summer-run chum salmon juveniles and hatchery-origin salmon.

3.2.7 Puget Sound Steelhead DPS

Abundance of natural-origin steelhead has declined in the project area over the last several decades (Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead). As a result, the Puget Sound Steelhead DPS has been listed as a threatened species under the ESA (72 Fed. Reg. 26722, May 11, 2007). Limiting factors for steelhead have not been formally identified (NMFS 2011c); however, the principal factors for decline of Puget Sound steelhead have been described as the present or threatened destruction, modification, or curtailment of its habitat or range including barriers to fish passage and adverse effects on water quality and quantity resulting from dams, the loss of wetland and riparian habitats, and agricultural and urban development activities (72 Fed. Reg. 26722, May 11, 2007). The DPS includes all natural-origin winter-run and summer-run steelhead populations in Puget Sound streams in the United States, westward to and including the Elwha River. Although discrete steelhead populations and their statuses have been difficult to determine, NMFS is currently preparing a recovery plan for the Puget Sound Steelhead DPS, as well as identifying limiting factors specific to steelhead. Once completed, the plan would be implemented to address the limiting factors associated with steelhead.

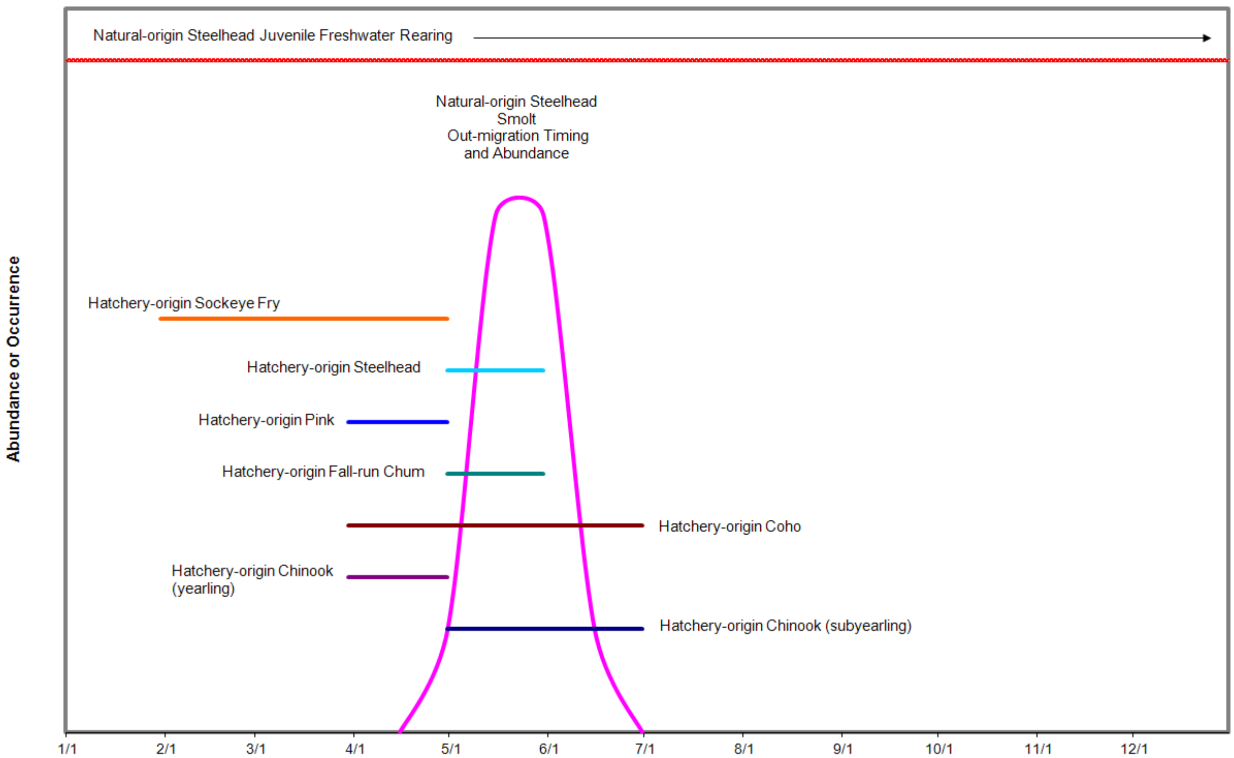
In addition to natural-origin steelhead, the DPS also includes hatchery-origin fish in two integrated conservation hatchery programs (Green River wild stock winter steelhead program and White River winter steelhead supplementation program), because they are no more than moderately diverged from their natural-origin source populations (NMFS 2004c) and are intended to aid in ESU recovery. Fish from two additional integrated conservation hatchery programs (Hood Canal steelhead supplementation program and Lower Elwha program) were proposed for inclusion in the DPS, also because they are no more than moderately diverged from their natural-origin source populations (Ford 2011) (78 Fed. Reg. 38270, June 26, 2013).

3.2.7.1 Life History of Natural-origin Steelhead

This subsection describes the general life history of steelhead, including incubation and fry emergence in fresh water, out-migration to estuarine areas, and subsequent return of adults to fresh water for spawning. The diversity (genetic and behavioral) represented by variation in steelhead life histories helps the DPS to be able to adapt to short-term and long-term changes in its environment over time (McElhany et al. 2000).

Natural-origin steelhead exhibit an especially diverse freshwater and marine life history. Myers et al. (2014) and Hard et al. (2014) describe the life history of the Puget Sound Steelhead DPS in detail, and information presented in those documents is summarized below. Steelhead exhibit distinct summer-run and winter-run adult return timings, can return to spawn more than once, and have highly variable freshwater rearing strategies prior to out-migrating as smolts. Most Puget Sound steelhead exhibit winter-run return timing. Adult winter-run steelhead typically return to fresh water from November through early June, with peak spawning occurring from mid-April through mid-May. Summer-run steelhead return to fresh water from April through October, and remain for several months in rivers to mature prior to spawning.

Natural-origin steelhead smolts in Puget Sound out-migrate in the spring, generally from late April through June (Figure 3.2-6) at an average size of 6.5 inches (165 mm) fork length (Table 3.2-4). These fish out-migrate after rearing for 1 to 3 winters in fresh water, and predominantly as 2-year-olds. However, some steelhead may spend up to 7 years in fresh water prior to out-migrating. Natural-origin steelhead smolts are generally equal to or larger in size than all species and life stages of fish released from Puget Sound hatcheries (Table 3.2-4). Because of their relatively large size, natural-origin steelhead smolts are not likely subject to predation by hatchery-origin fish in freshwater areas within Puget Sound.



Sources: Natural-origin steelhead data from WDFW juvenile out-migrant trapping reports (Volkhardt et al. 2006a, 2006b; Kinsel et al. 2007). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-6. Typical duration of natural-origin steelhead juvenile rearing, out-migration timing, relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

In spring through early summer, steelhead smolts enter marine areas and then move directly offshore (Hartt and Dell 1986; Light et al. 1989). Steelhead may spend up to 5 years rearing in marine waters before returning to spawn. However, most steelhead return as adults after spending 2 years in the ocean, although a substantial portion return as adults after rearing 3 years in the ocean.

Rather than migrating seaward as smolts, some progeny of naturally spawning steelhead may reside for an extended period in fresh water or for their entire life. Steelhead and resident rainbow trout represent the anadromous and resident life history forms of the same biological species (*O. mykiss*) (Subsection 3.2.13.1, Life History of Rainbow Trout). Steelhead can produce resident rainbow trout offspring, and resident rainbow trout can produce steelhead offspring (Narum et al. 2008; Scott and Gill 2008). Natural-origin steelhead and resident rainbow trout within a drainage can interbreed and tend to be closely related (Marshall et al. 2006), unless they are separated by barriers to migration. Resident life history may be advantageous when ocean conditions are unfavorable for steelhead, which may help maintain the genetic heritage and viability of populations (Hard et al. 2007), and contribute to the persistence and recovery of the Puget Sound Steelhead DPS (Hard et al. 2014).

3.2.7.2 Distribution and Abundance of Natural-origin Steelhead

The distribution of steelhead enables the DPS to adapt to short-term and long-term changes in its environment over time (McElhany et al. 2000). Natural-origin steelhead were historically found in almost every accessible tributary to Puget Sound (Myers et al. 2014). Because of reduced numbers and enumeration difficulties, data are scarce on the current distribution and status of natural-origin steelhead in the Puget Sound Steelhead DPS. Assessments of steelhead spawner abundance are difficult because of high spring flows and associated turbidity that hamper detection of redds. The lack of information complicates identification of discrete steelhead populations and their viability (Hard et al. 2014; Myers et al. 2014).

Natural-origin steelhead currently spawn throughout the Puget Sound Steelhead DPS (Figure 3.2-7). In 2002, WDFW delineated 53 Puget Sound steelhead stocks, of which 37 are winter-run stocks and 16 are summer-run stocks (WDFW 2002). Scott and Gill (2008) grouped Puget Sound steelhead into 10 river basins: Nooksack, Skagit, Stillaguamish, Snohomish, Lake Washington, Duwamish/Green, Puyallup, South Sound, Hood Canal, and Strait of Juan de Fuca (Table 3.2-14). Recently, the Puget Sound Steelhead Technical Recovery Team identified 32 demographically independent populations in three major population groups (Myers et al. 2014). Table 3.2-14 shows the relationships between the 53 steelhead stocks delineated by WDFW, the 10 river basins, and the 32 populations identified by the Puget Sound Steelhead Technical Recovery Team.

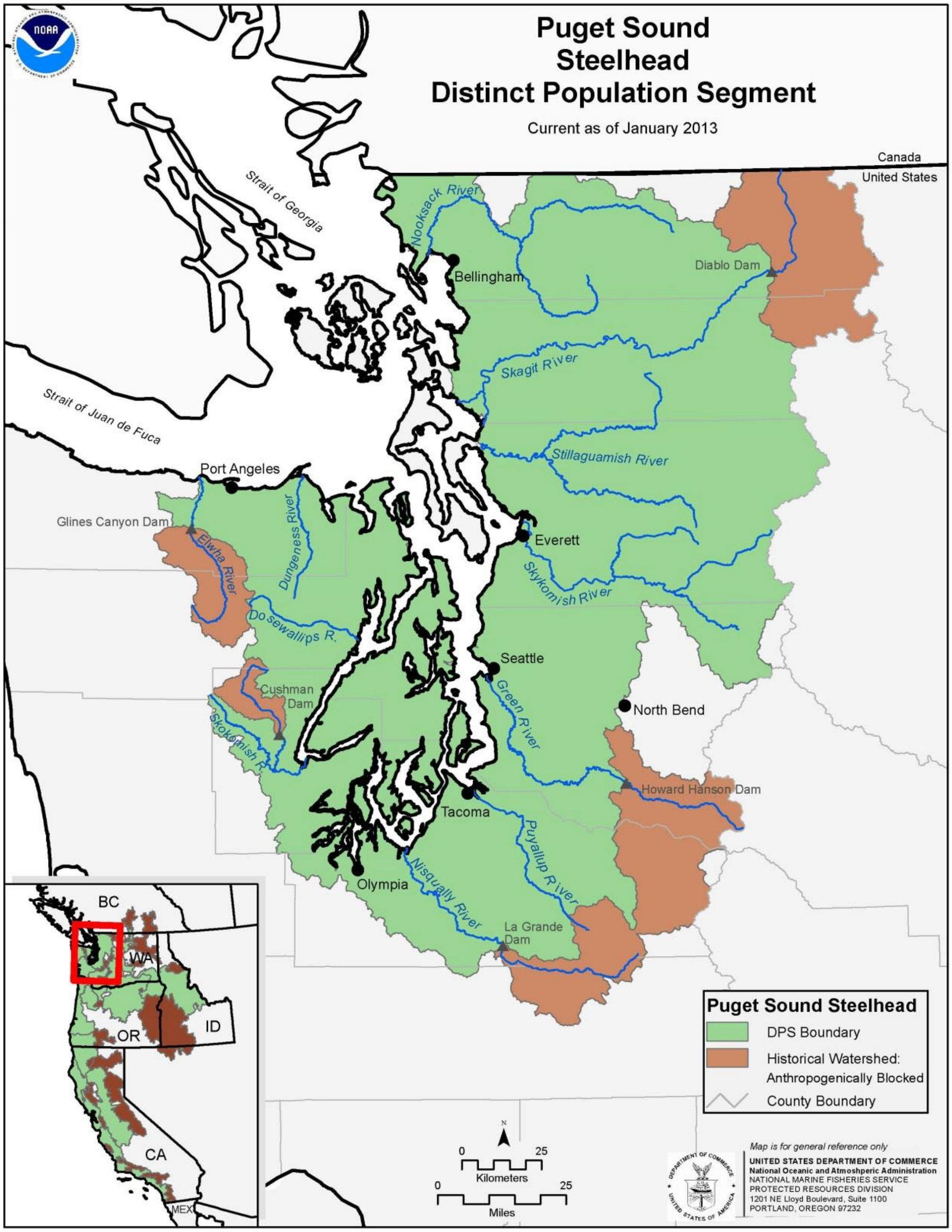


Figure 3.2-7. Geographic area of the Puget Sound Steelhead DPS.

Table 3.2-14. River basins, watersheds, steelhead stocks, and populations evaluated for the Puget Sound Steelhead DPS.

River Basin	Watershed	WDFW Stock[1]		TRT Population[2]		
		Winter-run	**Summer-run**	**Major Population Group**	**Winter-run**	**Summer-run**
Nooksack	Nooksack Samish	Dakota Creek Mainstem/North Fork Nooksack Middle Fork Nooksack South Fork Nooksack Samish	South Fork Nooksack	Northern Cascades	Drayton Harbor Tributaries Nooksack Samish and Bellingham Bay	South Fork Nooksack
Skagit	Skagit Cascade	Skagit/ Tributaries Sauk Cascade	Finney Creek Sauk Cascade		Baker (includes summer-run) Skagit (includes summer-run) Sauk (includes summer-run) Nookachamps Creek	
Stillaguamish	Stillaguamish	Stillaguamish	Deer Creek Canyon Creek		Stillaguamish	Deer Creek Canyon Creek
Snohomish	Snohomish Skykomish	Snohomish/ Skykomish Pilchuck Snoqualmie	North Fork Skykomish Tolt		Snohomish/ Skykomish Pilchuck Snoqualmie	North Fork Skykomish Tolt
Lake Washington	Lake Washington Sammamish River	Lake Washington		Central and South Sound	North Lake Washington and Lake Sammamish Cedar	
Green	Green Duwamish	Green			Green (includes summer-run[3])	
Puyallup	Puyallup Carbon White Mowich	Mainstem Puyallup White Carbon			Puyallup/Carbon White	
South Sound	Nisqually	Nisqually Eld Inlet Totten Inlet Hammersley Inlet Case/Carr Inlet East Kitsap			Nisqually South Sound Tributaries East Kitsap	

Table 3.2-14. River basins, watersheds, steelhead stocks, and populations evaluated for the Puget Sound Steelhead DPS, continued.

		WDFW Stock[1]		TRT Population[2]		
River Basin	**Watershed**	**Winter-run**	**Summer-run**	**Major Population Group**	**Winter-run**	**Summer-run**
Hood Canal	Skokomish Big Quilcene Duckabush Dewatto	Dewatto Tahuya Union Skokomish Hamma Hamma Quilcene/Dabob Bays	Skokomish Dosewallips	Hood Canal and Strait of Juan de Fuca	East Hood Canal South Hood Canal Skokomish (includes summer-run) West Hood Canal	
Strait of Juan de Fuca	Elwha Dungeness Snow Creek	Discovery Bay Sequim Bay Dungeness Morse Creek / MacDonald Elwha	Dungeness Elwha		Sequim/ Discovery Bay Tributaries Dungeness (includes summer-run) Strait of Juan de Fuca Tributaries Elwha (includes summer-run[4])	

[1] Source: WDF et al. (1993).
[2] Source: Myers et al. (2014).
[3] Existing Green summer-run population is considered non-native (historical population possibly extirpated) (Hard et al. (2014). At least two native Puget Sound steelhead stocks are extirpated: 1) the Baker River summer-run stock, because of construction of dams that blocked access to spawning areas in the upper river, and 2) the Chambers Creek winter-run stock, because of broodstock collection and selective breeding at the South Tacoma Hatchery (Myers et al. 2014). Hatchery-origin steelhead have likely resulted in the establishment of naturally producing out-of-DPS summer-run (Skamania stock) steelhead in the South Fork Stillaguamish, South Fork Skykomish, and Green Rivers, and a winter-run stock in the Deschutes River (Chambers Creek stock) (Myers et al. 2014).

The abundance of natural-origin steelhead over much of the Puget Sound Steelhead DPS has declined over the last several decades (Ford 2011). The historical returns of Puget Sound steelhead (409,200 to 682,000 fish) were likely at least an order of magnitude larger than they are currently (Myers et al. 2014; see also Gayeski et al. 2011). Over this time, returns declined principally because of habitat degradation, although other factors (e.g., harvest) likely also contributed (72 Fed. Reg. 26722, May 11, 2007). In recent years, natural-origin winter-run steelhead are most abundant in the Skagit, Snohomish, and Green River basins (Table 3.2-15). Spawner abundance in river basins in southern Puget Sound and the Olympic Peninsula is lower than in other river basins.

[4] Native Elwha summer-run steelhead may no longer be present (Hard et al. 2014).

Table 3.2-15. Mean numbers of winter-run steelhead spawning naturally by river basin and population, 2005-2009.

River Basin	Population[1]	Average Number of Spawners[2]
Nooksack	Samish	534
Skagit	Skagit	4,648
Stillaguamish	Stillaguamish	327
Snohomish	Snohomish	4,573
Lake Washington	Lake Washington	12
Green	Green	986
Puyallup	Puyallup White	326 265
South Sound	Nisqually South Sound tributaries	402 NC[3]
Hood Canal	East Hood Canal Skokomish West Hood Canal	213 355 208
Strait of Juan de Fuca	Strait of Juan de Fuca tributaries Elwha	147 NC

Sources: Ford (2011); Myers et al. (2014).
[1] Populations identified by Myers et al. (2014). These may not be exactly the same as those for which data are available from Ford (2011).
[2] Geometric mean (Ford 2011).
[3] Not calculated.

Certain hatchery programs may benefit the viability (including abundance) of the Puget Sound Steelhead DPS (Subsection 3.2.7.4.6, Benefits - Viability). Abundance is benefited when the number of naturally spawning listed hatchery-origin fish increases the number of natural-origin spawners. This type of benefit to the Puget Sound Steelhead DPS may accrue from the four integrated steelhead conservation hatchery programs (Green River wild stock winter steelhead program, White River winter steelhead supplementation program, Hood Canal steelhead supplementation program, and Lower Elwha program). More information on the topic of integrated conservation hatchery programs is in Subsection 2.2.2.1, Artificial Production Strategies, Subsection 3.2.7.4.6, Benefits - Viability, and Appendix B, Hatchery Effects and Evaluation Methods for Fish.

As described above, designation of steelhead populations by the Puget Sound Steelhead Technical Recovery Team has recently been proposed (Myers et al. 2014) (Table 3.2-14), and has not yet been finalized by NMFS. Thus, for the purposes of this EIS, the steelhead information and analyses are organized by river basin as shown in Table 3.2-14 and Table 3.2-15. River basins are described in more detail in Appendix H, Steelhead Effects Analysis by Basin.

3.2.7.3 Description of Hatchery-origin Steelhead

Myers et al. (2014) describe the life history of hatchery-origin steelhead in Puget Sound, and information from that document and other sources of information is summarized below. Hatchery-origin steelhead are released as yearling smolts predominantly in May and co-occur with natural-origin steelhead smolts (Figure 3.2-6), natural-origin Chinook salmon parr and yearlings, steelhead parr, coho salmon yearlings, chum salmon fry, and sockeye salmon fry (Table 3.2-4). Steelhead are not reared for release from hatcheries as fry or subyearlings. Steelhead yearlings are generally released at an average length of 8.1 inches (206 mm) fork length (Table 3.2-4). Hatchery-origin steelhead are often released high in watersheds compared to releases of hatchery-origin salmon. Hatchery-origin steelhead yearlings out-migrate to Puget Sound rapidly, spending little time in fresh water (a few days to several weeks).

After release, some hatchery-origin fish remain in fresh water rather than out-migrating to marine waters. These fish are called residuals[5]. No information exists on the extent and effects of residualism specifically for Puget Sound steelhead. However, information that is available on the incidence of residualism from studies in the Columbia River is likely applicable to Puget Sound because hatchery practices, fish sizes at release, and the natural environments are similar between the two areas. Those studies indicate that on average, between 5 and 10 percent of the hatchery-origin steelhead yearlings released (USFWS 1994) may residualize in fresh water (Viola and Schuck 1991; Whitesel et al. 1993). The incidence of residualism is greater for releases of smaller hatchery-origin steelhead. For example, Jonasson et al.(2006) found that hatchery-origin steelhead that were less than 7.1 inches (180 mm) fork length at release were more likely to residualize, and that the optimum size at release to minimize residualism was when fish were larger than 8.7 inches (221 mm) fork length. Where it occurs, residualism may contribute to predation by hatchery-origin steelhead on other natural-origin salmon and steelhead. Thus, to reduce the potential incidence of residualism, steelhead hatchery programs in Puget Sound attempt to release smolts that are from 7.1 to 9.1 inches (180 mm to 230 mm) fork length (Table 3.2-4) and when the fish show signs (e.g., physiological condition, increased activity, silvery coloration) that they are preparing for entry into marine water. Therefore, the potential negative effect of predation by residual hatchery-origin

[5] Residualism pertains to hatchery-origin fish that out-migrate slowly, if at all, after they are released. These fish are called residuals that residualize rather than out-migrating as most of their counterparts do.

steelhead on natural-origin steelhead and other species is assumed to be minimal and is not evaluated further in this EIS.

The size of hatchery-origin steelhead yearlings (8.1 inches [206 mm] fork length) is among the largest of hatchery-origin juveniles that are released into Puget Sound (Table 3.2-4). The large size of hatchery-origin steelhead yearlings results in the potential for the fish to prey on smaller, natural-origin salmon and steelhead. In addition, where hatchery programs release hatchery-origin steelhead yearlings high in watersheds, natural-origin salmon and steelhead are vulnerable to predation from hatchery-origin steelhead over greater stream areas compared to releases of hatchery-origin steelhead lower in watersheds.

Information on adult returns of hatchery-origin steelhead is not available for all hatchery programs, although some data is available for specific areas and specific hatchery programs as provided in Appendix H, Steelhead Effects Analysis by Basin.

Hatchery-origin steelhead yearling production for all Puget Sound steelhead programs currently averages about 2.5 million fish (Table 3.2-6). Steelhead hatchery production in Puget Sound has varied slightly over the last 20 years (Ford 2011). Hatchery-origin steelhead are released in all 10 river basins in Puget Sound described by Scott and Gill (2008), and in two-thirds of the areas occupied by the 32 populations identified by the Puget Sound Steelhead Technical Recovery Team (Hard et al. 2014). The average number released into river basins ranges from a low of 10,000 to a high of 334,000 yearlings per basin (Appendix A, Puget Sound Hatchery Programs and Facilities). There are 23 hatchery programs that release hatchery-origin steelhead (19 winter-run steelhead programs and 4 summer-run steelhead programs, of which 19 programs are isolated hatchery programs and 4 programs are integrated hatchery programs) (Table 3.2-5).

3.2.7.4 Hatchery Program Risks and Benefits

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, by providing a summary of the risks and benefits of hatchery programs to natural-origin steelhead. This subsection also summarizes evaluations of existing programs and supports the analysis of effects to individual natural-origin steelhead in the river basins forming the Puget Sound Steelhead DPS (Appendix H, Steelhead Effects Analysis by Basin).

3.2.7.4.1 Risks - Competition

The general effects of competition between hatchery-origin fish and natural-origin fish are summarized in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and competition is described as greatest when use of limited resources overlaps in time and space. Effects of hatchery-origin salmon and steelhead on natural-origin steelhead from competition are influenced by the timing of hatchery-origin fish releases, their locations of release, and their sizes at release. As shown in Figure 3.2-6 and Table 3.2-4, natural-origin steelhead juveniles are present in fresh water throughout the year. Natural-origin steelhead fry predominantly occur from June through October, parr from October through mid-May, and smolts from late April through June.

No hatchery-origin salmon fry are released during the time natural-origin steelhead fry occur (June through October). Thus, competition from other hatchery-origin fish would not affect natural-origin steelhead fry. Natural-origin steelhead parr occur from October through mid-May (Table 3.2-4), and may be affected by competition from hatchery-origin Chinook salmon subyearlings, because the two species may be present in freshwater streams during the same time period (May). However, this is at the end of out-migration timing, and potential competition with hatchery-origin Chinook salmon subyearlings is expected to be limited, especially because the steelhead parr are somewhat larger than the hatchery-origin Chinook salmon subyearlings. As a result, effects of competition from hatchery-origin fish on natural-origin steelhead younger than smolts are negligible. Thus, competition effects are considered only for natural-origin steelhead smolts as described below.

Most hatcheries only release steelhead at the yearling stage. Thus, competition between hatchery-origin steelhead and natural-origin steelhead is likely to occur between hatchery-origin steelhead yearlings and natural-origin steelhead smolts because hatchery-origin fish are 1) of similar size, 2) released in locations where natural-origin fish occur, 3) released during the peak out-migration period for natural-origin fish, and 4) released in large numbers (greater than 50,000 fish released). Among the 23 hatchery programs that release steelhead yearlings, the risk to natural-origin steelhead from these programs is moderate (average risk score is 1.6) (Table 3.2-16) because of the similarities of times and areas of occurrence, magnitudes of releases, and numbers of fish released (Appendix H, Steelhead Effects Analysis by Basin).

Table 3.2-16. Summary of risks and benefits for the Puget Sound Steelhead DPS from existing hatchery production.

	Risk					Benefit		
	Competition (from Steelhead Hatcheries)	**Competition (from Chinook Salmon Hatcheries)**	**Competition (from Coho Salmon Hatcheries)**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**	**Marine-derived Nutrients**
Average Overall Score (Rating)[1]	1.6 Moderate	1.6 Moderate	2.3 Moderate	1.2 Low	1.2 Low	1.2 Low	0.8 Low	Negligible

[1] Scores and ratings are averages from the 10 steelhead river basins in Appendix H, Steelhead Effects Analysis by Basin. One benefit (marine-derived nutrients) is evaluated at the DPS level only.

Other potential competitors with natural-origin steelhead smolts are hatchery-origin coho salmon yearlings, which are of similar size and are released during the peak steelhead out-migration period, and hatchery-origin Chinook salmon yearlings, which are large smolts released during the beginning of the peak out-migration period of natural-origin steelhead smolts (Figure 3.2-6; Table 3.2-4). Considering release sizes, times, and locations of release (high in the watershed for some hatchery programs), and numbers of fish released, the risks from yearling coho salmon (average risk score is 2.3) are higher than for yearling Chinook salmon (average risk score is 1.6), although both are rated as moderate (Table 3.2-16).

Competition in the marine environment is not expected to occur because, once steelhead smolts enter that environment, the fish tend to move directly offshore into areas where the hatchery-origin steelhead are dispersed and not present in numbers that would contribute to density-dependent effects (Hartt and Dell 1986; Light et al. 1989).

In summary, competition risks to natural-origin steelhead would primarily occur from yearling releases of steelhead, Chinook salmon, and coho salmon. Risks to natural-origin steelhead that are unlikely, and thus not further evaluated, include competition with hatchery-origin fish younger than yearlings and competition in marine water. Considering all of the steelhead hatchery programs collectively, the overall competition risk is moderate (average scores for hatchery-origin steelhead, Chinook salmon, and coho salmon as competitors ranges from 1.6 to 2.3) (Table 3.2-16). These risks are primarily based on the extent of spatial and temporal overlap between releases of hatchery-origin fish and rearing and out-migrating natural-origin steelhead.

3.2.7.4.2 Risks - Predation

The general effects of predation by hatchery-origin fish on natural-origin fish are summarized in Appendix B, Hatchery Effects and Evaluation Methods for Fish. As mentioned above, natural-origin steelhead fry occur from June through October (Table 3.2-4), and no hatchery-origin yearlings are released during this period. Thus, predation from hatchery-origin fish is not considered a risk factor to natural-origin steelhead fry. Natural-origin steelhead parr occur from October through mid-May and are generally not susceptible to predation from hatchery-origin fish because they would be at their peak size when hatchery-origin fish are released in the spring. Similarly, the peak out-migration period for natural-origin steelhead smolts may be at a time when other hatchery-origin fish are released, but the large size of the smolts (4.3 to 8.5 inches [109 to 21 mm] fork length) (Table 3.2-4) would prevent other hatchery-origin fish from preying on steelhead smolts. The large size of natural-origin steelhead smolts and their propensity to move directly offshore once in marine waters helps juvenile steelhead avoid risks from predation. As a result, predation on natural-origin steelhead is inconsequential in fresh water or marine waters, and is not evaluated further in this EIS.

3.2.7.4.3 Risks - Genetics

Hatchery programs for steelhead in Puget Sound have benefits and risks. Genetic risks are addressed in this subsection, whereas benefits are described in Subsection 3.2.7.4.6, Benefits - Viability. All 23 steelhead hatchery programs pose various degrees of genetic risk to natural-origin steelhead that compose the DPS (Table 3.2-5). Most hatchery programs for steelhead in the analysis area (19 of 23 programs) are operated as isolated programs, and are designed to increase the abundance of fish for harvest. Isolated hatchery programs for winter-run steelhead produce Chambers Creek steelhead, a hatchery stock whose time of return and spawning has been advanced through fish culture practices (i.e., hatchery-induced selection, sometimes called domestication) so that hatchery-origin fish escape fisheries and are less likely to interbreed with natural-origin steelhead (Crawford 1979). Similarly, all summer-run steelhead hatchery programs are operated as isolated programs producing Skamania steelhead, a stock derived from a lower Columbia River tributary (Crawford 1979). Both of the isolated hatchery stocks (Chambers Creek winter-run steelhead and Skamania summer-run steelhead) are considered more than moderately diverged genetically from any natural-origin Puget Sound steelhead, and are not included as part of the listed Puget Sound Steelhead DPS (72 Fed. Reg. 26722, May 11, 2007).

The steelhead produced by the isolated programs are not intended to spawn naturally, consistent with a management intent to minimize the likelihood for substantial genetic and ecological interactions with natural-origin steelhead. However, some Skamania summer-run fish spawn naturally and may substantially overlap with natural-origin summer-run steelhead in watersheds where indigenous summer-run steelhead are present. Several authors have concluded that the Chambers Creek winter-run and Skamania summer-run steelhead hatchery programs pose substantial risks to both the among-population diversity and the fitness of natural-origin steelhead populations in Puget Sound (Scott and Gill 2008; Beamer 2013; Hard et al. 2014).

Another genetic risk factor to natural-origin steelhead associated with out-of-DPS Chambers Creek and Skamania hatchery-origin steelhead is hatchery-induced selection that results in spawning and genetic introgression by hatchery-origin fish. Traditional production of hatchery-origin steelhead smolts that both out-migrate to sea quickly and survive to adult return at sufficiently high rates necessitates that they achieve smolt size in a hatchery environment in 1 year (Crawford 1979). The selective pressures in the hatchery environment over that long of a rearing interval are different from those experienced by natural-origin fish. The traits that intentionally and inadvertently are selected for in the hatchery environment make hatchery-origin steelhead ill-suited for survival and productivity in the natural environment after release. Subsequent interbreeding of the naturally spawning hatchery-origin fish with fish from a natural population (Leider et al. 1984; Seamons et al. 2012) is likely to have deleterious genetic consequences for natural-origin populations in terms of reduction of within- and among-population diversity, and potential loss of fitness (RIST 2009).

Although hatchery-origin winter-run steelhead from isolated programs spawn earlier than natural-origin steelhead, overlap in timing between the latest spawning hatchery-origin steelhead and the earliest spawning natural-origin steelhead has been demonstrated in some Puget Sound watersheds (McMillan et al. 2010). This overlap creates the potential for interbreeding and introgression from the hatchery-origin fish with the natural-origin fish, which may affect the genetic integrity and fitness of natural-origin steelhead.

Information that quantifies the amount of straying, natural spawning, and natural reproductive success by out-of-DPS hatchery-origin winter-run and summer-run steelhead in Puget Sound is limited. Available genetic information has documented introgression from hatchery-origin to natural-origin steelhead populations (e.g., Phelps et al. 1997; Winans et al. 2008; Pflug et al. 2013). However, the extent of introgression does not appear to be as widespread or pronounced as might be expected, considering the numbers and distribution of hatchery stocking and resulting adult escapements that have occurred over time (Marshall 2008; Scott and Gill 2008). Reasons for these differences are unclear. The lack of quantitative information about numbers of hatchery-origin fish straying into and spawning in natural spawning areas precludes estimates of the proportion of hatchery-origin steelhead spawning naturally, and quantitative assessment of introgression, hatchery-induced selection, and other genetic risks from isolated steelhead hatchery programs.

Appendix H, Steelhead Effects Analysis by Basin, describes analyses and results of the genetic risks for steelhead hatchery programs in each river basin. In summary, considering the out-of-DPS isolated steelhead hatchery programs that pose genetic risks to among-population diversity and fitness of natural-origin steelhead, and based on the methods used (Appendix B, Hatchery Effects and Evaluation Methods for Fish), the overall genetic risk to the Puget Sound Steelhead DPS is low (average score is 1.2) (Table 3.2-16).

3.2.7.4.4 Risks - Hatchery Facilities and Operation

Hatchery facilities and the practices used in their operation can pose risks to natural-origin steelhead (Appendix B, Hatchery Effects and Evaluation Methods for Fish), which includes broodstock collection; operations of hatcheries and traps, weirs, and water intake screens; and extent of withdrawals and discharges of hatchery effluents.

BMPs consistent with HSRG (2004) can help to minimize hatchery facilities and operation risks and include changes in broodstock collection practices, hatchery water withdrawals, diversion screen criteria, and effluent discharges, as well as implementing practices that decrease the likelihood of fish disease and pathogen incidence and transfer. These BMPs are described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Hatchery facilities and operation risk factors (considering use and/or non-use of these recommended BMPs) were evaluated for steelhead hatchery programs using the Hatchery Program Viewer Tool described in Appendix F, Hatchery Program Viewer (HPV) Analysis. Results are provided in Appendix H, Steelhead Effects Analysis by Basin.

This risk category includes the extent to which hatchery programs comply with BMPs, including performance standards and indicators in their hatchery management plans (PSTT and WDFW 2004) to address risks to natural-origin steelhead as part of an adaptive management framework. For about half of the river basins evaluated, the steelhead hatchery programs lack performance standards and indicators in their management plans.

Appendix H, Steelhead Effects Analysis by Basin, describes risks to natural-origin steelhead from hatchery facilities and operation. In summary, steelhead hatchery programs in Puget Sound pose hatchery facilities and operation risks primarily because of the lack of performance standards and indicators in their management plans, as well as two hatcheries that have dewatering risks. The overall risk to the Puget Sound Steelhead DPS from all hatchery programs is low (average score is 1.2) (Table 3.2-16).

3.2.7.4.5 Benefits - Total Return

The total return of hatchery-origin steelhead to fisheries and escapement can provide harvest and/or conservation benefits (Appendix B, Hatchery Effects and Evaluation Methods for Fish). The total return benefit is primarily associated with benefits to harvest, and is different from the abundance component used to assess viability benefits, which addresses benefits only to listed natural-origin fish and their recovery (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Total return benefits for steelhead occur from the 19 isolated steelhead hatchery programs that are intended to produce fish for harvest, and to a lesser extent from the four integrated conservation hatchery programs intended to aid recovery of natural-origin steelhead. For the purposes of this EIS, relative total return benefits are estimated by applying average smolt-to-adult return rates to the annual number of smolts released, as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. For most of the river basins, the projected total adult return of natural-origin steelhead and hatchery-origin steelhead is less than 50 percent of the adult return goal.

Appendix H, Steelhead Effects Analysis by Basin, describes analyses and results of the total return benefit that individual steelhead salmon hatchery programs contribute to total returns of steelhead. Considering all of the steelhead hatchery programs collectively, the overall total return benefit is low, largely because smolt-to-adult survival rates for hatchery-origin steelhead are generally 1 percent or less (average score is 1.2) (Table 3.2-16).

3.2.7.4.6 Benefits - Viability

Benefits can accrue to the viability of the Puget Sound Steelhead DPS when genetic resources important to the DPS reside in fish produced by hatchery programs. Under NMFS' policy for considering hatchery-origin fish in extinction risk evaluations (70 Fed. Reg. 37204, June 28, 2005), hatchery-origin fish can benefit populations to the extent that they positively contribute to the abundance, productivity, diversity, and spatial structure of natural populations, which are the four VSP parameters identified by McElhany et al. (2000). This type of benefit to the Puget Sound Steelhead DPS may accrue from the four integrated steelhead conservation hatchery programs (Green River wild stock winter steelhead program, White River winter steelhead supplementation program, Hood Canal steelhead supplementation program, and Lower Elwha program), but not from the 19 isolated hatchery programs. The isolated hatchery programs are intended to provide harvest opportunities, not conservation benefits. The integrated steelhead conservation hatchery programs are intended to increase the number of fish naturally spawning, the variety of locations where the fish spawn, and to help maintain genetic diversity, although these programs also pose risks to the fitness of naturally spawning populations.

Abundance is benefited when the number of naturally spawning listed hatchery-origin fish increases the number of natural-origin spawners. Diversity is benefited when genetic resources important to the DPS are contained and preserved by the hatchery program, and BMPs are applied in hatchery operations (e.g., type, number, and manner of broodstock collection; mating and rearing schemes) to limit the possibility that hatchery-origin fish would diverge from the natural population. Spatial structure is benefited when the program leads to the re-colonization of habitat by natural-origin fish. Productivity is predominantly driven by habitat quality and quantity, and is not expected to benefit from integrated conservation hatchery programs except in situations where the small size of a natural-origin population itself is a predominant factor that limits population growth. The integrated steelhead conservation hatchery programs may provide viability benefits to steelhead in 4 of the 10 river basins.

Appendix H, Steelhead Effects Analysis by Basin, describes analyses and results of the viability benefit that individual steelhead salmon hatchery programs contribute to steelhead viability. Considering all of the steelhead hatchery programs collectively, the overall abundance benefit is low (average score is 0.8) (Table 3.2-16) because there are relatively few integrated hatchery programs for steelhead that may contribute to this benefit at the DPS scale.

3.2.7.4.7 Benefits - Marine-derived Nutrients

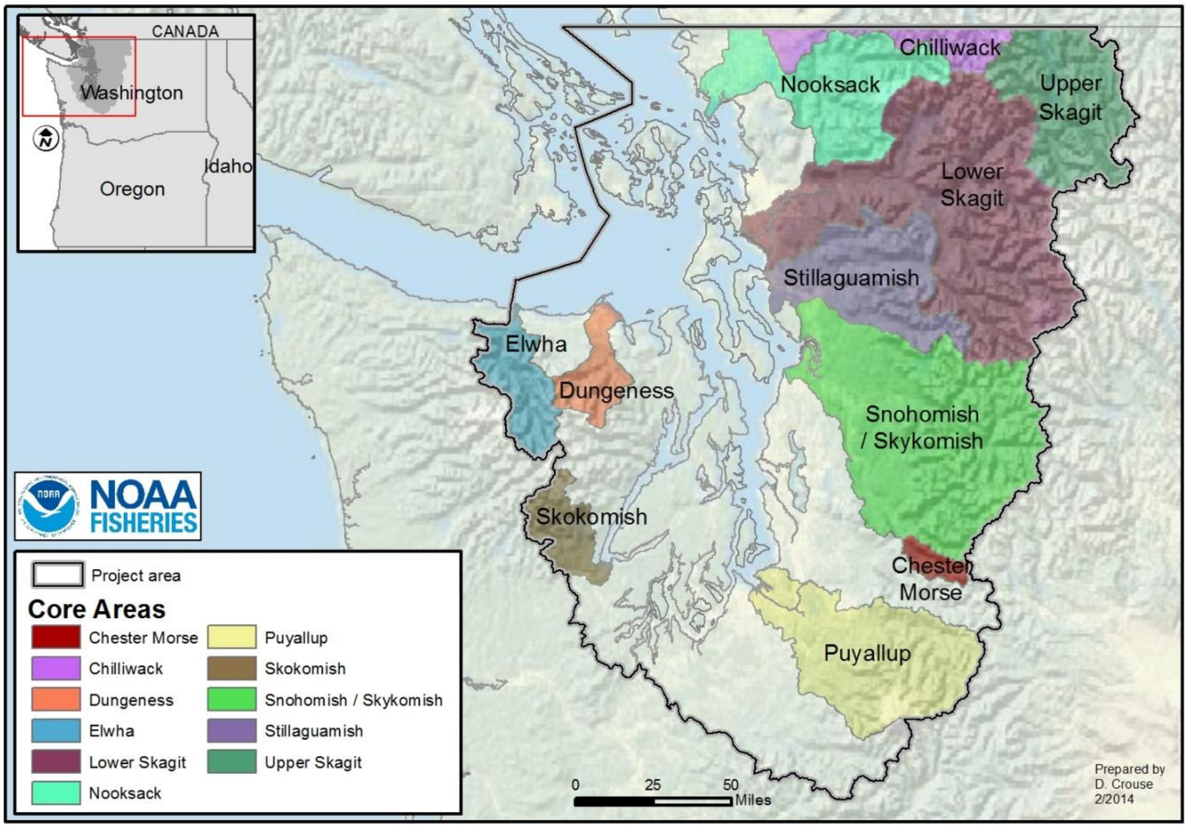
As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, natural-origin steelhead and their ecosystems can benefit from marine-derived nutrients that are delivered into fresh water by returning adult hatchery-origin and natural-origin salmon and steelhead that spawn and die. Salmon and steelhead carcasses provide a direct food source for juvenile salmon and steelhead, other fish, aquatic invertebrates, and terrestrial animals. The decomposition of these carcasses supplies nutrients that increase primary and secondary production and benefit the ecosystem. Thus, returning hatchery-origin adults help contribute to marine-derived nutrients in freshwater ecosystems, which benefits natural-origin steelhead.

Because of the complexity and limited understanding of marine-derived nutrient dynamics (Appendix B, Hatchery Effects and Evaluation Methods for Fish), along with uncertainties associated with natural-origin and hatchery-origin steelhead spawner escapements, it is not possible to determine effects at the river basin scale; however, benefits are assessed at the DPS scale. Only 1 percent of the total spawning escapement and biomass from natural-origin and hatchery-origin salmon and steelhead is composed of steelhead (Table 3-9 in Appendix B, Hatchery Effects and Evaluation Methods for Fish), and only 3 percent of the carcasses distributed from WDFW hatcheries in recent years have been steelhead (Table 3-10 in Appendix B, Hatchery Effects and Evaluation Methods for Fish). Thus, the influence of steelhead hatchery programs on marine-derived nutrient benefits to steelhead is negligible (Table 3.2-16) because of the relatively small program contribution to marine-derived nutrients in Puget Sound watersheds.

3.2.8 Washington Coastal-Puget Sound Bull Trout DPS

Because of declines in the status of bull trout, the USFWS listed the Washington Coastal-Puget Sound Bull Trout DPS as a threatened species under the ESA (64 Fed. Reg. 58910, November 1, 1999). Bull trout critical habitat was designated by the USFWS for the DPS (76 Fed. Reg.63898, October 18, 2010). Although a large portion of the DPS is within the project area (described in Subsection 1.4, Project and Analysis Areas), parts of the bull trout DPS include Washington coastal areas that are outside the project area. This subsection focuses on the DPS portion within the project area (Subsection 4.2.2, Analysis Area), which consists of watersheds entering Puget Sound and the Strait of Juan de Fuca west to the Elwha River (Figure 3.2-8). The Washington Coastal-Puget Sound Bull Trout DPS is of importance to the species as a whole because it contains the only anadromous form of bull trout in the United States outside of Alaska. Bull trout are listed as a candidate species of concern by Washington State (WDFW 2014b). Bull trout are not produced in hatcheries in the project area.

A draft recovery plan for the DPS was completed in 2004 (USFWS 2004a, 2004b). The draft bull trout recovery plan and most recent ESA status review (USFWS 2008a) identify bull trout core areas (Figure 3.2-8) as the closest approximation of biologically functioning units for the species, which may comprise one or more related populations. Summary information on the 11 bull trout core areas in the analysis area and their status is provided in USFWS (2008a). The bull trout recovery plan for the DPS (USFWS 2004a, 2004b) provides information that is summarized below regarding bull trout life history, distribution (including core area designations), abundance, and limiting factors. Bull trout limiting factors that have affected its historical and current distribution and abundance are associated with habitat, including water temperature (bull trout prefer colder streams typical of headwaters), cover (bull trout require complex cover forms, including large woody debris, undercut banks, bounders, and pools), channel form and stability, spawning and rearing substrate, migratory corridors, and human disturbance.



Source: USFWS 2004a, 2004b.

Figure 3.2-8. Coastal-Puget Sound bull trout DPS and core areas in the project area.

Of these limiting factors, migratory corridors (i.e., barriers to bull trout migration) are related to hatchery programs in the project area.

Also unique to this DPS is bull trout's overlap in distribution with Dolly Varden, another native char species that is very similar in appearance to bull trout, but distinct genetically. The Dolly Varden is a USFWS candidate species for ESA-listing.

3.2.8.1 Life History of Bull Trout

The life history of bull trout is diverse and is generally expressed in four life history forms. Some bull trout spend their entire lives in their natal stream (non-migratory or resident form), while most migrate downstream from natal streams to rear in larger rivers (riverine or fluvial form), lakes (lacustrine or adfluvial form), or marine water (anadromous form). The latter three forms would most commonly interact and occur in similar locations as salmon and steelhead during some parts of their lifespan, although the adfluvial form would also interact with sockeye salmon in lakes.

Bull trout tend to occur at higher elevations in areas having less disturbed habitats. These areas are often upstream from areas in which other salmon and steelhead predominate. The species requires colder water temperatures that are typical of headwater streams. In addition, bull trout require clean stream substrates for spawning and rearing, complex aquatic habitats, and habitats that connect to headwater streams for spawning and feeding migrations, which are necessary to complete their life history (USFWS 2004a, 2004b). Bull trout are generally of a larger size (up to 24 inches [61 cm] in total length) than other salmon, steelhead, and trout.

The most common interactions between bull trout and salmon and steelhead occur in streams. Juvenile migratory bull trout rear from 1 to 4 years in their natal stream before migrating to a river, lake/reservoir, or nearshore marine area to mature. Anadromous bull trout migrate from their natal rivers and occur throughout Puget Sound in freshwater, estuarine, and marine areas. For example, they forage and overwinter in the Lake Washington system and the Skagit River, and in nearshore marine areas throughout much of Puget Sound, including Hood Canal and the Strait of Juan de Fuca. Generally, migratory forms occupy lower freshwater and tidally influenced areas in lower elevation floodplains (USFWS 2004a, 2004b). Life history patterns are not fixed, and bull trout can switch from fluvial to anadromous behavior (Kraemer 2003; Brenkman et al. 2007).

For the anadromous form, mature bull trout return to fresh water from May through early July (Hayes et al. 2011), and may hold in upper river areas for several weeks before moving further upstream to their spawning grounds. After spawning, adults move back downstream, and eventually to marine waters to overwinter. Telemetry studies have tracked migratory bull trout moving between the major river basins in north Puget Sound (e.g., between the Skagit and Snohomish Rivers) to movements in river mouth estuaries (Hayes et al. 2011).

Juvenile anadromous bull trout migrate from fresh water to marine water at age 2, at a mean length of 7.4 inches (188 mm) fork length. Subadult anadromous bull trout also migrate downstream through lower rivers to estuaries. For example, in the Skagit River, juvenile and subadult bull trout from age 1 to age 3 migrate downstream through the lower river and into marine waters from early spring into the fall, and primarily from April to July. Peak abundance in estuarine channels of the Skagit River delta occurs in June (Goetz et al. 2004).

Resident and juvenile migratory bull trout feed on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on all life forms of various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Donald and Alger

1993; Brown 1994), including salmon and steelhead eggs and juvenile fish. Bull trout are able to eat fish that are about one-third to one-half their size. Anadromous juvenile bull trout tend to be larger than other salmon and steelhead that reside in similar areas. Thus, larger subadult and mature bull trout may prey on smaller young-of-the-year salmon and steelhead during freshwater migration. In marine areas, bull trout eat predominantly surf smelt, Pacific herring, Pacific sand lance, surf perch, stickleback, and a variety of macro-invertebrate species (Kraemer 2003; Goetz et al. 2004; USFWS 2004a, 2004b). When adult bull trout return from marine waters to headwater areas for spawning, they are also known to forage on salmon eggs and juvenile salmon (USFWS 2004a).

3.2.8.2 Distribution and Abundance of Bull Trout

The multiple life history forms of bull trout, as described above, are distributed throughout most of the major watersheds and associated tributary systems in the project area (USFWS 2004a, 2004b). As described in Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS, bull trout core areas are the closest approximation of biologically functioning units for the species. Of the 11 core areas in the analysis area, bull trout that are potentially affected by salmon and steelhead hatchery programs occur in 9 core areas, including the 3 core areas in the Olympic Peninsula (Skokomish, Dungeness, and Elwha watersheds), and 6 core areas in eastern Puget Sound (Nooksack, Lower and Upper Skagit, Stillaguamish, Snohomish/Skykomish, and Puyallup watersheds) (Figure 3.2-8). Two bull trout core areas (Chilliwack and Chester Morse) are not affected because there is no salmon and steelhead hatchery production in those areas (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

The abundance of bull trout in the nine core areas in the project area is likely relatively large in some core areas (e.g., Lower Skagit) and small in others (e.g., Skokomish) as previously documented (USFWS 2008a). Harvest records from the early 1900s suggest that bull trout were once more abundant in Puget Sound than they are currently, likely because of the past availability of suitable habitat, which has been severely reduced by timber harvest activities and urban and industrial development (USFWS 2004a, 2004b).

3.2.8.3 Relationship with Salmon and Steelhead

Risks and benefits to bull trout from hatchery programs are evaluated by considering the relationship between bull trout and salmon and steelhead (as described below), and then applying qualitative methods (Appendix B, Hatchery Effects and Evaluation Methods for Fish) to determine the extent of the risk and benefit to bull trout that occur within the project area. Risks and benefits to bull trout are evaluated for the 48 hatchery programs that operate in the 9 bull trout core areas in the project area (Subsection 3.2.8.2, Distribution and Abundance of Bull Trout), including 23 steelhead programs, 16 coho salmon programs, and 9 Chinook salmon programs.

Competition and Predation Risks. Bull trout, salmon, and steelhead can occur in similar aquatic habitat types; however, bull trout are more sensitive than salmon and steelhead to increased water temperatures, poor water quality, degraded habitat conditions, and low flow conditions in fresh water (USFWS 2004a, 2004b). Thus, as described in Subsection 3.2.8.1, Life History of Bull Trout, bull trout tend to occur at higher elevations where colder waters occur compared to lower elevations, and in areas having less disturbed habitats compared to salmon and steelhead. These differences tend to minimize temporal and spatial overlap between bull trout and salmon and steelhead, whereby juvenile and resident forms of bull trout tend to occur upstream from areas used by salmon and steelhead. However, bull trout that migrate downstream to rear in larger rivers (fluvial form), lakes (adfluvial form), or marine areas (anadromous form) would occur in similar locations as salmon and steelhead during some parts of their lifespan. Thus, fluvial, adfluvial, and anadromous bull trout that inhabit or seasonally migrate through the lower reaches of large rivers, estuaries, and nearshore marine waters of Puget Sound may interact with hatchery-origin salmon and steelhead that are also present in those areas. This is especially likely in estuarine and marine areas of Puget Sound where juvenile hatchery-origin salmon and steelhead are concentrated as they migrate from fresh water to the ocean. Bull trout isolated in the upper portions of watersheds and/or above impassable dams (typically the resident form) are not likely to be affected by salmon and steelhead hatchery programs, because hatchery releases occur below barriers.

Although juvenile bull trout feed on similar prey as salmon and steelhead, competition for food with salmon and steelhead during the bull trout's juvenile life stage is unlikely because bull trout occur in different habitats (colder headwater streams) than salmon and steelhead during their juvenile stage. When bull trout mature and commence migratory movements into streams, these migratory bull trout are larger than salmon and steelhead juveniles and the diet of bull trout changes to a piscivorous diet consisting of fish and fish eggs. Thus, bull trout are not considered competitors of salmon and steelhead, and salmon and steelhead do not prey on bull trout. As a result, competition and predation risks to bull trout from hatchery-origin salmon and steelhead are not considered further in this EIS. However, bull trout can prey on salmon and steelhead during their migration to larger rivers, lakes, and estuaries, which is considered a benefit to bull trout and is discussed under viability below.

Genetic Risks. Hatcheries in the project area do not produce bull trout; thus, there are no genetic risks to bull trout and this risk is not considered further in this EIS.

Hatchery Facilities and Operation Risks. Hatchery facilities and operation can impact bull trout through use of hatchery weirs and barriers to block migration of adult hatchery-origin fish attempting to spawn upstream of hatchery facilities. These barriers could also preclude migratory bull trout distribution. Thus, salmon and steelhead hatchery facilities and operation risks to bull trout occur at those hatcheries that have structures or barriers affecting upstream and/or downstream migration of bull trout. From a review of the hatchery programs in bull trout core areas (Appendix B, Hatchery Effects and Evaluation Methods for Fish), there are 13 potential migration barriers associated with the salmon and steelhead hatchery programs that affect bull trout, with 10 of these barriers in core bull trout areas and 3 barriers that are not in core areas. Most hatchery-related migration barriers in Puget Sound occur in streams below headwater areas where bull trout predominate, and most hatchery-related barriers operate seasonally for the purpose of obtaining broodstock for hatchery operations. These structures are regularly monitored by hatchery personnel and, as bull trout are encountered, the fish are manually passed upstream or downstream from the weirs and barriers as appropriate. From review of these hatchery facilities that affect bull trout, the overall risk of effects from migration barriers to bull trout is low (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Total Return Benefits. Because bull trout are not produced by hatchery programs in the project area, there are no total return benefits from hatchery programs to bull trout. Thus, total return benefits for bull trout are not considered further in this EIS.

Viability Benefits. The viability of bull trout is benefited when limited food supplies are increased, thus contributing to improved growth and survival. The prey base for bull trout includes natural-origin and hatchery-origin salmon and steelhead and many other freshwater and marine fish species, such as cyprinids, forage fish, and juvenile groundfish. Bull trout can also prey on salmon eggs and juvenile salmon and steelhead seasonally in fresh water, and especially in years having large salmon and steelhead returns (e.g., years when pink salmon return) (USFWS 2004a, 2004b). Viability benefits from hatchery programs are likely to be greatest in marine waters, because that is where hatchery-origin salmon and steelhead commingle with bull trout on their migration to the ocean. Releases of juvenile hatchery-origin salmon and steelhead form a relatively small part of the total abundance and biomass of prey species. For example, the abundance of one fish species in Puget Sound that contributes to the bull trout prey base–the Georgia Basin DPS of Pacific herring–is estimated to be 500 million fish with a biomass of 100,000 metric tons (NMFS 2005b). Considering the variety of other potential bull trout prey species in marine areas, even if substantial numbers of hatchery-origin salmon or steelhead were present in marine areas where bull trout are actively foraging, it is unlikely that the hatchery-origin fish would form a large part of the bull trout diet. In addition, because the numbers of bull trout are small and distributed broadly in the project area, the food supply is not likely limiting the recovery of bull trout at that scale.

In summary, hatchery programs for salmon and steelhead can benefit the viability of bull trout by increasing their food base. This benefit is likely to be greatest in marine waters, because that is where hatchery-origin salmon and steelhead commingle with bull trout on their migration to the ocean. Thus, the overall viability benefit to bull trout from the contribution of hatchery-origin fish to the bull trout food supply in the analysis area is low, because hatchery-origin fish make a relatively small contribution to the prey base of bull trout, especially in marine waters (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

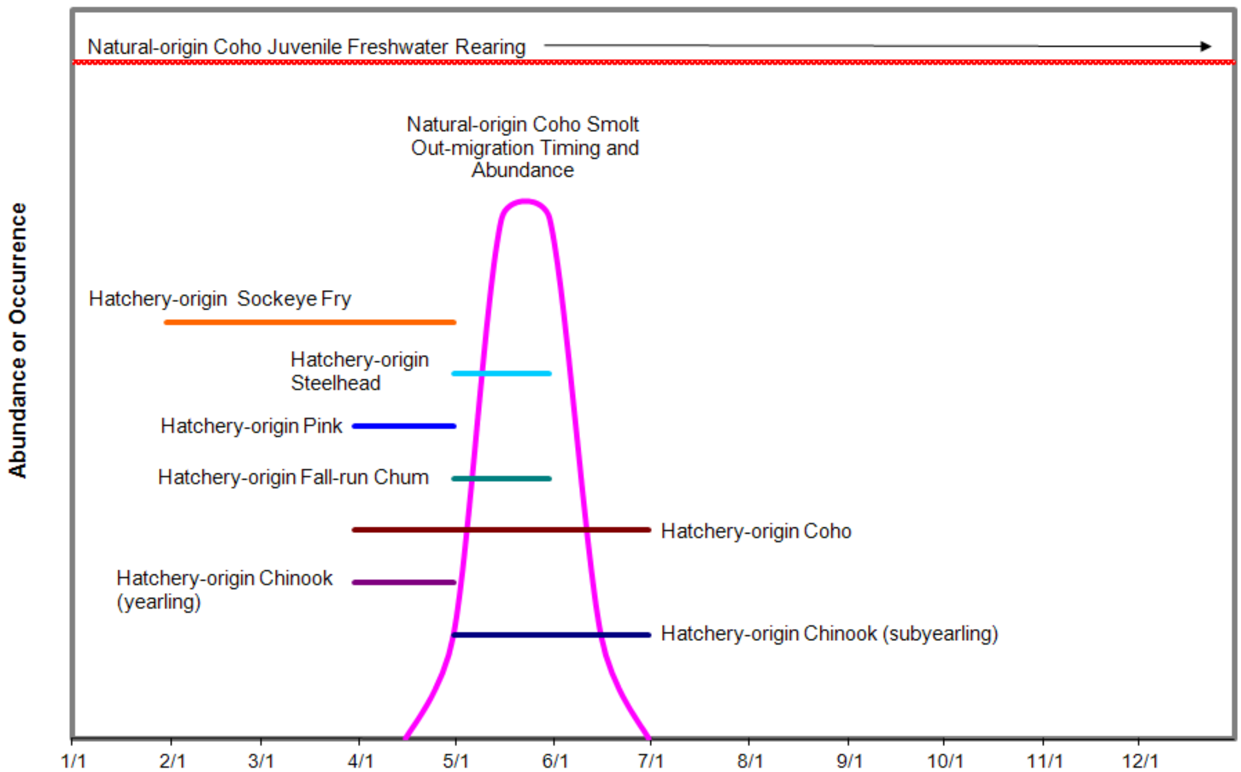
3.2.9 Puget Sound/Strait of Georgia Coho Salmon ESU

The Puget Sound/Strait of Georgia Coho Salmon ESU includes all naturally spawning coho salmon in streams entering Puget Sound from the Canadian border west to, and including, the Elwha River. An initial review of the status of the ESU under the ESA found that escapements of natural-origin coho salmon were generally abundant and stable (Weitkamp et al. 1995), and determined that ESA listing was not warranted (60 Fed. Reg. 38011, July 25, 1995). The ESU was subsequently classified as a Federal species of concern (69 Fed. Reg. 19975, April 15, 2004). Factors for decline include hatchery production (which has affected genetic risks such as hybridization, introgression, and indirect changes from competition, predation and disease, and loss of locally adapted populations), harvest of coho salmon, logging, agriculture, urbanization, dams and hydropower, flood control, pollution, drought, and unfavorable ocean production conditions (NMFS 2009a). A more recent NMFS review of the ESU concluded that its status is similar to, or perhaps somewhat improved from, its status at the time of the 1995 status review, and that listing was again not warranted (75 Fed. Reg. 38776, July 6, 2010). Puget Sound coho salmon are not listed as a species of concern by Washington State (WDFW 2014b).

3.2.9.1 Life History of Natural-origin Coho Salmon

Natural-origin adult coho salmon typically spawn in tributaries of river systems in the project area in October and November. Their eggs incubate in spawning gravels and fry emerge from redds about 100 to 115 days later, depending on water temperature (Koski 1966), at an average size of 1.2 inches (30 mm) fork length (Table 3.2-4).

Natural-origin juvenile coho salmon rear in fresh water for about 15 months (from February to May). During their freshwater residence time, the juveniles may migrate seasonally upstream or downstream, rearing in small tributaries, side channels, and beaver ponds. They may also reside briefly in tidally influenced delta channels before dispersing into Puget Sound (Drucker 1972; Crone and Bond 1976) and out-migrating into the ocean. Smolt out-migration timing typically spans from April through June (Salo and Bayliff 1958), peaking in May (Figure 3.2-9).



Sources: Natural-origin coho salmon data from Topping et al. (2008) (for smolts); juvenile rearing duration information from Weitkamp et al. (1995). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-9. Typical duration of natural-origin coho salmon juvenile rearing, out-migration timing and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

Hatchery-origin and natural-origin coho salmon have similar diets after entering Puget Sound marine waters. Upon entering Puget Sound, juvenile coho salmon primarily prey on juvenile pink salmon and chum salmon fry (Duffy 2003). Other fish prey include Pacific sand lance, Pacific herring (*Clupea pallasii)*, and juvenile flounders (*Pleuronectes spp*., *Platichthys stellatus*). Older juveniles may consume crustaceans, amphipods, euphausiids, and fish (Pacific sand lance and Pacific herring) (Duffy 2003).

Occurrence timing and abundance of natural-origin coho salmon smolts in estuarine areas varies across Puget Sound. Relatively few coho salmon were observed in samples collected in recent years in the

Nisqually River delta (Ellings and Hodgson 2007), although Duffy (2003) observed peak coho salmon abundance at Puget Sound nearshore sites in May and June. Rowse and Fresh (2003) concluded that yearling coho salmon migrate very quickly through the Snohomish River estuary. In contrast, subyearling coho salmon can rear in brackish waters of estuaries during summer and fall, and move back upstream to overwinter in tidal marshes and tributaries (Miller and Sadro 2003).

After leaving fresh water as smolts, most natural-origin Puget Sound coho salmon rear in marine waters for about 16 months, and migrate back as adults to Puget Sound watersheds through the Strait of Georgia in British Columbia, or along the west coast of Vancouver Island and into the Strait of Juan de Fuca. Entry timing of returning mature, 3-year-old adults into fresh water is quite variable, beginning as early as late August and continuing into January in some streams. However, most adult coho salmon enter fresh water from mid-September through October, and spawn in October and November.

3.2.9.2 Distribution and Abundance of Natural-origin Coho Salmon

Natural-origin coho salmon in the project area are found in large river systems and small independent streams. Washington Department of Fisheries (WDF) et al. (1993) identified 39 coho salmon stocks in the project area, extending from the Canadian border to the Elwha River. Based on genetic and life history similarities, coho salmon originating in Puget Sound and Canadian tributaries to Georgia Strait are aggregated into a single ESU (Weitkamp et al. 1995) that overlaps the project area. The majority of coho salmon stocks have both natural-origin and hatchery-origin adult returns. Natural-origin production predominates in the Skagit River, Stillaguamish River, and Snohomish River systems, and composes a substantial proportion of production in the rest of Puget Sound (Weitkamp et al. 1995). From 1995 to 2010, total escapements of natural-origin coho salmon in Puget Sound ranged from a low of 105,189 in 2010 to a high of 672,200 in 2004 (Table 3.2-17).

3.2.9.3 Description of Hatchery-origin Coho Salmon

Most hatchery-origin coho salmon are typically released as yearling smolts from Puget Sound hatcheries from April through June (Figure 3.2-9). A small number of programs also release fed or unfed fry in March and/or April, and one program releases subyearlings in November. Yearlings are typically released at an average length of 5.5 inches (140 mm) fork length, fry are released at an average length of 1.7 inches (43 mm) fork length, and subyearlings are released at an average length of 4.1 inches (104 mm) fork length (Table 3.2-4).

Table 3.2-17. Annual spawning escapements of natural-origin Puget Sound coho salmon and harvest of hatchery-origin Puget Sound coho salmon from 1995 to 2010.

Year	Escapement of Natural-origin Coho Salmon	Total Run Size[1]	Harvest of Hatchery-origin Coho Salmon[2]
1995	200,182		206,000
1996	132,150		140,100
1997	243,314	611,489	150,700
1998	396,709	698,742	121,100
1999	138,086	645,973	91,200
2000	297,169	1,021,201	283,500
2001	616,887	1,410,650	240,701
2002	372,541	958,493	200,306
2003	556,705	1,063,714	147,717
2004	672,200		325,755
2005	253,849		193,025
2006	131,780		162,861
2007	305,572		120,249
2008	106,928		185,781
2009	251,888		193,020
2010	105,189		97,003

Source: PFMC (2012).
[1] Natural-origin and hatchery-origin coho salmon spawning escapement plus harvest.
[2] Commercial net catches.

Coho salmon are released from 43 hatchery programs in Puget Sound. These include both isolated and integrated hatchery programs (Table 3.2-5). Most programs (39) operate for harvest purposes, and 4 programs operate for conservation purposes (Table 3.2-5). The total number of juvenile hatchery-origin coho salmon released annually averages nearly 15 million fish (Table 3.2-6).

Hatchery-origin coho salmon contribute substantially to commercial, sport, and tribal fisheries (PFMC 2012). For example, from 1995 to 2010, the annual harvest of hatchery-origin Puget Sound coho salmon ranged from a low of 91,200 in 1999 to a high of 325,755 in 2004 (Table 3.2-17). Hatchery-origin coho salmon averaged 76 percent of the total harvest of the species in commercial net fisheries from 2006 to 2010 (PFMC 2012).

3.2.9.4 Hatchery Program Risks and Benefits

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, by providing a summary of the current risks of hatchery programs to natural-origin coho salmon. Risks and benefits to natural-origin coho salmon from salmon and steelhead hatchery programs are qualitatively evaluated based on inferences from the general relationship between coho salmon and other salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects, risks and benefits for coho salmon are evaluated qualitatively and generally do not use the four rating categories and terms as used for listed salmon, steelhead, and trout (with the exception of hatchery facilities and operation risk). Rather, risks and benefits are generally described using relative qualitative terms (e.g., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.9.4.1 Risks - Competition

The effects of competition between hatchery-origin fish and natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Competition is greatest where and when species overlap in space and time and share a demand for resources that are in limited supply. Competition may occur between natural-origin coho salmon and hatchery-origin salmon and steelhead, both in freshwater and marine environments. Flagg et al. (2000) determined that after coho salmon are released from hatcheries, these fish (along with hatchery-origin Chinook salmon and steelhead) may compete for food and rearing space with natural-origin coho salmon juveniles in freshwater and nearshore marine areas.

The risk of competition effects may be temporary because hatchery-origin Chinook salmon, coho salmon, and steelhead are typically released as smolts that actively migrate and disperse seaward, and do not remain for extended periods in freshwater and estuarine areas where rearing and out-migrating natural-origin coho salmon may be present (Levings et al. 1986; Fuss et al. 2000). However, hatchery-origin yearling Chinook salmon, coho salmon, and steelhead are generally released from hatcheries during the peak out-migration period of coho salmon (Figure 3.2-9), and would likely compete with natural-origin coho salmon smolts in locations where they overlap in time and space.

Competition would be expected to be greatest in fresh water where hatchery-origin fish are released in upriver locations and when the fish are released during the peak out-migration period for natural-origin juvenile coho salmon. In addition, in marine areas, competition would be expected to be greatest from hatchery-origin coho salmon smolts that may compete for food with co-occurring natural-origin coho salmon juveniles (SIWG 1984). Finally, risks of competition effects would be expected to be greatest in areas where there is a high proportion of hatchery-origin fish compared to natural-origin fish.

Hatchery-origin fall-run chum salmon, sockeye salmon, and pink salmon likely pose minimal competition risks to natural-origin coho salmon because of differences in species' diet preference, migration timing, and/or behavior (Duffy 2003; Fresh 2006). Thus, competition risk from these hatchery-origin species with coho salmon is not considered further in this EIS.

In summary, competition risks to natural-origin coho salmon are likely to occur from hatchery-origin yearling coho salmon, Chinook salmon, and steelhead, specifically where the hatchery-origin fish are released in fresh water where natural-origin coho salmon smolts also occur, and in marine areas.

3.2.9.4.2 Risks - Predation

The effects of predation by hatchery-origin fish on natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Predation may occur where and when piscivorous predators overlap in space and time with natural-origin fish of a size vulnerable to predation. Hatchery-origin Chinook salmon, coho salmon, and steelhead may prey on co-occurring natural-origin coho salmon fry and parr depending on the relative size of the hatchery-origin fish compared to the natural-origin fish, and based on the location and timing of the hatchery releases. At the time of release, hatchery-origin steelhead and coho salmon yearlings average 8.1 inches (206 mm) and 5.5 inches (140 mm) fork length, respectively, whereas the average lengths of natural-origin coho salmon fry and parr are 1.2 and 2.1 inches (30 and 56 mm), respectively (Table 3.2-4). Hatchery-origin Chinook salmon yearlings (average 6.1 inches [155 mm] fork length) and subyearlings (average 3.1 inches [80 mm] fork length) (Table 3.2-4) may also prey on smaller natural-origin coho salmon fry. The larger size and piscivorous behavior (Duffy 2003) of yearling hatchery-origin Chinook salmon and coho salmon compared to natural-origin coho salmon fry and parr means these hatchery-origin fish have the potential to prey on the two earliest life stages of natural-origin coho salmon (SIWG 1984; Hawkins and Tipping 1999). In addition, hatchery-origin steelhead yearlings that are released high in watersheds increases exposure time of coho salmon to predation in fresh water. However, Sharpe et al. (2008) and Naman and Sharpe (2012) found that hatchery-origin steelhead prey on other salmonid juveniles to a very low degree during their migration seaward. The risks of predation effects are temporary because hatchery-origin fish disperse seaward within a few weeks after their release.

Hatchery-origin Chinook salmon and coho salmon subadults (resident) may also prey on natural-origin coho salmon during the first year of their marine rearing period if the natural-origin coho salmon smolts are of a small enough size to be vulnerable to predation (Buckley 1999).

Most chum salmon, sockeye salmon, and pink salmon are released from hatcheries as fry, and range in length from 1.1 to 2.0 inches (28 to 50 mm) fork length (Table 3.2-4). Their generally small size and non-piscivorous diet precludes them from being predators of natural-origin coho salmon. Thus, predation risks from these species to natural-origin coho salmon are not considered further in this EIS.

In summary, predation may occur on natural-origin coho salmon fry and parr from hatchery-origin Chinook salmon yearlings and subyearlings, and from coho salmon and steelhead yearlings, because these hatchery-origin species are considerably larger than the natural-origin coho salmon fry and parr that may be encountered, and would be released during the peak out-migration period of natural-origin coho salmon. These risks occur in fresh water. Predation risks to natural-origin coho salmon in marine areas are from hatchery-origin subadult (resident) Chinook salmon and coho salmon. These risks are greatest where large numbers of hatchery-origin coho salmon yearlings are released compared to the number of natural-origin fish present.

3.2.9.4.3 Risks - Genetics

Genetic risks from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Available genetic data for coho salmon indicate that genetic risks to natural-origin coho salmon are associated with potential hatchery-induced selection effects (sometimes called domestication) on coho salmon reared in hatcheries, and the potential for those hatchery-origin adult coho salmon to stray and interbreed with natural-origin coho salmon, which may affect genetic diversity and long-term fitness of the natural-origin fish.

For most areas of Puget Sound, some information is available on hatchery-origin coho salmon straying and spawning and how hatchery-origin coho salmon affect the genetic structure of natural-origin coho salmon (Eldridge and Naish 2007; Eldridge et al. 2009). This information suggests introgression from hatchery-origin coho salmon has occurred to some extent. Similarly, a few studies are available that document the spawning success of hatchery-origin coho salmon in Puget Sound relative to their natural-origin counterparts (Berejikian and Ford 2004; Ford et al. 2008). As an example, for Oregon coast coho salmon, Emlen et al. (1990) and Nickelson (2003) found that hatchery releases negatively affected productivity, but the authors did not quantify the relative magnitude of the effect compared to other factors like habitat loss and degradation.

In summary, available information suggests that hatchery programs for coho salmon pose genetic risks from straying and interbreeding with natural-origin coho salmon.

3.2.9.4.4 Risks - Hatchery Facilities and Operation

Hatchery facilities and operation risks from hatchery-origin salmon and steelhead programs to natural-origin salmon and steelhead are generally described in Subsection 3.2.3.4, Risks - Hatchery Facilities and Operation, and Appendix B, Hatchery Effects and Evaluation Methods for Fish. Coho salmon are produced in the same hatcheries that produce Chinook salmon, using the same facilities and BMPs (e.g., broodstock collection, spawning, fish release, disease control, and use of water and barriers) that are used for Chinook salmon production (especially yearling Chinook salmon). Therefore, hatchery facilities and operation risks to natural-origin coho salmon are the same as the hatchery facilities and operation risks to natural-origin Chinook salmon described in Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation (Chinook Salmon), because the effects of hatchery facilities and operation on coho salmon are the same. Compliance with BMPs for Chinook salmon at the ESU scale is generally good (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon]), and Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Therefore, considering all coho salmon hatchery programs, the overall hatchery facilities and operation risk for coho salmon is low, because most programs operate in compliance with BMPs (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon]).

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, there are three hatcheries where dewatering associated with hatchery facilities and operation affects coho salmon: North Fork/Johnson Creek Hatchery (Stillaguamish River watershed), Voights Creek Hatchery (Puyallup River watershed), and Minter Creek Hatchery (Carr Inlet). However, effects of these water withdrawals are unlikely to impact coho salmon because the withdrawals affect limited areas on tributaries that are small and do not form major spawning areas for the species.

3.2.9.4.5 Benefits - Total Return

The total return of hatchery-origin coho salmon to fisheries can provide harvest benefits. Benefits from hatchery-origin fish to the total returns of salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. The total return benefit occurs from the 39 coho salmon hatchery programs whose primary purpose is to produce fish for harvest and substantially increase the total returns of the species (Table 3.2-5). Over the past 5 years for which data are available (Table 3.2-17), harvest of hatchery-origin coho salmon ranged from about 91,000 to 326,000 hatchery fish.

3.2.9.4.6 Benefits - Viability

Benefits can accrue to viability (natural-origin abundance, diversity, spatial structure, and productivity) when genetic resources important to an ESU reside in fish produced by hatchery programs, as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Viability benefits to natural-origin coho salmon would occur from the 13 integrated coho salmon hatchery programs (Table 3.2-5). These hatchery programs may contribute to naturally spawning coho salmon abundance and spatial structure viability parameters by increasing numbers and distribution.

3.2.9.4.7 Benefits - Marine-derived Nutrients

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, salmon and steelhead carcasses provide a direct food source for juvenile salmon and steelhead, other fish, aquatic invertebrates, and terrestrial animals, and the decomposition of carcasses supplies nutrients that benefit the ecosystem. Natural-origin and hatchery-origin coho salmon spawners contribute 10 percent of the total biomass of carcasses from all salmon and steelhead species that supply marine-derived nutrients in the project area (Appendix B, Hatchery Effects and Evaluation Methods for Fish). In addition, the largest percentage of the total number of hatchery-origin carcasses distributed from WDFW hatcheries into natural areas in recent years has been coho salmon (44 percent) (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Therefore, the marine-derived nutrient benefit from hatchery-origin coho salmon is moderate.

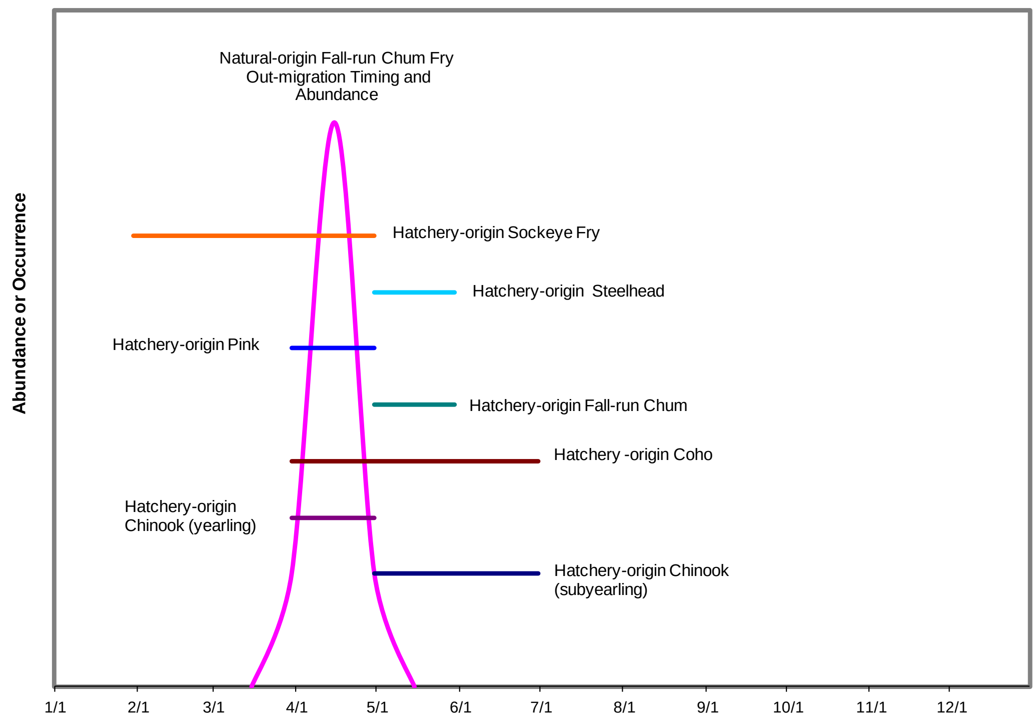
3.2.10 Puget Sound/Strait of Georgia Chum Salmon ESU

The Puget Sound/Strait of Georgia Chum Salmon ESU includes all naturally spawning chum salmon in streams entering Puget Sound from the Canadian border west to, and including, the Elwha River. NMFS evaluated the status of the ESU in 1997 (Johnson et al. 1997), found that the ESU is generally healthy, and determined that ESA listing was not warranted (63 Fed. Reg. 11773, March 10, 1998). The majority of stocks (45) in the ESU are fall-run (spawning from October to January) (see Subsection 3.2.10.2, Distribution and Abundance of Natural-origin Chum Salmon), four are summer-run (spawning from September to November), and two are winter-run populations (spawning from January to March) in southern Puget Sound. The summer-run chum salmon in southern Puget Sound are genetically more similar to Puget Sound fall-run chum salmon than to the summer-run chum salmon in Hood Canal and the Strait of Juan de Fuca that form a separate Hood Canal Summer-run Chum Salmon ESU (Subsection 3.2.6, Hood Canal Summer-run Chum Salmon ESU). This review focuses on fall-run chum salmon, because they are abundantly distributed throughout the Puget Sound/Strait of Georgia Chum Salmon ESU, and because all chum salmon hatchery production in the ESU is of the fall-run type. The Puget Sound/Strait of Georgia Chum Salmon ESU is not listed as threatened, endangered, or a species of concern by Washington State (WDFW 2014b).

3.2.10.1 Life History of Natural-origin Chum Salmon

The life history of natural-origin Puget Sound/Strait of Georgia chum salmon involves use of mainstem areas and lower tributaries of large rivers, and many small independent streams for a relatively short time before juveniles out-migrate to marine areas to rear to the adult stage. After the chum salmon fry emerge from stream gravels, their residence in freshwater habitats is of short duration compared to other anadromous salmon and steelhead species (Salo 1991). Chum salmon survival is strongly influenced by flow conditions in fresh water during egg incubation (Johnson et al. 1997), and by conditions in marine areas, particularly during their early estuary residence (Simenstad et al. 1980; Bax 1983; SIWG 1984). There are similarities between the life histories of Puget Sound/Strait of Georgia chum salmon and Hood Canal summer-run chum salmon (e.g., use of rearing habitat) along with some differences (e.g., timing of adult return). For more detailed information on Hood Canal summer-run chum salmon, refer to Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon.

Most chum salmon in Puget Sound spawn in the lower reaches of streams and rivers. However, in the Skagit River and some other large river systems, spawning occurs 20 or more miles upstream. Chum salmon fry typically out-migrate immediately upon emergence from the gravel (Bakkala 1970) at an average length of 1.5 inches (38 mm) fork length (Table 3.2-4), so the upstream distribution of spawning determines their potential for freshwater interaction with hatchery-origin fish. For fall-run chum salmon, the gravel emergence and out-migration period ranges from late January to June, with a peak in April (Healey 1982) (Figure 3.2-10). In Hood Canal, fall-run chum salmon spawn in Hood Canal streams predominantly in November and December, and the resulting fry emerge from the stream gravels in February through May, peaking in April (Koski 1975; Tynan 1997) (Table 3.2-4), followed by immediate out-migration to estuarine areas.



Sources: Natural-origin chum salmon data are from Volkhardt et al. (2006c) (Green River fall-run). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-10. Typical duration of natural-origin fall-run chum salmon fry out-migration timing and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

Post-emergent chum salmon entering nearshore estuarine and marine rearing areas consume copepods and amphipods (crustaceans that occur in aquatic environments) (Simenstad et al. 1982). Chum salmon diets shift to predominantly euphausiids as the fish grow and transition to pelagic waters (Duffy 2003; Fresh 2006; Brodeur et al. 2007).

In general, natural-origin juvenile chum salmon are present in estuaries from mid-January through June, depending on spawn and emergence timing, and environmental factors in the estuary (Bax et al. 1979; Simenstad et al. 1980; Bax 1982).

Interactions between natural-origin fall-run chum salmon juveniles and hatchery-origin fall-run chum salmon in Puget Sound marine areas occur as the fish out-migrate from mid-March to mid-May (Figure 3.2-4). Natural-origin juvenile fall-run chum salmon in south Puget Sound occupy nearshore marine habitats for about 10 weeks, with an average individual residence time of 24 days (Johnson et al. 1997; Duffy 2003). Duffy (2003) observed juvenile chum salmon in south Puget Sound nearshore areas from April to June, with a peak occurrence in May.

3.2.10.2 Distribution and Abundance of Natural-origin Chum Salmon

WDF et al. (1993) identified 45 fall-run chum salmon stocks in Puget Sound, including 9 stocks in the north Puget Sound (Canada-Washington border south to the Stillaguamish River), 30 stocks in the south Puget Sound (Snohomish River to south Puget Sound and Hood Canal), and 6 stocks in the Strait of Juan de Fuca. They found the status of most stocks to be healthy (unknown status for 13 stocks and healthy for all of the others). Annual total run size of natural-origin fall-run chum salmon from 1995 to 2009 ranged from about 517,000 fish in 2000 to about 3 million fish in 2002 (Table 3.2-18). The long-term abundance trend has been upward. From 1975 to 2009, annual total run sizes ranged from a low of 155,000 fish in 1975 to about 3 million fish in 2002 (WDFW 2014a). Spawning escapement provides an indication of the abundance of natural-origin Puget Sound fall-run chum salmon. From 1995 to 2009, escapements ranged from about 168,000 fish in 1997 to nearly 1.1 million fish in 2002 (Table 3.2-18).

Table 3.2-18. Annual spawning escapements of natural-origin fall-run chum salmon, total run size, and harvest of hatchery-origin Puget Sound fall-run chum salmon from 1995 to 2009.

Year	Escapement of Natural-origin Fall-run Chum Salmon	Total Run Size[1]	Harvest of Hatchery-origin Fall-run Chum Salmon	
			Number	Percent of Total Chum Salmon Harvest[2]
1995	444,411	1,269,024	247,546	30
1996	840,202	1,818,659	236,149	24
1997	167,819	693,247	241,742	46
1998	888,467	1,908,269	352,848	35
1999	339,231	659,281	62,607	20
2000	193,895	517,209	75,046	23
2001	574,387	2,369,365	747,322	42
2002	1,079,710	3,076,219	574,562	29
2003	695,722	2,312,914	720,693	45
2004	870,415	2,843,033	628,394	32
2005	287,596	979,685	216,733	31
2006	806,999	2,446,967	508,765	31
2007	482,700	2,036,204	604,191	39
2008	238,867	1,200,639	370,657	39
2009	224,687	891,963	367,675	55

Source: WDFW (2014a).
[1] Natural-origin and hatchery-origin fall-run chum salmon spawning escapement plus harvest.
[2] Percentage of the total harvest (total run size minus escapement) that is hatchery-origin chum salmon.

3.2.10.3 Description of Hatchery-origin Chum Salmon

Hatchery-origin chum salmon are released as fry in mid-March through May at a time when natural-origin Chinook salmon fry and yearlings; steelhead parr and smolts; coho salmon fry, parr, and yearlings; chum salmon fry; pink salmon fry; and sockeye salmon fry and smolts are out-migrating in freshwater rivers and streams (Figure 3.2-4). Fall-run chum salmon are not reared for release past the fry stage, and no yearlings are released. The fish are generally released at an average length of about 2.0 inches (50 mm) fork length (Table 3.2-4).

Chum salmon (not including summer-run chum salmon) are released from 14 hatchery programs in Puget Sound, half of which are isolated programs and half are integrated programs (Table 3.2-5). The purpose of all but one of these hatchery programs is harvest. The purpose of one hatchery program (Lower Elwha Fish Hatchery) is conservation. The number of juvenile hatchery-origin chum salmon produced annually averages about 45 million fish (Table 3.2-6).

Hatchery-origin fall-run chum salmon contribute substantially to commercial, recreational, and tribal fisheries, representing 29 percent of total annual chum salmon returns (Appendix B, Hatchery Effects and Evaluation Methods for Fish). From 1995 to 2009, harvest of hatchery-origin Puget Sound fall-run chum salmon ranged from a low of 62,000 fish in 1999 to a high of about 747,000 fish in 2001 (Table 3.2-18). The annual contribution of hatchery-origin fall-run chum salmon to chum salmon fisheries averaged 35 percent of total annual harvests of the species from 1995 to 2009 (Table 3.2-18).

3.2.10.4 Hatchery Program Risks and Benefits

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, by providing a summary of the current risks and benefits of hatchery programs to natural-origin chum salmon. Risks and benefits to natural-origin fall-run chum salmon from salmon and steelhead hatchery programs are qualitatively evaluated based on inferences from the general relationship between fall-run chum salmon and salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects, risks and benefits for fall-run chum salmon are evaluated qualitatively and generally do not use the four rating categories and terms as used for listed salmon, steelhead, and trout (with the exception of hatchery facilities and operation risk). Rather, risks and benefits are generally described using relative qualitative terms (e.g., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.10.4.1 Risks - Competition

The effects of competition between hatchery-origin fish and natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. This risk category includes effects from juvenile and adult fish, as well as effects which may occur in fresh water and marine water. Competition is greatest where and when species overlap in space and time and share a demand for resources that are in limited supply. Chum salmon, like pink salmon and fall-run Chinook salmon, have life histories involving very short freshwater residence periods. After emergence, the small natural-origin fry out-migrate promptly to marine waters. Thus, after their release from hatcheries, the potential for hatchery-origin fall-run chum salmon juveniles to compete for food and rearing space with natural-origin fall-run chum salmon juveniles in fresh water is minimal because interactions are of short duration and because releases of hatchery-origin fall-run chum salmon occur after the peak out-migration period for natural-origin fall-run chum salmon (Figure 3.2-4). As described in Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead, hatchery-origin fish tend to be more aggressive than natural-origin fish, which may result in hatchery-origin fish competing with natural-origin fish. As described by SIWG (1984), the risk of competition effects from hatchery-origin chum salmon to natural-origin fall-run chum salmon is greatest in nearshore marine areas.

Hatchery-origin pink salmon may compete with natural-origin fall-run chum salmon wherever releases of pink salmon occur in areas where natural-origin fall-run chum salmon fry occur. Releases of hatchery-origin pink salmon occur during the peak out-migration of natural-origin fall-run chum salmon. However, these releases occur only in lower areas of Whatcom Creek near Bellingham Bay, Finch Creek in western Hood Canal, and the Elwha River. Thus, the effects of competition on natural-origin fall-run chum salmon from releases of hatchery-origin pink salmon are limited to these three freshwater areas.

There are minimal risks of competition effects from hatchery-origin subyearling Chinook salmon to natural-origin fall-run chum salmon because subyearling Chinook salmon are typically released after the natural-origin chum salmon fry out-migration period (Figure 3.2-4). In addition, competition for food resources between hatchery-origin Chinook salmon and natural-origin fall-run chum salmon in Puget Sound marine areas is not likely a risk factor because of spatial and temporal differences in out-migration behaviors and residence time (SIWG 1984; Fresh 2006), and partitioning of available food resources among species (Duffy 2003; Brodeur et al. 2007). In addition, hatchery-origin steelhead, coho salmon, and Chinook salmon yearlings would not be expected to compete with natural-origin fall-run chum salmon for prey because of the substantially larger size of these three species compared to natural-origin chum salmon and resulting preferences for different prey sizes. Thus, hatchery-origin Chinook salmon, steelhead, and coho salmon are not considered competitors with natural-origin fall-run chum salmon and are not considered further in this EIS.

Competition risks from hatchery-origin sockeye salmon on natural-origin fall-run chum salmon are unlikely. Hatchery-origin sockeye salmon released from the Cedar River Hatchery program present no competition risk to natural-origin fall-run chum salmon because natural-origin fall-run chum salmon are not present in the Lake Washington watershed. Sockeye salmon released from the Baker Lake Hatchery program are unlikely to present competition risks to natural-origin fall-run chum salmon because of their lake rearing location, their non-piscivorous diet, and the lack of substantial spatial and temporal overlap with juvenile natural-origin fall-run chum salmon that out-migrate from the Skagit River. Thus, hatchery-origin sockeye salmon are not competitors with natural-origin fall-run chum salmon and are not considered further in this EIS.

In summary, the most likely competition effects to natural-origin fall-run chum salmon would occur from hatchery-origin species that are about the same size (pink salmon and fall-run chum salmon fry), released in the same general locations, and at the time of the peak out-migration period for natural-origin fall-run chum salmon fry. Thus, freshwater competition with natural-origin fall-run chum salmon would be limited to hatchery-origin pink salmon releases in Whatcom Creek near Bellingham Bay, Finch Creek near Hood Canal, and the Elwha River. Additional competition effects may occur in estuaries and marine waters where hatchery-origin fall-run chum salmon and natural-origin fall-run chum salmon co-occur before migrating to the ocean.

3.2.10.4.2 Risks - Predation

The effects of predation by hatchery-origin fish on natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Natural-origin fall-run chum salmon are likely to be affected in Puget Sound marine waters by predation from hatchery-origin fish. Predation may occur where and when piscivorous predators overlap in space and time with natural-origin fish of a size vulnerable to predation. Risks of predation are greatest when large numbers of hatchery-origin smolts encounter newly emerged fry or fingerlings, and when hatchery-origin fish are large relative to the natural-origin fish (SIWG 1984). As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, hatchery-origin juvenile salmon and steelhead can prey on smaller fish that are 40 to 50 percent of their body size. Thus, potential predators of natural-origin fall-run chum salmon would include hatchery-origin Chinook salmon, steelhead, and coho salmon. Hatchery-origin fall-run chum salmon, pink salmon, and sockeye salmon fry are too small (size is 2.0 inches [50 mm] fork length or less) to prey on natural-origin fall-run chum salmon fry.

Releases of hatchery-origin Chinook salmon yearling smolts overlap the out-migration period for natural-origin fall-run chum salmon (Figure 3.2-4). Predation effects from Chinook salmon yearlings would be greatest during the spring months where overlap in time and space between hatchery-origin and natural-origin fish are greatest. However, these predation effects are likely of limited duration because the hatchery-origin fish would move away from river mouths and nearshore areas where natural-origin fall-run chum salmon fry initially concentrate a few weeks after their release (as reviewed for Chinook salmon and coho salmon in Appendix D, PCD RISK 1 Assessment). Predation impacts from hatchery-origin Chinook salmon subyearlings are not expected in fresh water because of the later release times for hatchery-origin Chinook salmon subyearlings that limits the potential for interaction with chum salmon that are of a size vulnerable to predation (Figure 3.2-4). In marine areas, predation effects from hatchery-origin Chinook salmon yearlings on natural-origin fall-run chum salmon are unlikely because, although hatchery-origin Chinook salmon yearlings are larger than natural-origin fall-run chum salmon, the hatchery-origin fish would be expected to disperse rapidly toward the ocean.

Hatchery-origin steelhead yearlings are released after the peak out-migration period for natural-origin fall-run chum salmon, thereby resulting in minimal predation risks (Figure 3.2-4). Thus, the extent of predation on natural-origin fall-run chum salmon from hatchery-origin steelhead is not considered further in this EIS.

In contrast, hatchery-origin coho salmon yearlings are released about the same time as the peak out-migration of natural-origin fall-run chum salmon (Figure 3.2-4), thus resulting in a greater potential for predation. In marine areas, predation effects from hatchery-origin coho salmon yearlings on natural-origin fall-run chum salmon are not of concern because, although the hatchery-origin coho salmon yearlings are larger than natural-origin fall-run chum salmon, the hatchery-origin fish would be expected to disperse rapidly toward the ocean.

Predation from other hatchery-origin salmon species (pink salmon, sockeye salmon, and fall-run chum salmon) on natural-origin fall-run chum salmon is unlikely because of similarities in fish size among the species, their lack of a piscivorous diet, and/or differences in release times of hatchery-origin fish compared to peak out-migration timing for natural-origin fall-run chum salmon. Thus, predation effects from these species to natural-origin fall-run chum salmon are not considered further in this EIS.

In summary, predation risks to natural-origin fall-run chum salmon fry are most likely to occur from hatchery-origin Chinook salmon yearlings and coho salmon in fresh water because of the large body size of these two species compared to the size of natural-origin fall-run chum salmon fry and the release timing of these hatchery-origin species occurring during the peak out-migration period of natural-origin fall-run chum salmon fry.

3.2.10.4.3 Risks - Genetics

Genetic risks from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Genetic risks to natural-origin fall-run chum salmon are associated with potential effects of hatchery-induced selection from fall-run chum salmon reared in hatcheries, and the potential for those hatchery-origin fall-run chum salmon to stray and interbreed with natural-origin fall-run chum salmon, which may result in reductions in genetic diversity and long-term fitness of natural-origin fish.

However, genetic risks to natural-origin fall-run chum salmon from hatchery production in Puget Sound are likely minimal. Available studies of genetic diversity (Small et al. 2009) and reproductive success (Berejikian et al. 2009) did not find significant differences between natural-origin chum salmon and offspring of hatchery-origin summer-run chum salmon from hatchery programs using local broodstock. These findings are likely to be generally applicable to chum salmon in the project area because of similarities in the chum salmon hatchery practices used (e.g., short length of time in hatcheries). Although there are no comprehensive assessments of the extent of straying and spawning by hatchery-origin fall-run chum salmon in natural-origin fall-run chum salmon production areas in the project area, available studies of hatchery-origin fall-run chum salmon straying indicate that the fish have a high fidelity to their release sites (Fuss and Hopley 1991), and the tendency to stray is minimal. Therefore, genetic risks are not considered further in this EIS because they are ameliorated by the use of local broodstocks for hatchery production, the short time that chum salmon are reared in hatcheries, the high fidelity of returning adult chum salmon to their sites of release, and available studies of genetic diversity and reproductive success of hatchery-origin and natural-origin fall-run chum salmon.

3.2.10.4.4 Risks - Hatchery Facilities and Operation

Hatchery facilities and operation risks from hatchery-origin salmon and steelhead programs to natural-origin salmon and steelhead are generally described in Subsection 3.2.3.4, Risks - Hatchery Facilities and Operation, and Appendix B, Hatchery Effects and Evaluation Methods for Fish. Chum salmon are produced in the same hatcheries that produce Chinook salmon using the same facilities and BMPs (e.g., broodstock collection, spawning, fish release, disease control, and use of water and barriers) that are used for Chinook salmon production (especially subyearling Chinook salmon). Therefore, hatchery facilities and operation risks to natural-origin chum salmon are the same as the hatchery facilities and operation risks to natural-origin Chinook salmon described in Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation (Chinook Salmon), because the effects of hatchery facilities and operation on chum salmon are the same. Compliance with BMPs for Chinook salmon at the project area scale is generally good (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon], and Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Therefore, considering all chum salmon hatchery programs, the overall hatchery facilities and operation risk is low, because most programs operate in compliance with BMPs (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon]).

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, there are three hatcheries where dewatering impacts chum salmon: Little Boston Creek Hatchery (Port Gamble Bay), Voights Creek Hatchery (Puyallup River), and Minter Creek Hatchery (Carr Inlet). However, effects of these water withdrawals as part of hatchery facilities and operation risks are unlikely because the withdrawals affect limited areas on tributaries that are small and do not form major spawning areas for the species.

3.2.10.4.5 Benefits - Total Return

The total return of hatchery-origin chum salmon returning to fisheries can provide harvest benefits. Benefits from hatchery-origin fish to the total returns of salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. This benefit occurs primarily from the 13 chum salmon hatchery programs whose primary purpose is to produce fish for harvest (Table 3.2-5). Over the past 5 years for which data are available (Table 3.2-18), harvest of hatchery-origin chum salmon ranged from about 217,000 to 604,000 fish. The contribution of hatchery-origin chum salmon to the total chum salmon harvest has tended to increase over time. For example, from 1995 to 1999 the hatchery-origin chum salmon contributed an average of 31 percent of the total harvest of the species; whereas, from 2005 to 2009, hatchery-origin chum salmon contributed an average of 39 percent (Table 3.2-18).

3.2.10.4.6 Benefits - Viability

Benefits can accrue to the viability of fish species when genetic resources important to the ESU reside in fish produced by hatchery programs. Viability benefits from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Viability benefits to natural-origin chum salmon vary depending on the hatchery program. This type of benefit to natural-origin chum salmon can occur from the seven integrated chum salmon hatchery programs (Table 3.2-5). These programs may contribute to the natural-origin chum salmon abundance and spatial structure parameters and may contribute to the diversity parameter to some extent.

3.2.10.4.7 Benefits - Marine-derived Nutrients

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, salmon and steelhead carcasses provide a direct food source for juvenile salmonids, other fish, aquatic invertebrates, and terrestrial animals, and the decomposition of carcasses supplies nutrients that increase primary and secondary production and benefit the ecosystem. Of the total biomass of carcasses from all salmon and steelhead species that supply marine-derived nutrients to the project area, natural-origin and hatchery-origin chum salmon spawners contribute the largest percentage (49 percent) (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, relatively few carcasses distributed from WDFW hatcheries in recent years have been fall-run chum salmon (10 percent) (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Therefore, the marine-derived nutrient benefit from hatchery-origin chum salmon is negligible.

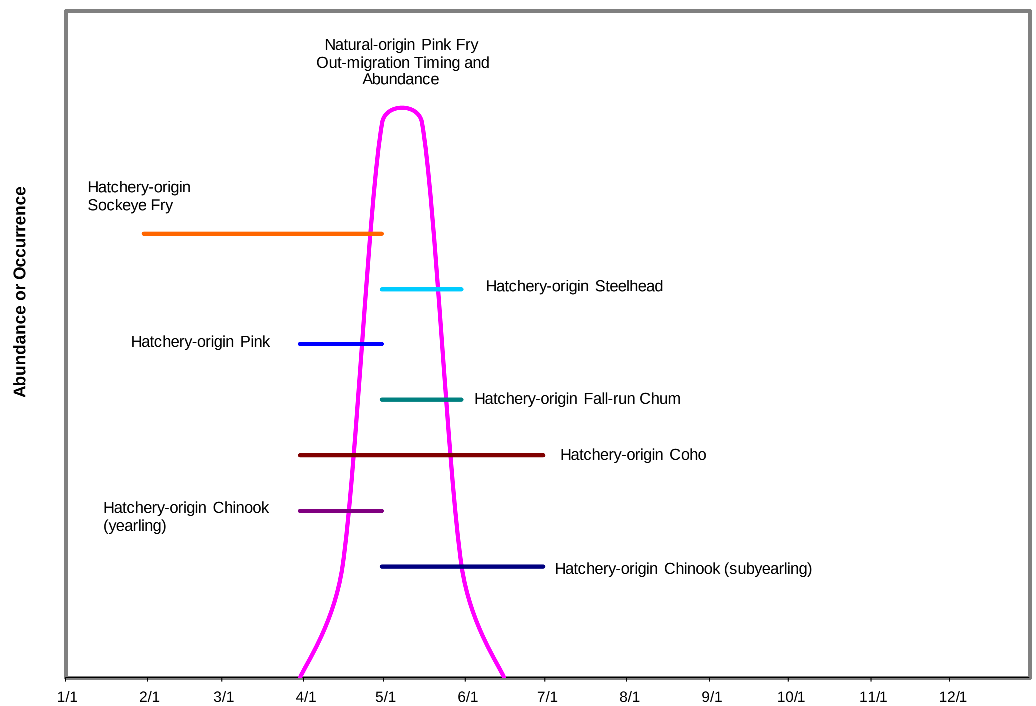
3.2.11 Odd-year and Even-year Pink Salmon ESUs

There are two pink salmon ESUs (odd-year and even-year) in Washington State. The Odd-year Pink Salmon ESU includes fish that spawn in odd-numbered years in Puget Sound watersheds from the Canadian border to, and including, the Elwha River. The Even-year Pink Salmon ESU is confined to fish that spawn in even-numbered years in the Snohomish River. NMFS evaluated the status of the two ESUs in 1994 and 1995 (Hard et al. 1996), and determined that ESA listing was not warranted (60 Fed. Reg. 51928, October 4, 1995). The pink salmon ESUs are not listed as threatened, endangered, or a species of concern by Washington State (WDFW 2014b).

3.2.11.1 Life History of Natural-origin Pink Salmon

The majority of pink salmon in the project area return in odd-numbered years. Natural-origin pink salmon enter fresh water in late August and early September, and spawn in late September and October (WDF et al. 1993). Pink salmon tend to spawn in the mainstem reaches of rivers, closer to tidewater than most other salmon; however, some spawners migrate considerable distances upstream and also use larger tributaries (Heard 1991). The timing and distribution of natural-origin pink salmon spawners overlaps that of natural-origin fall-run Chinook salmon in some rivers in the project area (e.g., Green River).

Natural-origin pink salmon fry hatch and emerge from spawning gravels in March and April (Simenstad et al. 1982; Hard et al. 1996), and out-migrate rapidly in April and May at an average length of 1.3 inches (34 mm) fork length (Table 3.2-4). They may not feed until they reach the estuary. Figure 3.2-11 illustrates the overlap in timing between out-migrating natural-origin pink salmon and timing of salmon and steelhead hatchery releases.



Sources: Natural-origin pink salmon data from Topping et al. (2008) (Dungeness pink salmon). Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-11. Typical duration of natural-origin pink salmon fry out-migration timing and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

Most natural-origin juvenile pink salmon out-migrating from Puget Sound rivers use nearshore areas extensively for early rearing (Jewell 1966), whereas late-emergent fry migrate through the estuary quickly (Hurley and Woodall 1968). Pink salmon congregate in dense schools along the shorelines of Puget Sound where their diet is predominantly zooplankton and aquatic insects. Juvenile pink salmon are vulnerable to predation during this early marine phase, and their survival is dependent on achieving rapid growth. Thus, they occupy highly productive estuarine areas where food is abundant (Parker 1971). Pink salmon diets change as the fish grow and transition to pelagic waters (Duffy 2003; Fresh 2006; Brodeur et al. 2007).

3.2.11.2 Distribution and Abundance of Natural-origin Pink Salmon

The Odd-year Pink Salmon ESU comprises twelve populations, including those in the Nooksack, Skagit, Stillaguamish, and Snohomish Rivers in northern Puget Sound; Puyallup and Nisqually Rivers in south Puget Sound; Hamma Hamma, Duckabush, and Dosewallips Rivers in Hood Canal; and the Dungeness River (two populations) in the Strait of Juan de Fuca (Hard et al. 1996; WDFW 2002). A genetically unique odd-year pink salmon population has also been identified in the Elwha River (Ward et al. 2008). There is one population (Snohomish River) that composes the Even-year Pink Salmon ESU (Hard et al. 1996).

The abundance of adult pink salmon in Puget Sound is greatest in odd-numbered years. Natural-origin juveniles are thus abundant in even-years (juveniles out-migrate the year following spawning). Tens of millions of juvenile pink salmon may enter the marine waters of Puget Sound some years. The long-term abundance trend has been upward. Abundance of returning adults is typically highest in northern Puget Sound rivers, such as the Skagit River and Snohomish River systems, but some stocks in south Puget Sound have increased markedly in recent years (Hard et al. 1996; Kyle Adicks, pers. comm., WDFW, Resource Program Manager, July 17, 2006). From 1991 to 2009, annual total run sizes ranged from a low of about 441,000 fish in 1997 to a high of nearly 10 million fish in 2009 (Table 3.2-19). During the same time span, annual escapement of natural-origin pink salmon ranged from about 294,000 fish in 1997 to nearly 9 million fish in 2009 (Table 3.2-19).

The abundance of even-year pink salmon in the Snohomish River increased from 1996 through 2004, but has since declined to the low abundance levels observed in the 1980s (WDFW 2013a). This increased abundance of pink salmon was probably related to favorable marine survival, and favorable flow conditions during the egg incubation period (K. Adicks, pers. comm., WDFW, Resource Program Manager, September 27, 2010).

Table 3.2-19. Annual spawning escapements of natural-origin odd-year pink salmon, and total run size and harvest of hatchery-origin pink salmon from 1991 to 2009.

Year	Escapement of Natural-origin Pink Salmon	Total Run Size[1]	Harvest of Hatchery-origin Pink Salmon	
			Number	Percent of Total Pink Salmon Harvest[2]
1991	776,600	1,094,210	905	0.3
1993	839,642	1,062,275	640	0.3
1995	1,431,530	2,110,401	1,587	0.2
1997	294,390	441,229	2,344	1.6
1999	897,998	954,297	17	< 0.1
2001	3,161,493	3,548,996	563	0.2
2003	2,433,048	2,906,354	931	0.2
2005	1,186,839	1,228,260	357	0.9
2007	2,359,590	2,446,559	118	0.1
2009	8,612,877	9,837,251	3,423	0.3

Source: WDFW data.
[1] Natural-origin and hatchery-origin pink salmon spawning escapement plus harvest.
[2] Percentage of the total harvest (total run size minus escapement) that is hatchery-origin pink salmon.

3.2.11.3 Description of Hatchery-origin Pink Salmon

Hatchery-origin pink salmon are released as fry in April at a time when natural-origin Chinook salmon fry, parr, and yearlings; sockeye salmon fry; and coho salmon parr and yearlings are out-migrating in freshwater rivers and streams (Table 3.2-4). Pink salmon are reared in hatcheries only to the fry life stage and no yearlings are released. The fish are released at an average length of 2.0 inches (50 mm) fork length (Table 3.2-4).

Pink salmon are released near marine waters from two isolated harvest hatchery programs and one integrated conservation program (Table 3.2-5). The total number of juvenile hatchery-origin pink salmon produced annually averages 4.5 million fry (Table 3.2-6).

Puget Sound pink salmon contribute to commercial and recreational fisheries primarily during fisheries aimed at Chinook salmon (NMFS 2004a), but at low levels (Table 3.2-19). From 1991 to 2009, harvest of hatchery-origin Puget Sound pink salmon ranged from a low of 17 fish in 1999 to a high of about 3,400 fish in 2009 (Table 3.2-19). The low harvest numbers reflect the small number of pink salmon hatchery programs in Puget Sound (three programs), and low hatchery production levels compared to other salmon species (Table 3.2-6).

3.2.11.4 Hatchery Program Risks and Benefits

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, by providing a summary of the current risks of hatchery programs to natural-origin pink salmon. Risks and benefits to natural-origin pink salmon from salmon and steelhead are qualitatively evaluated based on inferences from the general relationship between pink salmon and other salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects, risks and benefits for pink salmon are evaluated qualitatively and generally do not use the four rating categories and terms as used for listed salmon, steelhead, and trout (with the exception of hatchery facilities and operation risk). Rather, risks and benefits are generally described using relative qualitative terms (e.g., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.11.4.1 Risks - Competition

The effects of competition between hatchery-origin fish and natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. This risk category includes effects from juvenile and adult fish, as well as effects which may occur in fresh water and marine water. Competition is greatest where and when species overlap in space and time and share a demand for resources that are in limited supply. Pink salmon, like chum salmon and fall-run Chinook salmon, have life histories involving very short freshwater residence periods. After emergence, the small natural-origin fry out-migrate promptly to marine waters. Similar-sized hatchery-origin pink salmon fry are generally released from hatcheries prior to the peak out-migration period for natural-origin pink salmon (Figure 3.2-11), which would result in minimal competition risks. Thus, competition risks from hatchery-origin pink salmon to natural-origin pink salmon are not considered further in this EIS.

In contrast, releases of the similar sized hatchery-origin chum salmon may pose a competition risk to natural-origin pink salmon because they are primarily released during the pink salmon peak out-migration period (Figure 3.2-11). After their release from hatcheries, chum salmon fry may compete with pink salmon fry for food and rearing space in freshwater and nearshore marine areas where the groups interact (SIWG 1984).

Other hatchery-origin salmon (Chinook salmon, sockeye salmon, coho salmon) and steelhead are not likely to pose risks of competition effects to natural-origin pink salmon because they are larger, their diet preferences are different from pink salmon, and/or because they are not released during the pink salmon peak out-migration period (Figure 3.2-11). Pink salmon release locations are close to marine water and decrease the potential for competition effects on natural-origin pink salmon in fresh water.

In summary, hatchery-origin chum salmon pose the primary competition risk to natural-origin pink salmon because of their similar size and because hatchery-origin chum salmon are released during the peak out-migration period for natural-origin pink salmon.

3.2.11.4.2 Risks - Predation

The effects of predation by hatchery-origin fish on natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. These risks may occur where and when piscivorous predators overlap in space and time with natural-origin fish of a size vulnerable to predation. Risks of predation are greatest when large numbers of hatchery-origin smolts encounter newly emerged fry, and when hatchery-origin fish are large relative to the natural-origin fish (SIWG 1984). Because of their comparatively large size (Table 3.2-4), yearling releases of hatchery-origin Chinook salmon, steelhead, and coho salmon may prey on natural-origin pink salmon fry in freshwater and adjacent marine areas. However, these effects would be of short duration because the hatchery-origin fish would disperse seaward after release, beyond the shallow estuarine and nearshore marine areas where natural-origin pink salmon fry congregate for a few weeks (as reviewed in Appendix D, PCD RISK 1 Assessment).

Hatchery-origin steelhead and coho salmon yearlings are released during the peak out-migration period for natural-origin pink salmon fry, and some hatchery-origin Chinook salmon subyearlings and yearlings are also released during that same period (Figure 3.2-11). Thus, predation impacts to natural-origin pink salmon may occur in fresh water. However, similar to the size considerations above, effects would be of short duration because the hatchery-origin fish would disperse seaward after release, beyond the marine areas in which natural-origin pink salmon congregate for a few weeks before dispersing seaward. Predation effects to natural-origin pink salmon from hatchery-origin pink salmon, chum salmon, and sockeye salmon are unlikely because of similarities in fish size, their lack of piscivorous diets, and/or lack of overlaps in time of release with the peak out-migration timing of natural-origin pink salmon. Thus, predation effects from hatchery-origin pink salmon, chum salmon, and sockeye salmon on natural-origin pink salmon are not considered further in this EIS.

In summary, predation may occur on natural-origin pink salmon in freshwater and adjacent marine areas from releases of hatchery-origin yearling steelhead, yearling coho salmon, and yearling and subyearling Chinook salmon because of the larger size of these hatchery-origin fish compared to natural-origin pink salmon fry, and because releases of the hatchery-origin fish occur during the peak out-migration period for natural-origin pink salmon.

3.2.11.4.3 Risks - Genetics

Genetic risks from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. The risks to natural-origin pink salmon are associated with potential hatchery-induced selection effects on pink salmon reared in hatcheries, and the potential for these hatchery-origin adult pink salmon to stray and interbreed with natural-origin pink salmon, which may result in reductions in genetic diversity and long-term fitness of natural-origin fish.

Genetic risks to natural-origin pink salmon in the project area are minimal because of the limited number and size of the pink salmon hatchery programs, use of hatchery broodstocks derived from local natural-origin stocks (integrated programs), the short duration of rearing in the hatchery (which limits hatchery-induced selection effects [Berejikian et al. 2009]), the small number of returning hatchery-origin adults compared to the total returns of natural-origin pink salmon, and the locations of release sites that are removed from major natural-origin pink salmon production areas and marine areas. Thus, genetic risks to pink salmon are not considered further in this EIS.

3.2.11.4.4 Risks - Hatchery Facilities and Operation

Hatchery facilities and operation risks from hatchery-origin salmon and steelhead programs to natural-origin salmon and steelhead are generally described in Subsection 3.2.3.4, Risks - Hatchery Facilities and Operation, and Appendix B, Hatchery Effects and Evaluation Methods for Fish. Pink salmon are produced at hatcheries that also produce other salmon or steelhead. These facilities use the same BMPs (e.g., broodstock collection, spawning, fish release, disease control, and use of water and barriers) for pink salmon that are used for production of the other salmon and steelhead. Hatchery facilities and operation risks for natural-origin Chinook salmon and steelhead are low, as described in Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon], and Subsection 3.2.7.4.4, Risks - Hatchery Facilities and Operation [Steelhead]), because most programs operate in compliance with BMPs (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation [Chinook Salmon], and Subsection 3.2.7.4.4, Risks - Hatchery Facilities and Operation [Steelhead]).

Returns of natural-origin pink salmon are considerable (Subsection 3.2.11.2, Distribution and Abundance of Natural-origin Pink Salmon) and there are only a small number of pink salmon hatchery programs (three programs); thus, hatchery production of pink salmon is considerably less than the production levels for other salmon species (Table 3.2-6). Therefore, considering all pink salmon hatchery programs, the overall hatchery facilities and operation risk to pink salmon is negligible, because there are few pink salmon programs and most operate in compliance with BMPs.

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, there is one hatchery where dewatering impacts pink salmon: Voights Creek Hatchery (Puyallup River watershed). However, effects of water withdrawals for operation of this hatchery are likely minimal because the withdrawal affects limited areas on a small tributary, which does not form a major spawning area for the species. Therefore, effects of water withdrawals on natural-origin pink salmon are not considered further in this EIS.

3.2.11.4.5 Benefits - Total Return

The total return of hatchery-origin pink salmon returning to fisheries can provide harvest benefits. Benefits from hatchery-origin salmon and steelhead to the total return of salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Most pink salmon harvested are natural-origin fish (Table 3.2-19). In contrast, from 2005 to 2009, harvest of hatchery-origin pink salmon ranged from 118 to 3,423 fish, and contributed less than 1 percent (0.4 percent) to the total harvest of Puget Sound pink salmon (Table 3.2-19). Thus, the overall total return benefits to total harvest of the species from the two isolated pink salmon hatchery programs intended to produce fish for harvest and one new integrated conservation program (Elwha pink salmon program) are minimal, and are not considered further in this EIS.

3.2.11.4.6 Benefits - Viability

Benefits can accrue to the viability of fish species when genetic resources important to the ESU reside in fish produced by hatchery programs. Viability benefits from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Viability benefits to natural-origin pink salmon vary depending on the hatchery program. Viability benefits to natural-origin pink salmon could occur from the one integrated conservation hatchery program for pink salmon (Elwha pink salmon program). That program is too new for viability benefits to natural-origin pink salmon to be evaluated. However, because there is only one pink salmon hatchery program with the potential to benefit viability at a local scale, the viability benefit to natural-origin pink salmon overall is assumed to be minimal, because there is only one integrated conservation hatchery program in the entire project area. Thus, viability as a benefit for pink salmon is not considered further in this EIS.

3.2.11.4.7 Benefits - Marine-derived Nutrients

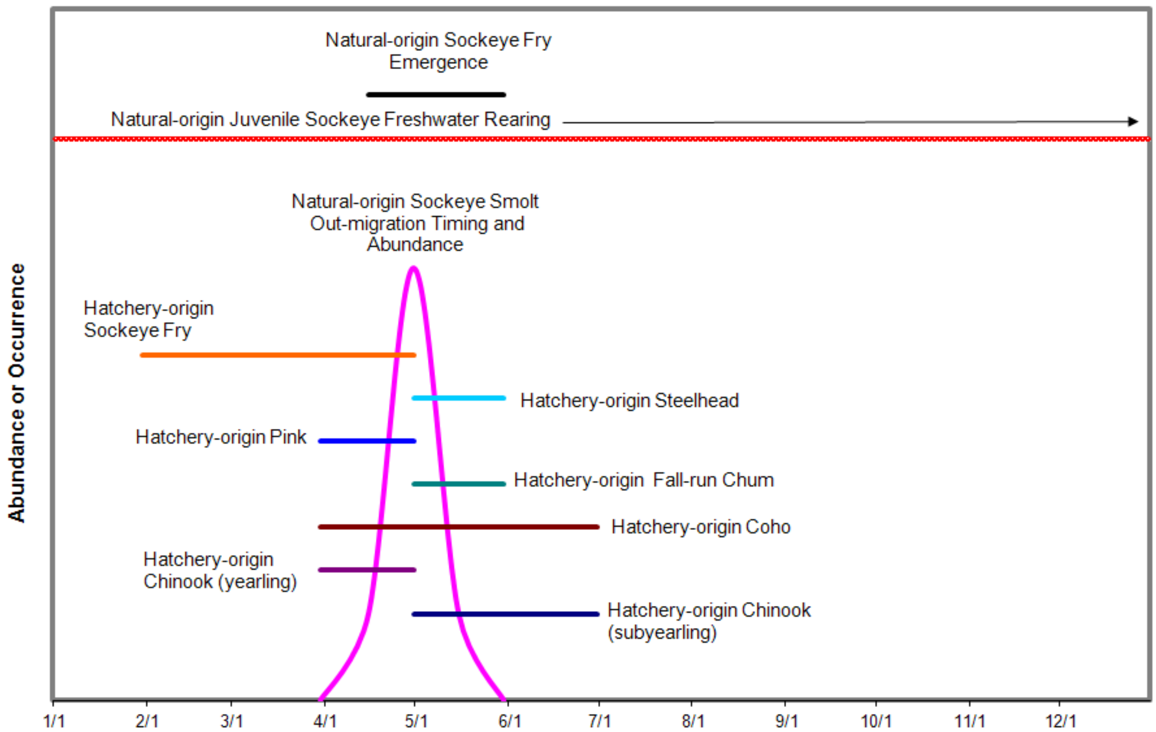
As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, salmon and steelhead carcasses provide a direct food source for juvenile salmon and steelhead, other fish, aquatic invertebrates, and terrestrial animals, and the decomposition of carcasses supplies nutrients that increase primary and secondary production and benefit the ecosystem. Natural-origin and hatchery-origin pink salmon spawners contribute 31 percent of the total biomass of carcasses from all salmon and steelhead species that supply marine-derived nutrients to the project area (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, relatively few carcasses distributed from WDFW hatcheries into the natural environment in recent years have been pink salmon (1 percent) (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Thus, marine-derived nutrients as a benefit for pink salmon are negligible.

3.2.12 Sockeye Salmon

This subsection describes sockeye salmon in Puget Sound. In its 1999 status review, NMFS delineated one sockeye salmon ESU that occurs in Puget Sound, which comprises naturally spawning sockeye salmon returning to the Baker River in the Skagit River watershed (Gustafson et al. 1997). Although sockeye salmon occur in other watersheds in Puget Sound, including Lake Washington, they were not deemed to be ESUs or parts of ESUs because the fish were believed to be non-local populations resulting from transplants. NMFS determined that ESA listing was not warranted for the Baker River Sockeye Salmon ESU (64 Fed. Reg. 14528, March 25, 1999). This EIS emphasizes the Baker River Sockeye Salmon ESU, and addresses three other sockeye salmon stocks that spawn in the Lake Washington watershed. Gustafson et al. (1997) acknowledged the occurrence of riverine-spawning sockeye salmon that spawn in some other rivers (e.g., Nooksack, Skagit, and Sauk Rivers), but found that information was insufficient to determine their ESU status. Sockeye salmon are not listed as threatened, endangered, or a species of concern by Washington State (WDFW 2014b). Kokanee are the non-anadromous life history form of sockeye salmon (*Oncorhynchus nerka*) that spend their entire life cycle in fresh water, and are described in Subsection 3.2.18.1, Kokanee.

3.2.12.1 Life History of Natural-origin Sockeye Salmon

The life history of Puget Sound sockeye salmon is described in detail in Gustafson et al. (1997) and summarized below. Natural-origin sockeye salmon spawn in rivers and streams, and along lakeshores. Freshwater entry of adults occurs from mid-June through August, and spawning generally occurs from September through November, but can begin as early as August and, for some stocks, extend into February. After emerging from the gravel, sockeye salmon fry migrate downstream to the deep waters of nursery lakes from January through June, predominating in April and May (Figure 3.2-12), at an average length of 1.1 inches (28 mm) fork length (Table 3.2-4).



Sources: Natural-origin sockeye salmon data from Burgner (1991) for Lake Washington sockeye salmon. Hatchery-origin fish release data are from WDFW salmon and steelhead HGMPs, and WDFW and PNPTT (2000).

Figure 3.2-12. Typical duration of natural-origin sockeye salmon juvenile rearing, out-migration timing, and relative abundance, and predominant timing of juvenile hatchery-origin salmon and steelhead releases.

Natural-origin juvenile sockeye salmon in Puget Sound tend to rear in lakes for up to 2 years where they feed on aquatic insects and plankton. They out-migrate to sea, and once they move offshore, feed mainly on amphipods, copepods, squid, and some fishes.

3.2.12.2 Distribution and Abundance of Natural-origin Sockeye Salmon

The distribution and abundance of sockeye salmon in Puget Sound is generally related to rivers that have accessible lakes in their watersheds for juvenile rearing. Four natural-origin sockeye salmon stocks occur in Puget Sound: the Baker River Sockeye Salmon ESU (in the Skagit River watershed) and three stocks of non-local origin in the Lake Washington watershed. Prior to construction of Baker Dam, sockeye salmon ascended the Baker River. Currently, sockeye salmon are trapped and released above the dam to spawn along the lakeshore and in the upper Baker River.

The three natural-origin sockeye salmon stocks in the Lake Washington system are the Cedar River, northern Lake Washington tributaries, and Lake Washington beach spawners (WDF et al. 1993). Of the three, the Cedar River stock is the predominant stock, which originated from releases of Baker Lake and Cultus Lake (British Columbia) sockeye salmon that were transferred into the Cedar River from the 1930s to 1950s (Ames 2006). Natural spawning of the stock occurs in the lower 21 river miles of the Cedar River below Landsburg Dam. Natural production is supplemented by a recently constructed hatchery and spawning channel. Natural-origin sockeye salmon are also produced in tributaries to northern Lake Washington and Lake Sammamish, including Big Bear, Cottage Lake, North, and Little Bear Creeks (Ames 2006). Although the population structure of these stocks is not clear, DNA analysis suggests that all Lake Washington sockeye salmon stocks are, at least in part, descendants of introduced Baker Lake sockeye salmon (Spies 2002; Ames 2006).

Natural-origin sockeye salmon have also been observed spawning in several Puget Sound river systems that lack accessible lake habitat, including the Nooksack, Skagit, Stillaguamish, Green, and Skokomish Rivers (Gustafson et al. 1997; Gustafson and Winans 1999).

Spawning escapement provides an indication of the abundance of natural-origin sockeye salmon in Puget Sound (Table 3.2-20). From 1995 to 2012, the combined annual natural-origin plus hatchery-origin sockeye salmon escapement to the Baker River ranged from 2,181 fish in 1995 to 28,407 fish in 2012 (Table 3.2-20). Baker River sockeye salmon escapement is strongly dependent on the trap and haul program that provides fish access to spawning and rearing areas, and on hatchery production that supplements the population. From 1995 to 2012, Cedar River escapements have ranged from 15,408 fish in 2009 to 237,981 fish in 1996 (Table 3.2-20). The combined annual natural-origin plus hatchery-origin escapement to north Lake Washington tributaries (e.g., Big Bear, Cottage Lake, and Issaquah Creeks) from 1995 to 2008 has varied from 677 fish in 2008 to 82,090 fish in 2000 (Table 3.2-20).

Table 3.2-20. Annual spawning escapements (natural-origin plus hatchery-origin) and harvest, and total returns of sockeye salmon to the Baker River and Lake Washington system (Cedar River, and north Lake Washington [Lake Sammamish] tributaries) from 1995 to 2012.

	Baker Lake			Lake Washington			
Year	**Escapement**	**Harvest**	**Total Returns**	**Cedar River Escapement**	**North Tributaries Escapement**	**Harvest**	**Total Returns**
1995	2,181	60	2,241	24,895	4,196	790	29,881
1996	7,769	8	7,777	237,981	75,261	139,263	452,865
1997	7,0993,418	168	7,267	109,295	11,126	2,305	122,726
1998	13,18713,187	188	13, 375	54,403	11,087	3,542	69,032
1999	4,6544,654	3	4,657	23,670	2,080	937	26,887
2000	10,40410,504	406	10,810	156,880	82,090	119,431	358,401
2001	4,9424,942	90	5,032	124,774	14,930	3,817	143,521
2002	4,0234,023	16	4,093	203,619	56,700	66,457	326,776
2003	20,23620,236	731	20,967	115,363	3,365	3,994	122,722
2004	9,11310,779	2,222	11,335	125,533	16,107	55,598	197,238
2005	3,1923,191	395	3,587	55,162	5,824	1,351	62,337
2006	8,3258,325	1,548	9,873	114,584	26,727	115,560	256,871
2007	2,7632,763	953	3,716	47,183	1,900	468	49,551
2008	3,2113,211	2,502	5,713	19,226	677	2,118	22,021
2009	6,4866,487	275	6,761	15,408	960	1	16,369
2010	18,80918,809	3,967	22,776	66,910	16,966	2,803	86,679
2011	27,18727,195	9,888	37,075	30,266	1,464	619	32,349
2012	28,40728,407	20,439	48,846	101,135	9,830	4,217	115,182

Sources: Baker Lake sockeye salmon data are from A. Dufault, pers. comm., WDFW, Fish Biologist, March 4 and 5, 2014.

3.2.12.3 Description of Hatchery-origin Sockeye Salmon

The majority (99 percent) of hatchery-origin sockeye salmon (35,000,000) are released as fry (Table 3.2-6) from February through April (Figure 3.2-12). Small numbers of fingerlings and yearlings (Table 3.2-6) are also released in Baker Lake in the spring and fall. These releases occur at a time when natural-origin Chinook salmon fry and yearlings; steelhead smolts; coho salmon fry, parr, and yearlings; chum salmon fry; pink salmon fry; and sockeye salmon fry are out-migrating in freshwater rivers and streams (Table 3.2-4). Hatchery-origin sockeye salmon fry are released at an average length of 1.2 inches (30 mm) fork length (Table 3.2-4).

Sockeye salmon are released from two hatchery programs into two lake systems. The Baker Lake integrated conservation sockeye program releases fry, subyearlings, and yearlings from Baker Lake sockeye spawning beach facilities into Baker Lake. The Cedar River integrated harvest sockeye program in the Lake Washington system releases fry from the Cedar River Hatchery into the Cedar River.

Sockeye salmon can contribute to commercial and recreational fisheries, with relatively small numbers of sockeye salmon harvested in commercial fisheries in Bellingham Bay and Samish Bay that target Chinook salmon (NMFS 2004a). For example, from 1995 to 2012 the harvest of Baker Lake sockeye salmon ranged from 3 fish in 1999 to 20,439 fish in 2012 (Table 3.2-20). In addition, in Lake Washington, sporadic recreational and tribal commercial sockeye salmon fisheries occur when run size is expected to exceed the escapement goal of 350,000 (NMFS 2004a). From 1995 to 2012, harvest of sockeye salmon ranged from 1 fish in 2009 to 139,263 fish in 1996 (Table 3.2-20). The overall low numbers of sockeye harvested reflects the small number of sockeye salmon hatchery programs in Puget Sound (two programs), and low hatchery production levels compared to other salmon species (Table 3.2-6).

3.2.12.4 Hatchery Program Risks and Benefits

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, by providing a summary of the current risks of hatchery programs to natural-origin sockeye salmon. Risks and benefits to natural-origin sockeye salmon from salmon and steelhead hatchery programs are qualitatively evaluated based on inferences from the general relationship between sockeye salmon and other salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish). As described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects, risks and benefits for sockeye salmon are evaluated qualitatively and do not use the four rating categories and terms as used for listed salmon, steelhead, and trout. Rather, risks and benefits are generally described using relative qualitative terms (e.g., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.12.4.1 Risks - Competition

The effects of competition between hatchery-origin fish and natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. This risk category includes effects from juvenile and adult fish, as well as effects that may occur in fresh water and marine water. Competition is greatest where and when species overlap in space and time and share a demand for resources that are in limited supply. All hatchery-origin species are released during at least part of the peak natural-origin sockeye salmon smolt out-migration period (Figure 3.2-12).

As described in Subsection 3.2.12.1, Life History of Natural-origin Sockeye Salmon, most juvenile sockeye salmon rear in lakes and feed on aquatic insects and plankton. Other salmon and steelhead species do not have natural lake rearing life histories similar to sockeye salmon, and hatchery releases do not generally occur in lake systems. Thus, effects of competition in fresh water from hatchery-origin fish are mostly confined to streams and rivers below lakes that natural-origin sockeye salmon smolts use as migration corridors to marine areas.

Of all hatchery-origin species, coho salmon yearlings (5.5 inches [140 mm] fork length) are most likely to compete with natural-origin sockeye salmon smolts (4.9 inches [125 mm] fork length) because of similarities in size (Table 3.2-4). However, the diet preferences of the two species differ, which decreases the likelihood of competition effects. Other hatchery-origin salmon species and steelhead are not likely to pose competition risks to natural-origin sockeye salmon, primarily because of size differences (Table 3.2-4), although differences in diet preferences also contribute to reducing the likelihood of competition. Thus, competition effects from other hatchery-origin salmon and steelhead species to natural-origin sockeye salmon are not considered further in this EIS.

It is unlikely that competition occurs between the similar sized hatchery-origin sockeye salmon fry (1.2 inches [30 mm] fork length) and natural-origin sockeye salmon fry (2.0 inches [51 mm] fork length) in Baker Lake, mainly because of size differences and because the hatchery-origin fish are released primarily outside the peak out-migration period for natural-origin sockeye salmon (Figure 3.2-4). In the Cedar River, effects of competition from hatchery-origin sockeye salmon to natural-origin sockeye salmon are not a conservation concern because the natural-origin stock is of non-indigenous origin (Seattle Public Utilities 2005; WDFW 2005). Thus, hatchery-origin sockeye salmon as competitors to natural-origin sockeye salmon are not considered further in this EIS.

In marine waters, because of their co-occurrence and similarities in size, hatchery-origin Chinook salmon yearlings and coho salmon yearlings have the greatest potential to pose competition risks to natural-origin sockeye salmon smolts. However, competition impacts on natural-origin sockeye salmon smolts from these species are unlikely because of differences in diet preferences and migration behaviors of the species in the marine environment (Duffy et al. 2005). Thus, competition in marine waters between hatchery-origin fish and natural-origin sockeye salmon is not considered further in this EIS.

In summary, hatchery-origin coho salmon yearlings are the most likely competitors with natural-origin sockeye salmon in fresh water and marine water because they are released in locations where natural-origin sockeye salmon occur, are released during the peak sockeye salmon out-migration period, and are similar in size to natural-origin sockeye salmon smolts.

3.2.12.4.2 Risks - Predation

The effects of predation by hatchery-origin fish on natural-origin fish are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. These risks may occur where and when piscivorous species overlap in space and time with natural-origin fish of a size vulnerable to predation. Risks of predation are greatest when large numbers of hatchery-origin smolts encounter newly emerged fry and when hatchery-origin fish are large relative to the natural-origin fish (SIWG 1984). As described in Subsection, 3.2.12.1, Life History of Natural-origin Sockeye Salmon, most juvenile sockeye salmon rear in lakes and feed on aquatic insects and plankton. Other salmon and steelhead species do not have lake-rearing life histories like sockeye salmon, and hatchery releases are generally not made into lake systems. Thus, effects of predation from hatchery-origin species are mostly confined to streams and rivers below lakes that natural-origin sockeye salmon smolts use as migration corridors to marine areas.

In general, natural-origin sockeye salmon smolts (4.9 inches [125 mm] fork length) may be most impacted by predation (in fresh water) from hatchery-origin steelhead yearlings because of the large size of steelhead smolts (8.1 inches [206 mm] fork length) and their release during the peak out-migration period for natural-origin sockeye salmon (Figure 3.2-12). Hatchery-origin steelhead are not released in the Baker River watershed or the Cedar River watershed, and thus are not predators of natural-origin sockeye salmon in those locations. However, hatchery-origin steelhead are released in the Skagit River watershed and are larger than natural-origin sockeye salmon smolts, and thus are likely to pose a predation risk to natural-origin Baker Lake sockeye salmon.

Predation by hatchery-origin Chinook salmon yearlings (6.1 inches [155 mm] fork length) and coho salmon (5.5 inches [140 mm] fork length) on sockeye salmon smolts (4.9 inches [125 mm] fork length) (Table 3.2-4) is unlikely because of the size similarities, and, in lakes, because of the spatial separation resulting from different feeding, schooling, and resting strategies (Burgner 1991). In addition, predation is limited because the coho salmon and Chinook salmon released in Lake Washington actively out-migrate as smolts and leave the lake system within a few weeks (as reviewed in Appendix D, PCD RISK 1 Assessment). Hatchery-origin sockeye salmon, pink salmon, and chum salmon are not considered predators because they are only released as fry that are small (2.0 inches [50 mm] fork length or less).

Thus, hatchery-origin Chinook salmon, coho salmon, pink salmon, chum salmon, and sockeye salmon as predators to natural-origin sockeye salmon are not considered further in this EIS.

In summary, overall predation risks to sockeye salmon are most likely to occur in fresh water from hatchery-origin steelhead yearlings, because the steelhead are released during the sockeye salmon peak out-migration period and are of a size that is capable of preying on natural-origin sockeye salmon during the sockeye salmon peak out-migration period.

3.2.12.4.3 Risks - Genetics

Genetic risks from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. The risks to natural-origin sockeye salmon are primarily associated with potential hatchery-induced selection effects on sockeye salmon reared in hatcheries. However, genetic risks to natural-origin sockeye salmon from hatchery production are minimal because of the nature of the relationship of hatchery-origin sockeye to the natural-origin sockeye salmon in Puget Sound. For example, genetic risks to natural-origin sockeye salmon from straying by hatchery-origin sockeye salmon are unlikely because there is only one sockeye salmon ESU (Baker Lake Sockeye Salmon ESU), and hatchery-origin sockeye salmon stocks that may stray are related to that ESU.

The Baker Lake Hatchery produces listed sockeye salmon as part of an integrated conservation program for the Baker Lake Sockeye Salmon ESU. Genetic risks to the natural-origin Baker Lake sockeye salmon population associated with the hatchery program are inconsequential because broodstock are derived from the natural-origin Baker Lake Sockeye Salmon ESU, a large number of spawners are used (at least 3,000 fish), and hatchery operations use strategies that mimic natural spawning conditions (i.e., hatchery-origin spawners use artificial Baker Lake beaches), which collectively limit risks of hatchery-induced selection effects (Berejikian et al. 2009).

The Cedar River Hatchery in the Lake Washington system produces non-listed sockeye salmon as part of an integrated harvest program. Genetic risks to natural-origin Cedar River sockeye salmon associated with the program are not a concern because the hatchery program sustains the naturally spawning stock and the natural-origin and hatchery-origin components are genetically indistinguishable. Broodstock are from transplanted, non-local stock derived from Baker Lake sockeye salmon that have become localized to, and are now trapped in, the Cedar River. The hatchery program uses a large number of spawners and strategies to avoid genetic risks (juveniles are not in the hatchery long, and are released as unfed fry), thus minimizing the potential for hatchery-induced selection effects. As a result, overall genetic risks to sockeye salmon are minimal, and are not considered further in this EIS.

3.2.12.4.4 Risks - Hatchery Facilities and Operation

Hatchery facilities and operation risks from hatchery-origin salmon and steelhead programs to natural-origin salmon and steelhead are generally described in Subsection 3.2.3.4, Risks - Hatchery Facilities and Operation, and Appendix B, Hatchery Effects and Evaluation Methods for Fish. No other salmon species or steelhead are produced at the hatchery facilities used to produce sockeye salmon. Thus, sockeye salmon hatchery programs comply with BMPs associated with broodstock sources and numbers of spawners, and it is likely that BMP compliance for the two sockeye salmon hatchery programs would be similar to that for Chinook salmon and steelhead because hatchery facilities and BMPs are likely to be similar. In addition, because there are only two hatchery programs for sockeye salmon in the entire project area, it is likely that the overall hatchery facilities and operation risk to natural-origin sockeye salmon is negligible.

3.2.12.4.5 Benefits - Total Return

The total return of hatchery-origin sockeye salmon returning to fisheries can provide harvest benefits. Benefits from hatchery-origin salmon and steelhead to the total return of salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. The total return benefit to sockeye salmon (Table 3.2-8) likely occurs from the Cedar River sockeye salmon integrated harvest program and, to a lesser extent, the smaller-sized Baker Lake integrated conservation sockeye program.

3.2.12.4.6 Benefits - Viability

Benefits can accrue to the viability of fish species when genetic resources important to the ESU reside in fish produced by hatchery programs. Viability benefits from hatchery-origin salmon and steelhead to natural-origin salmon and steelhead are generally described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. This type of benefit may occur from both of the integrated sockeye salmon hatchery programs to the extent the programs contribute to abundance and spatial structure benefits for the naturally spawning sockeye salmon populations.

3.2.12.4.7 Benefits - Marine-derived Nutrients

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, salmon and steelhead carcasses provide a direct food source for juvenile salmonids, other fish, aquatic invertebrates, and terrestrial animals, and the decomposition of carcasses supplies nutrients that increase primary and secondary production and benefit the ecosystem. Of the total biomass of carcasses from all salmon and steelhead species that supply marine-derived nutrients in the project area, natural-origin and hatchery-origin sockeye salmon spawners contribute only 4 percent (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, 25 percent of all carcasses distributed from WDFW hatcheries into the natural environment in recent years have been sockeye salmon (Appendix B, Hatchery Effects and Evaluation Methods for Fish). The hatchery-origin sockeye salmon carcasses result from only two hatchery programs, and the contribution of carcasses from them is more localized (e.g., Cedar River) than from the broader distribution of hatchery programs for other species that distribute carcasses more widely. Based on the overall contribution of sockeye salmon carcasses, the marine-derived nutrient benefit from hatchery-origin sockeye salmon is considered a moderate benefit.

3.2.13 Rainbow Trout

This subsection describes rainbow trout, the non-anadromous form of the species *Oncorhynchus mykiss*. Steelhead are the anadromous form of the species and are described in Subsection 3.2.7, Puget Sound Steelhead DPS. Under the ESA, steelhead are under the regulatory jurisdiction of NMFS, whereas rainbow trout are under the jurisdiction of the USFWS. Rainbow trout are native to Puget Sound and have the potential to interact with salmon and steelhead (Scott and Gill 2008; Myers et al. 2014). Most information on rainbow trout results from data collection efforts targeted at other species, typically salmon and steelhead; thus, there is a high level of uncertainty about the species (Myers et al. 2014). Rainbow trout in the project area are not considered to be at risk of extinction, are not listed as a Federal species of concern, and are not listed as threatened, endangered, or a species of concern by Washington State (WDFW 2014b).

Rainbow trout are part of the other fish species group described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, and in contrast to listed salmon, steelhead, and trout, and non-listed salmon, risks and benefits for these other fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators). Descriptions of risks and benefits use qualitative evaluations that are generally described using relative terms (i.e., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.13.1 Life History of Rainbow Trout

Rainbow trout remain in fresh water for their entire life cycle, whereas steelhead reside in fresh water for 1 to 3 years before out-migrating to marine water as smolts to feed and mature for 1 to 3 years before returning to fresh water to spawn. Rainbow trout and steelhead use spawning gravels in rivers and streams, and can spawn in multiple successive years in the spring months. They appear to reside in similar areas during freshwater rearing and may interbreed. Studies in Puget Sound watersheds have been conducted on the biological relationships between co-occurring rainbow trout and steelhead (Phelps et al. 2001; Marshall et al. 2006; McMillan et al. 2007; Berejikian et al. 2013), but such relationships are poorly understood. Rainbow trout can produce anadromous offspring, and steelhead can produce non-anadromous rainbow trout offspring (Narum et al. 2008; Scott and Gill 2008). The maximum life span for resident rainbow trout is typically 6 years. Rainbow trout feed on insects, crayfish, and other crustaceans. Adults feed on fish eggs, alevins (newly hatched salmon and steelhead), fry, smolts, and salmon and steelhead carcasses.

3.2.13.2 Distribution and Abundance of Rainbow Trout

Natural-origin rainbow trout are found in streams and rivers throughout Puget Sound (Myers et al. 2014). Hatchery-origin non-native resident rainbow trout produced for recreational fishery enhancement purposes are not released into waters accessible to anadromous salmon, but are distributed in Puget Sound lakes (Wydoski and Whitney 2003). The abundance of resident rainbow trout in project area watersheds has not been established (Myers et al. 2014).

3.2.13.3 Relationship to Salmon and Steelhead

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, which describes the categories of risks and benefits of salmon and steelhead hatchery programs on fish. Available studies generally do not indicate whether or not some fish species (including resident rainbow trout) distinguish between natural-origin and hatchery-origin salmon and steelhead in terms of competition, predation, or other risk or benefit categories. Therefore, because natural-origin salmon and steelhead generally resemble hatchery-origin salmon and steelhead in attributes such as behavior, size, and distribution, the relationships of hatchery-origin fish and resident rainbow trout are assumed to be the same as the relationships of natural-origin salmon and steelhead to resident rainbow trout. Thus, in absence of more specific information, the general information collectively serves as a proxy for relationships between hatchery-origin fish and natural-origin resident rainbow trout. Risks and benefits to rainbow trout from salmon and steelhead hatchery programs are qualitatively evaluated based on inferences from the general relationship between rainbow trout and salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Where resident rainbow trout and steelhead have evolved together over long time periods, it is reasonable to expect the coexistence of both forms (Scott and Gill 2008). Competition for food and space between the two forms, although limited, is likely greatest during the stream-rearing period for juvenile steelhead. However, resident rainbow trout are widely distributed and often inhabit the smaller or higher elevation streams not used by adult steelhead, and this partitioning reduces competition risks, including those associated with overlap in spawning areas. Available information does not indicate that rainbow trout prey on juvenile steelhead or are prey of steelhead (Scott and Gill 2008).

Hatchery-origin salmon and steelhead have the potential to compete with and prey on juvenile rainbow trout in areas where they overlap in space and time, especially when large numbers of hatchery-origin fish are released high in watersheds and in large numbers. However, competition would not be expected when rainbow trout are larger than the hatchery-origin fish because of differences in food preferences and space requirements. In contrast to competition, because of their large size, hatchery-origin Chinook salmon, coho salmon, and steelhead yearlings are potential predators of small juvenile rainbow trout where the species overlap. Overall, competition and predation risks to rainbow trout from hatchery releases are likely unsubstantial.

As described above, natural-origin steelhead and rainbow trout are naturally occurring life history forms (anadromous and resident, respectively) of the biological species *O. mykiss*. Returning steelhead from hatchery programs can interbreed with natural-origin resident rainbow trout, and to the extent the hatchery-origin steelhead are different from natural-origin steelhead, pose risks to the genetic diversity of resident rainbow trout. Where rainbow trout and steelhead interbreed, genetic risks to resident rainbow trout are likely greatest from hatchery-origin steelhead of Chambers Creek winter-run and Skamania summer-run lineages because the hatchery-origin fish are substantially diverged from natural-origin Puget Sound *O. mykiss* (Subsection 3.2.7.4.3, Risks - Genetics [Steelhead]). In contrast, genetic risks are likely less from the integrated conservation hatchery programs that use natural-origin broodstock (i.e., the Soos Creek Hatchery natural-origin winter-run steelhead program, the White River steelhead program, the Hood Canal Steelhead Supplementation program, and the Lower Elwha program), because the local sources of hatchery broodstocks are genetically related, and perhaps genetically indistinguishable, from the rainbow trout that may be affected by interbreeding with the hatchery-origin steelhead.

Resident rainbow trout may be incidentally harvested in fisheries aimed at salmon and steelhead depending on the overlap in fishery locations, the type of gear used to harvest salmon and steelhead, and the size and life stages of rainbow trout present. No information is available on the extent of incidental resident rainbow trout harvest in salmon and steelhead fisheries. However, because of differences in the size of fish (e.g., steelhead and salmon targeted in fisheries are larger than rainbow trout) and gear types used in salmon and steelhead fisheries, it is likely that harvest impacts on rainbow trout are minimal. Thus, this potential risk is not considered further in this EIS.

There are no known hatchery facilities and operation risks from hatchery programs, and hatcheries in the project area do not produce rainbow trout. Thus, hatchery facilities and operation risk, total return benefits, and marine-derived nutrient benefits are not considered further in this EIS because there is no hatchery production of rainbow trout.

Hatchery production may benefit the viability of resident rainbow trout to the extent that the rainbow trout are larger than the hatchery-origin fish (i.e., salmon fry) and use them as a food source, although this benefit is likely unsubstantial because of spatial separation between rainbow trout and potential hatchery-origin salmon prey.

3.2.14 Coastal Cutthroat Trout

This subsection describes coastal cutthroat trout (*Oncorhynchus clarkii clarkii*), a species native to Puget Sound, that occurs throughout the project area and expresses multiple life histories, including resident (non-anadromous) and migratory (freshwater and marine water) forms. In 1999, NMFS completed a status review for coastal cutthroat trout, identified proposed ESUs (Johnson et al. 1999), and determined that listing was not warranted for this species in Puget Sound (64 Fed. Reg. 16397, April 5, 1999). Subsequently, the USFWS assumed sole regulatory jurisdiction for the species (65 Fed. Reg. 21376, April 21, 2000). Coastal cutthroat trout in the project area are not considered to be at risk of extinction, are not listed as a Federal species of concern, and are not listed as threatened, endangered, or a species of concern by Washington State (WDFW 2014b). Factors for its decline include forest management, agricultural and livestock management, dams and barriers, urban and industrial development, mining, and estuary degradation (64 Fed. Reg. 16402, April 5, 1999). Most information on coastal cutthroat trout results from data collection efforts targeted at other species, typically salmon and steelhead; thus, there is a high level of uncertainty about the species (Leider 1997; Johnson et al. 1999; Anderson 2008).

Coastal cutthroat trout are part of the other fish species group described in Subsection 3.2.1, Introduction, and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, and in contrast to listed salmon, steelhead, and trout, and non-listed salmon, risks and benefits for these other fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators). Descriptions of risks and benefits use qualitative evaluations that are generally described using relative terms (i.e., likely, minimal). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish, and the reasoning for this is described in Subsection 3.2, Fish.

3.2.14.1 Life History of Coastal Cutthroat Trout

In general, there are three life-history forms of coastal cutthroat trout: 1) a non-migratory form (also known as resident cutthroat trout) that occurs only in fresh water in small streams and upper headwater tributaries, and exhibits little instream movement; 2) a freshwater-migratory form that migrates entirely within fresh water, sometimes between lakes and tributaries, for spawning; and 3) a marine water-migratory (anadromous) form (also known as sea-run cutthroat trout) that spawns in fresh water and migrates to the ocean or estuary before returning to spawn (Johnson et al. 1999). Like steelhead, progeny of freshwater-migratory and marine water-migratory cutthroat trout parents can exhibit either life history (Johnson et al. 1999). Also like steelhead, coastal cutthroat do not die after spawning and are able to spawn in multiple successive years (Johnson et al. 1999). The average length of adult coastal cutthroat trout ranges from 6 to 20 inches (152 to 508 mm) fork length with resident forms smaller in size (Johnson et al. 1999).

The freshwater forms of coastal cutthroat trout are represented by several life history types that live entirely within fresh water, varying by the extent to which they move between streams, rivers, and lakes for rearing and spawning (Johnson et al. 1999). The resident form of coastal cutthroat trout spawns in smaller headwater streams and tributaries of watersheds (often above natural barriers that prevent access by anadromous fish) throughout the project area in the spring, and exhibits little instream movement.

Juveniles of the freshwater-migratory form spawn in headwater areas and rear there for about 1 year before migrating downstream into mainstem river areas or lakes, where they may rear for up to 9 years, and then return to headwater streams and tributaries to spawn.

The anadromous form of coastal cutthroat trout typically spawns from December through June, with peak spawning in February (Johnson et al. 1999). Anadromous cutthroat trout typically spawn in upper tributary areas where the emerging fry are at minimal risk of competition with salmon and steelhead. Juvenile anadromous coastal cutthroat trout rear in streams for 2 to 4 years before out-migrating to marine water at an average length of approximately 6 inches (160 mm) fork length for 2-year-old fish (Johnston 1979). Unlike other anadromous salmon and steelhead that spend multiple years feeding at sea, coastal cutthroat trout remain within a few miles of nearshore areas and the coast, with some fish overwintering in freshwater streams and feeding at sea only during the warmer months (Johnson et al. 1999). In rivers with extensive estuary systems, coastal cutthroat trout may move to intertidal areas to feed. They may also move upriver or out to sea on feeding migrations at sizes ranging from about 8 to 10 inches (200 to 250 mm) fork length (Johnson et al. 1999).

Coastal cutthroat trout are opportunistic feeders, eating primarily aquatic insects, although larger cutthroat trout in marine areas may feed entirely on fish (Trotter 1997; Jauquet 2003). Post-spawning coastal cutthroat trout and adults are known to feed on out-migrating juveniles of other salmon species in both freshwater and estuarine habitats (Pearcy 1997; Northcote 1997).

3.2.14.2 Distribution and Abundance of Coastal Cutthroat Trout

All life history forms of coastal cutthroat trout are found in streams and rivers throughout the project area. The anadromous life history type is generally found in streams at lower elevations and in lower gradient waters that are downstream of barriers to upstream migration, whereas resident and freshwater-migratory forms are generally found upstream of barriers. However, all forms generally spawn in upper headwater areas that are generally not used by other salmon and steelhead for spawning (Johnson et al. 1999).

The abundances of coastal cutthroat trout in the project area are generally not well known because most information on the species results from data collection efforts targeted at other species, typically salmon and steelhead (Johnson et al. 1999; WDFW 2000; Anderson 2008), and available abundance indices for this species generally are the result of ancillary efforts aimed at salmon and steelhead (e.g., through smolt trapping, and escapement and abundance surveys), indicating the populations are generally small (Anderson 2008).

Coastal cutthroat trout are not produced in hatcheries in the project area (Leider 1997; Anderson 2008).

3.2.14.3 Relationship to Salmon and Steelhead

This subsection supplements the general information in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, which describes the categories of risks and benefits of salmon and steelhead hatchery programs on fish. Available studies generally do not indicate whether or not some fish species (including coastal cutthroat trout) distinguish between natural-origin and hatchery-origin salmon and steelhead in terms of competition, predation, or other risk or benefit categories. Therefore, because natural-origin salmon and steelhead generally resemble hatchery-origin salmon and steelhead in attributes such as behavior, size, and distribution, the relationships of hatchery-origin fish and coastal cutthroat trout are assumed to be the same as the relationships of natural-origin salmon and steelhead to coastal cutthroat trout. Thus, in absence of more specific information, the general information collectively serves as a proxy for relationships between hatchery-origin fish and natural-origin coastal cutthroat trout. Risks and benefits to coastal cutthroat trout from salmon and steelhead hatchery programs are qualitatively evaluated based on inferences from the general relationship between coastal cutthroat trout and salmon and steelhead, considering the best available scientific information (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Although interactions can occur, life history traits of coastal cutthroat trout differ from salmon and steelhead, which helps to minimize the likelihood of overlap and interspecific competition for shared resources (Johnson et al. 1999). For example, natural-origin subyearling coho salmon and juvenile coastal cutthroat trout tend to partition their preferred habitats (Trotter 1989), and salmon and coastal cutthroat trout spawn in different areas (Johnson et al. 1999).

In areas where the species overlap, competitive interactions can occur between coastal cutthroat trout and salmon and steelhead. Generally, non-migratory freshwater resident coastal cutthroat trout that occur above barriers do not compete with salmon and steelhead. However, the freshwater-migratory and anadromous forms of coastal cutthroat trout can compete with salmon and steelhead in fresh water, and anadromous coastal cutthroat trout can compete in marine areas as well. Competition for food and space would not be expected when co-occurring coastal cutthroat trout are larger than other species because food preferences and space requirements differ. However, in areas of overlap in fresh water and in marine areas, natural-origin and hatchery-origin yearling steelhead (6.5 inches [165mm] and 8.1 inches [206 mm] fork length, respectively) (Table 3.2-4), and hatchery-origin Chinook salmon yearlings (6.1 inches [155 mm] fork length) (Table 3.2-4) can compete with similarly-sized coastal cutthroat trout smolts and adults (6 to 10 inches [160 to 250 mm] fork length) (Subsection 3.2.14.1, Life History of Coastal

Cutthroat Trout). Because coastal cutthroat trout spawn in streams upstream from salmon and steelhead, the species is not expected to substantially compete with salmon and steelhead for spawning sites. Predation on small coastal cutthroat trout by larger hatchery-origin juvenile salmon and steelhead can occur in areas of overlap, but this effect is likely transitory as the hatchery-origin fish migrate to and through marine areas into the ocean. Overall, hatchery-origin Chinook salmon and steelhead yearlings pose risks of competition to coastal cutthroat trout in freshwater and marine areas. In addition, these hatchery-origin species and large coho salmon yearlings potentially pose risks of predation to freshwater-migratory and anadromous coastal cutthroat trout juveniles, although these risks are unlikely because temporal overlaps are limited.

Hybridization between anadromous coastal cutthroat trout and natural-origin steelhead is a natural occurrence (Campton and Utter 1985; Hawkins 1997). However, risks to the genetic diversity of coastal cutthroat trout can occur to the extent hatchery-origin steelhead interbreed with coastal cutthroat trout. This risk is likely unsubstantial because of the tendency of anadromous coastal cutthroat to spawn in areas upstream from areas used by steelhead.

Coastal cutthroat trout are not targeted in commercial fisheries and most harvest of the species is incidental to recreational fisheries targeting salmon and steelhead (Johnson et al. 1999). Harvest of coastal cutthroat trout is likely greatest when large coastal cutthroat trout are present during those fisheries and when gear types used are compatible with the harvest of coastal cutthroat trout. Thus, the potential risk of harvest is likely minimal because of its incidental nature, because coastal cutthroat trout are considerably smaller than the salmon and steelhead targeted in recreational fisheries, and because the gear types used in those fisheries would not target coastal cutthroat trout. Thus, this potential risk is not considered further in this EIS.

There are no known hatchery facilities and operation risks from hatchery programs, and hatcheries in the project area do not produce coastal cutthroat trout. However, as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, there are three hatcheries where hatchery facilities and operation-related dewatering may impact coastal cutthroat trout: North Fork/Johnson Creek Hatchery, Voights Creek Hatchery, and Minter Creek Hatchery. Water withdrawals for operation of these hatcheries are likely minimal because the withdrawals affect limited areas on tributaries that are small and do not form major spawning areas for the coastal cutthroat trout. As a result, the hatchery facilities and operation risk and total return benefits from hatchery production of coastal cutthroat trout are not considered further in this EIS.

Hatchery production may benefit the viability of coastal cutthroat trout to the extent that the cutthroat trout are larger than co-occurring hatchery-origin fish and use them as food sources. This benefit is likely greatest from releases of small hatchery-origin coho salmon, chum salmon, and pink salmon fry in areas of overlap with large juveniles and adult coastal cutthroat trout (e.g., lower river and estuary areas).

3.2.15 Sturgeon and Lamprey

This group consists of two species of sturgeon and three species of lamprey that occur in Puget Sound (Table 3.2-21). Like salmon, sturgeon and lamprey are anadromous species that spawn in fresh water and migrate to marine waters as they mature. These species are often subject to similar natural and anthropogenic effects on their habitat as salmon and steelhead (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Sturgeon and lamprey populations have declined, resulting in three of the five species that occur in Puget Sound being listed as Federal threatened species or species of concern, and/or being listed by Washington State as threatened or endangered. Many recovery efforts are also focused on the recovery of sturgeon and lamprey, which are an important historic and current food resource to Native American tribes for ceremonial, subsistence, and commercial harvests.

Table 3.2-21. Range in Puget Sound and status of sturgeon and lamprey and their potential types of interactions with salmon and steelhead.

Species	Range in Puget Sound	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead
Green sturgeon (*Acipenser medirostris*)	May forage in marine waters as adults	Southern DPS is a Federal threatened species; northern DPS is a Federal species of concern	Bycatch in salmon gill-net fisheries
White sturgeon (*A. transmontanus*)	May forage in marine waters	None	Bycatch in salmon gill-net fisheries
Pacific lamprey (*Lampetra tridentata*)	Throughout marine waters and rivers	Federal species of concern and state monitor species	Scavenger, parasite, and prey of salmon and steelhead; salmon and steelhead can prey on juvenile lamprey
River lamprey (*L. ayresi)*	Most river systems	Federal species of concern and state candidate species	Parasite and predator of salmon and steelhead; salmon and steelhead can prey on juvenile lamprey
Western brook lamprey (*L. richardsoni*)	Streams in central Puget Sound	Federal species of concern	Salmon and steelhead can feed on young and adult lamprey

Sturgeon and lamprey are part of the other fish species group described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, risks and benefits for these fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators).

3.2.15.1 Green Sturgeon

There are two green sturgeon DPSs. The Northern Green Sturgeon DPS includes all populations starting with the Eel River in California and extending northward. Fish that compose the northern DPS spawn in two rivers—the Klamath River in California and the Rogue River in Oregon (NMFS 2010a). The Southern Green Sturgeon DPS includes all populations south of the Eel River with the only known population being in the Sacramento River (Adams et al. 2002). The Southern Green Sturgeon DPS is listed as threatened under the ESA (71 Fed. Reg. 17757, April 6, 2006), and their critical habitat is designated (74 Fed. Reg. 52300, October 9, 2009). NMFS (2005c) concluded that the Northern Green Sturgeon DPS was not in danger of extinction now or likely in the future. However, because of lack of historical data or understanding of population trends, NMFS recommended that the northern DPS be designated a Federal species of concern (69 Fed. Reg. 19975, April 15, 2004).

Life History. Green sturgeon that occur in Puget Sound originate from watersheds in Oregon and California where the fish return to spawn every 3 to 5 years (Adams et al. 2002). Green sturgeon spawning has not been documented in any Puget Sound watershed (Adams et al. 2002; NMFS 2005c). After hatching, green sturgeon larvae spend 1 to 3 years in fresh water before they enter the ocean. Juvenile and adult green sturgeon are benthic feeders that prey on shrimp, amphipods, clams, worms, and small fish. The species disperses widely in the ocean after their out-migration from fresh water and before their return migration to spawn in fresh water. Green sturgeon can attain a size of 6.5 feet (2 m) during their marine residence period.

Distribution and Abundance. Both northern green sturgeon and the southern green sturgeon adults and/or subadults have been detected in telemetry studies in Puget Sound or through incidental capture in fisheries directed at other species. Fish from the ESA-listed Southern Green Sturgeon DPS are relatively uncommon in Puget Sound. The relatively few detections of fish from the Southern Green Sturgeon DPS indicate a low frequency of occurrence in Puget Sound, but available data also suggest that it resides in marine waters for a considerable time (NMFS 2008a). Coast-wide catch data show a decline in green sturgeon over time; however, bycatch of green sturgeon in the Klamath River has been relatively constant for the past 20 years (NMFS 2007).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the green sturgeon's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Green sturgeon occur in similar estuary habitat as salmon and steelhead; however, unlike salmon and steelhead, green sturgeon are benthic (bottom-dwelling) fish that feed on crustaceans and benthic invertebrates in estuaries and the ocean. Thus, the likelihood of competition and predation with salmon and steelhead is minimal. Furthermore, fisheries directed at salmon are unlikely to incidentally capture green sturgeon (NMFS 2010a). The primary risk to green sturgeon from salmon and steelhead fisheries is green sturgeon bycatch in salmon gill-net fisheries (NMFS 2009b). A few green sturgeon adults and/or subadults have been incidentally captured in fisheries in Puget Sound, mostly in trawl fisheries directed at groundfish (Adams et al. 2002). Sport fisheries directed at returning salmon in marine and estuarine areas within Puget Sound have minimal potential for intercepting sturgeon incidentally. Thus, the primary risk to green sturgeon from salmon and steelhead is incidental fisheries bycatch. Salmon and steelhead provide no benefits to green sturgeon.

3.2.15.2 White Sturgeon

White sturgeon originate from major river systems north and south of Puget Sound (Lower Columbia and Fraser Rivers), and their population status is considered healthy. Thus, white sturgeon are not listed.

Life History. The white sturgeon may use estuarine and marine habitats; however, the species spawns only in fresh water (Nelson et al. 2004). The species does not require the marine environment as part of its life history. White sturgeon can attain a maximum size of 13 feet (4 m) when mature. White sturgeon do not spawn in Puget Sound.

Like green sturgeon, white sturgeon are benthic feeders, subsisting on a variety of foods including benthic worms, crustaceans, clams, and small fish in river delta and marine waters (Adams et al. 2002; Moyle 2002). White sturgeon feed on Pacific eulachon, anchovies, lamprey, and shad in marine waters and salmon carcasses in river systems. Larval white sturgeon primarily feed on algae and aquatic insects while remaining in rivers and estuarine environments. Subadult and adult white sturgeon primarily feed on fish, shellfish, crayfish, and on various aquatic invertebrates, clams, amphipods, and shrimp (NMFS 2008a).

Distribution and Abundance. It is rare to find white sturgeon in Puget Sound (PFMC 1996). However, tag recovery data indicate that white sturgeon originating from the Columbia River (T. Johnson, pers. comm., WDFW, Fish Biologist, June 30, 2009) are sporadically present in the lower reaches of Strait of Juan de Fuca streams in Puget Sound, apparently feeding in the streams and associated estuaries. None of the watersheds in the project area are important juvenile production and rearing areas for white sturgeon. The species disperses in Washington marine waters along the Pacific coast, with occurrences in several small coastal estuaries and rivers in the project area (eastern Strait of Juan de Fuca and northern Puget Sound) (Nelson et al. 2004). These occurrences, however, are transitory, likely reflecting feeding forays by migrating fish originating from one of the larger three California and Pacific Northwest watersheds where spawning has been documented (i.e., the Sacramento, Columbia, and Fraser Rivers [Nelson et al. 2004]).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the white sturgeon's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Similar to green sturgeon, the primary risk to white sturgeon from salmon and steelhead is white sturgeon bycatch in salmon fisheries (NMFS 2009b). In addition, a benefit to white sturgeon is that salmon carcasses have been identified as an important food resource in fresh water.

3.2.15.3 Pacific Lamprey

The Pacific lamprey is a Federal species of concern (USFWS 2014a) and a state monitor species (WDFW 2014b). Factors that have contributed to its decline include impeded passage at dams and diversions, altered management of water flows and dewatering of stream reaches, dredging, chemical poisoning, poor ocean conditions, degraded water quality, disease, over-utilization, introduction and establishment of non-native fishes, predation, and stream and floodplain degradation (Luzier et al. 2011).

Life History. Within Puget Sound, Pacific lamprey adults begin their upstream migration in fresh water to spawn between July and September and migration continues to late May or early June the following year (as reviewed in Roberge et al. 2002). Pacific lamprey do not become sexually mature until October to March, and spend between 7 to 9 months in fresh water before spawning. Spawning takes place from April to July in sandy gravels in headwater streams and rivers. Pacific lamprey die after spawning, although they may spawn more than once. Larvae emerge from the gravel within 2 to 3 weeks after hatching and move downstream to soft-bottomed areas into which they burrow and grow into the larval form of the species (called ammocoetes). The young ammocoetes spend from 4 to 6 years in mud before transforming into adults that migrate downstream to the ocean or a lake. As young Pacific lamprey mature and migrate downstream to the ocean or lakes, they feed on bottom fauna and fish. Ocean residency of adults lasts from 12 to 20 months before they return to streams to spawn. In the ocean, adults feed on adult fish (including salmon) and marine mammals. Adult size ranges from 4.8 to 26.8 inches (122 to 682 mm) in length. Pacific lamprey are adults for approximately 2.5 years, and their total life span lasts up to 7 years (Beamish and Levings 1991).

Distribution and Abundance. The current distribution of Pacific lamprey in Puget Sound includes most large rivers and streams along the Strait of Juan de Fuca and throughout Puget Sound, including the Nisqually Reach and portions of the Hood Canal Basin (Cook-Tabor 1999; Wydoski and Whitney 2003). USFWS concluded that, based on long-term sampling, Pacific lamprey have declined over time because of water diversions, turbine intakes, screen impingement, other impassable barriers, water quality impacts, harvest, predation by non-native species, and a variety of other factors. However, total population size is unknown (69 Fed. Reg. 77158, December 27, 2004).

Relationship with Salmon and Steelhead. Pacific lamprey are parasitic as adults and feed on a variety of marine and anadromous fish (salmon, flatfish, rockfish, and pollock) and marine mammals (whales). Declines in salmon, hake, walleye, and pollock have been cited as affecting lamprey survival and growth (USFWS 2008b). Salmon and steelhead may also prey on juvenile lamprey in river areas where the hatchery-origin fish and lamprey co-occur. Thus, salmon and steelhead provide a prey benefit to Pacific lamprey, but are also a risk to Pacific lamprey when salmon and steelhead feed on juvenile Pacific lamprey.

3.2.15.4 River Lamprey

The river lamprey is a Federal species of concern (USFWS 2014b) and a state candidate species (WDFW 2014b). The primary reasons for its decline include loss or degradation of habitat through dams, diversions, pollution, stream channelization, and urbanization (Moyle et al. 1995).

Life History. River lamprey is mainly a benthic feeding species when in fresh water, eating microscopic plants (mostly diatoms) and animals during their extended 4 to 6 year larval rearing period. River lamprey migrate up rivers to spawning grounds starting in July and probably spawn over gravel (Roberge et al. 2002). The ammocoetes will feed on microscopic plants and animals while in the river. Their metamorphosis to the adult form usually begins in July and may take until April of the next year to complete. River lamprey enter marine waters between May and July and promptly begin feeding. They typically remain very close to the shoreline and are strictly surface feeders. Adult river lamprey are predatory and parasitic, feeding on fish, particularly smelt, herring, and salmon. Typical size of adult river lamprey ranges from 4.6 to 13 inches (117 to 330 mm) (Scott and Crossman 1973; Kostow 2002).

Distribution and Abundance. No detailed records of distribution and abundance are available for river lamprey in Washington, but the species likely occurs in most major river systems (Wydoski and Whitney 2003).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the river lamprey's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Similar to Pacific lamprey, river lamprey are parasitic as adults and feed on a variety of fish, although their preferred prey species appear to be herring and salmon (Moyle 2002). Information from studies in the Strait of Georgia (Beamish and Neville 1995) suggests that river lamprey preyed on Chinook salmon and coho salmon in large numbers (a minimum of 18 million Chinook salmon and 2 million coho salmon in the years studied). These high mortalities indicate that river lamprey predation is likely a major source of natural mortality of Chinook salmon and coho salmon in the Strait of Georgia. However, salmon and steelhead (including hatchery releases) have the potential to prey on juvenile lamprey in river areas where they co-occur. Thus, similar to Pacific lamprey, salmon and steelhead provide a prey benefit to river lamprey, but are also a risk to river lamprey when salmon and steelhead feed on juvenile river lamprey.

3.2.15.5 Western Brook Lamprey

Western brook lamprey are a Federal species of concern (USFWS 2014c).

Life History. The western brook lamprey is a slow-growing species, living up to 6 years and reaching a size of 5 to 8 inches (13 to 20 cm) when mature (Roberge et al. 2002). This lamprey species is the only one in Washington that spends its entire life cycle in fresh water (Wydoski and Whitney 2003). Brook lamprey spawn between April and July in riffles on rock, sand, or gravel bottoms. All adults die after spawning. Eggs hatch within 15 days, and the ammocoetes burrow in the mud and silt at stream margins where they rear for up to 6 years (Roberge et al. 2002). During that time, the ammocoetes feed on microscopic plants. They metamorphose into adults between August and November. The adults do not feed during their adult life of several months (Wydoski and Whitney 2003; Roberge et al. 2002).

Distribution and Abundance. Western brook lamprey are found in most coastal streams in western Washington, with collections of the species documented in the central portion of the project area (the Lake Washington watershed) (Wydoski and Whitney 2003). USFWS has concluded that, although overall abundance is unknown, there are no known threats that would impact existing populations of western brook lamprey (69 Fed. Reg. 77158, December 27, 2004).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the brook lamprey's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Salmon and steelhead may feed on brook lamprey eggs and young adults. Thus, risk to brook lamprey is salmon and steelhead predation on young brook lamprey. Salmon and steelhead provide no benefit to brook lamprey.

3.2.16 Forage Fish

Forage fish comprise a group of small, schooling species that are related by habitat use, trophic position in the ecosystem, and life history strategies as described in Lemberg et al. (1997), Bargmann (1998), and Penttila (2007). Species in the forage fish group (Table 3.2-22) are largely confined to marine waters of Puget Sound for all or a majority of their life histories. In general, information on these fishes in Puget Sound is limited. Forage fish may occur throughout Puget Sound at various life stages. Forage fish abundance and distribution tend to fluctuate greatly, with fluctuations attributable to natural factors, such as changes in environmental conditions and reproductive success (Bargmann 1998). Changes in abundance can also be caused by harvest of the species in Puget Sound. Forage fishes naturally experience short periods of high abundance followed by lengthy periods of lessened abundance. Many different species of birds, fish, and marine mammals are known to prey on forage fish in marine areas within or adjacent to Puget Sound (Lassuy 1989; Bargmann 1998).

Table 3.2-22. Range in Puget Sound and listing status of forage fish species and their potential types of interactions with salmon and steelhead.

Species	Range in Puget Sound	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead
Pacific eulachon *(Thaleichthys pacificus)*	Marine waters	Southern DPS Federal threatened species and state candidate species	Prey of salmon and steelhead
Pacific herring (*Clupea pallasi*)	Marine waters	Federal species of concern and state candidate species	Prey of salmon and steelhead
Pacific sandlance (*Ammodytes hexapterus)*	Marine waters	None	Prey of salmon and steelhead
Northern anchovy (*Engraulis mordax*)	Marine waters	None	Prey of salmon and steelhead
Osmeridae (smelt) - surf smelt (*Hypomesus pretiosus*) and longfin smelt (*Spirinchus thaleichthys*)	Throughout	None	Prey of salmon and steelhead. In Lake Washington, longfin smelt compete with salmon for prey resources.
Pacific sardine (*Sardinops sagax*).	May occur in Admiralty Inlet	None	Prey of salmon and steelhead. Sardine fisheries may result in salmon and steelhead bycatch.

Forage fish are part of the other fish species group described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, risks and benefits for these fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators).

3.2.16.1 Pacific Eulachon

Two DPSs of Pacific eulachon occur on the Pacific Coast. The southern DPS occurs from the Mad River in northern California north into British Columbia, while the northern DPS occurs from the Nass River, British Columbia north into Alaska (NMFS 2008b; Gustafson et al. 2010). In 2010, NMFS determined that the southern DPS of Pacific eulachon was likely to become endangered within the foreseeable future and listed it as threatened under the ESA (75 Fed. Reg. 13012, March 18, 2010). Pacific eulachon are also a state candidate species (WDFW 2014b). Threats to Pacific eulachon are overfishing, accidental bycatch in other fisheries, industrial pollution of freshwater and marine habitats, human impacts on their spawning habitat, and climate change (Hay and McCarter 2000; Gustafson et al. 2010).

Life History. Little is known about the life history of Pacific eulachon. Their habitat is the nearshore ocean bottom and coastal inlets. In the Pacific Northwest, adult Pacific eulachon spend most of their lives rearing in the Pacific Ocean, and may range from Oregon to Vancouver Island before returning to the Columbia and Fraser River basins to spawn (Bargmann 1998; Gustafson et al. 2010). Small numbers of maturing Pacific eulachon (10 to 50 per year) have been recorded recently through salmon smolt trapping studies in the Elwha River (M. McHenry, pers. comm., Lower Elwha Klallam Tribe, Habitat Biologist, March 12, 2010). The species uses the Columbia and Fraser River watersheds for reproduction (Bargmann 1998; Gustafson et al. 2010). Young fish consume larvae, copepods, and zooplankton, while adults consume crustaceans (Morrow 1980).

Distribution and Abundance. Pacific eulachon are rare in the estuaries around Puget Sound (Gustafson et al. 2010). No self-sustaining populations are known to occur within Puget Sound. Spawning populations of this species in the Pacific Northwest have only been identified in the Columbia and Fraser Rivers (Gustafson et al. 2010). The species has variable and cyclical run sizes, thus making it difficult to detect abundance trends.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the Pacific eulachon's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. In marine waters, Pacific eulachon are important in the food chain as prey of salmon and steelhead (Gustafson et al. 2010). Newly hatched and juvenile Pacific eulachon are a food source for a variety of larger marine fish species, including salmon and steelhead (Bargmann 1998; Duffy

2003). Thus, salmon and steelhead are a predation risk to Pacific eulachon. Salmon and steelhead provide no benefit to Pacific eulachon.

3.2.16.2 Pacific Herring

Pacific herring are a Federal species of concern and a state candidate species. Spawning populations of Pacific herring from Puget Sound and the Strait of Georgia constitute the Georgia Basin Pacific Herring DPS. As a result of reviews of the status of the Georgia Basin Pacific Herring DPS (Stout et al. 2001a; Gustafson et al. 2006), NMFS determined that the DPS overall is at low risk and that listing under the ESA is not warranted (70 Fed. Reg. 33117, June 7, 2005).

Life History. The Pacific herring is a marine species that deposits its eggs on vegetation or other substrates in shallow waters. Following metamorphosis from the larval stage, juvenile Pacific herring spend their first year in Puget Sound. Some Pacific herring spend their entire life in Puget Sound, while others migrate to the ocean. Young Pacific herring feed on phytoplankton, while adult herring feed on zooplankton, small fish, and fish larvae.

Distribution and Abundance. Pacific herring occur throughout coastal areas of Washington and in Puget Sound. There are 19 documented Pacific herring spawning stocks in Puget Sound, including Cherry Point (70 Fed. Reg. 33117, June 7, 2005).

Since monitoring began in the 1930s, the abundance of the DPS is at historically high levels in terms of estimated tonnage (recent abundance of well over 100,000 metric tons) and numbers (more than half a billion mature herring) (Gustafson et al. 2006). However, the biomass of the Cherry Point herring stock declined 80 percent from historic levels over the past two decades, although between 2000 and 2004, the size of the Cherry Point stock more than doubled from low abundance levels observed in the 1990s (Gustafson et al. 2006). By 2003, the stock was at its highest level since 1993. The stock was still at only about half the level needed to sustain a commercial fishery, and abundance had not recovered to historic levels.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the Pacific herring's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. In the project area, Chinook salmon and coho salmon rely heavily on Pacific herring as food (Bargmann 1998). Herring account for 62 percent and 58 percent, respectively, of the diets of those two salmon species (Lemberg et al. 1997; Duffy 2003). During their seaward migration, juvenile salmon feed on larval herring. Pacific herring are an important bait fish used to catch natural-origin and hatchery-origin Chinook salmon and coho salmon in Puget Sound recreational fisheries and are harvested commercially in Puget Sound for that purpose (Bargmann 1998). The annual catch of herring for use as bait fish is low relative to the total biomass of the species (about 3 percent of total biomass). Thus, salmon and steelhead are a predation risk to Pacific herring and an indirect fisheries risk through the provision of Pacific herring as bait fish. Salmon and steelhead provide no benefit to Pacific herring.

3.2.16.3 Pacific Sandlance

Pacific sandlance are not listed. The spawning habitat of Pacific sandlance is considered a marine habitat of special concern in the Washington Administrative Code (WAC) Hydraulic Code Rules (WAC 220-110-250 (3)(a, b)).

Life History. Very little is known about the life history or biology of Pacific sandlance in Puget Sound. Surveys have documented Pacific sandlance spawning habitat on 129 miles of Puget Sound shoreline (Penttila 1995). Puget Sound Pacific sandlance appear to be upper intertidal spawners, depositing their eggs from November through February in sand-gravel substrates up to 5 feet above the mean high tide line. Individual broods of eggs incubate in the beach substrate for about 1 month, after which the larvae are a common component of the nearshore plankton in many parts of Puget Sound. Several spawnings may occur at any given beach site during the November to February spawning season. Spawning sites appear to be used year-after-year. Incubating Pacific sandlance eggs occur in the same substrate with the eggs of surf smelt spawning populations, with both species using the same stretches of beach for spawning at the same times of year. Pacific sandlance travel in schools in open marine waters and feed on zooplankton at every stage of its life cycle.

Distribution and Abundance. Pacific sandlance are widespread within Puget Sound, the Strait of Juan de Fuca, and the coastal estuaries of Washington (Bargmann 1998). Sandlance are not amenable to standard stock assessment techniques used to determine status (Bargmann 1998). However, based on available anecdotal information, it is possible that there are thousands of tons of Pacific sandlance residing in Puget Sound.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the Pacific sandlance's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Pacific sandlance are food for salmon (Lassuy 1989; Lemberg et al. 1997; Bargmann 1998; Duffy 2003). They compose 35 percent of the diet of juvenile salmon generally, and 60 percent of the diet of juvenile Chinook salmon specifically (Ecology 2010). Thus, salmon and steelhead are a predation risk to Pacific sandlance. Salmon and steelhead provide no benefit to Pacific sandlance.

3.2.16.4 Northern Anchovy

Northern anchovy are not listed or classified as a state or Federal sensitive species.

Life History. Northern anchovy are pelagic schooling fish that spawn and incubate their eggs in open marine waters. Little is known regarding the life history of northern anchovy inhabiting Puget Sound. The species is believed to spawn from mid-June to mid-August (Penttila 2007) and spawning success does not depend on any specific shoreline. Anchovies feed on a variety of planktonic organisms (both plants and animals) (Penttila 2007).

Distribution and Abundance. Northern anchovy occur throughout the project area and spawn in both southern Puget Sound and the Strait of Georgia during the summer months, suggesting the existence of resident populations (Penttila 2007). The status of northern anchovies in the project area is unknown (Penttila 2007). Anchovies were reported as abundant in Puget Sound in the 1890s (Bargmann 1998). Abundance was most recently (circa 1980) estimated to be between 100,000 and 1,000,000 metric tons. There are some indications that abundance has declined since that time (Bargmann 1998).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the northern anchovy's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Northern anchovy are prey for Pacific salmon (Lassuy 1989; Lemberg et al. 1997; Bargmann 1998; Duffy 2003). The species is also used as a bait fish for recreational salmon fishing. Thus, salmon and steelhead are a predation risk to northern anchovy and an indirect fisheries risk through the provision of northern anchovy as bait fish. Salmon and steelhead provide no benefit to northern anchovy.

3.2.16.5 Smelt (Surf Smelt and Longfin Smelt)

Surf smelt and longfin smelt are not listed or classified as state or Federal sensitive species.

Life History. Surf smelt reside in marine areas for their entire life cycle, and appear to have a short life span. The species inhabits shallower nearshore habitats, and/or remains close to the benthic zone at all times (Bargmann 1998). Surf smelt appear to rarely, if ever, form open-water pelagic schools. Bargmann (1998) noted that stocks of mixed juvenile and post-spawning surf smelt occur in the general vicinity of known spawning grounds between spawning seasons, suggesting some long-term residency. Spawning occurs year-round at age 1 and age 2, at high tides, and on sand and gravel beaches in the upper intertidal zone. Surf smelt feed on plankton.

The longfin smelt is an anadromous species, although some populations are landlocked (e.g., Lake Washington). Little is known about the biology of anadromous stocks of longfin smelt in the Pacific Northwest. As described by Wydoski and Whitney (2003), longfin smelt in Lake Washington have a short life span, with few fish surviving to their third year of life. The fish are pelagic, inhabiting open water in the lake system for the majority of their life span. Longfin smelt in Lake Washington feed almost exclusively on zooplankton, and grow to an average size of 3.5 to 4.7 inches (9 to 12 cm). Lake Washington longfin smelt spawn at age 2 (rarely at age 3) between mid-January through mid-April (main spawning period is late February through late March) in at least four tributaries, with the Cedar River receiving the majority of spawning. After spawning, most smelt die.

Distribution and Abundance. Surf smelt are a common resident fish in many marine areas of Puget Sound (Penttila 2007). Anadromous forms of longfin smelt are locally common in a few estuarine areas within Puget Sound and spawning populations may occur in northern Puget Sound (Penttila 2007). Longfin smelt are abundant enough in some years to attract fishing pressure when they return to spawn in the Cedar River (in the Lake Washington basin). The only well-documented marine/anadromous longfin smelt spawning population in Puget Sound occurs in the Nooksack River and the adjacent marine waters of Bellingham Bay and neighboring Skagit and San Juan Counties. Longfin smelt are also thought to occur in the Duwamish River (Penttila 2007).

Available annual fishery harvest data indicates that the abundance of surf smelt is stable and that there is little concern about the overall status of most local stocks (Bargmann 1998). The status of anadromous longfin smelt aggregations is unknown, as there is little information on the species in marine waters within Puget Sound (Bargmann 1998).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the surf smelt's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Surf smelt are prey for salmon and steelhead. Longfin smelt in the Lake Washington basin inhabit pelagic areas where they may feed on the same zooplankton species as juvenile hatchery-origin sockeye salmon. Interspecific competition between sockeye salmon and the large even-year broods of longfin smelt appears to limit sockeye salmon in the system in odd years as evidenced by lower growth and survival of sockeye salmon (McPherson and Woodey 2009). Longfin smelt and hatchery-origin sockeye salmon appear to occupy similar niches in the lake system and compete for the same resources, and it is possible that the competitive effects of longfin smelt on hatchery-origin sockeye salmon also apply to competitive effects of sockeye salmon on smelt. Thus, salmon and steelhead are a predation risk to surf smelt, and sockeye salmon are a competition risk to longfin smelt. Salmon and steelhead provide no benefit to smelt.

3.2.16.6 Pacific Sardine

Pacific sardines are not listed or classified as a state or Federal sensitive species.

Life History. The Pacific sardine is a schooling pelagic marine species dependent on warmer waters (55° to 72°F [13° to 22°C]) for spawning. The species spawns mostly in California and in Oregon, and it is not known if spawning occurs in Puget Sound. In its second summer, the species migrates north to Washington and Canada. Pacific sardine feed on zooplankton.

Distribution and Abundance. Pacific sardine inhabit coastal areas of Washington and potentially inhabit the Admiralty Inlet portion of Puget Sound. The species was historically abundant up through the 1930s when it declined dramatically because of substantial fishing pressure. Abundance remained low until 1997 when sardines once again became common in Washington coastal areas. This upward trend in abundance is likely to continue as recruitment has been strong, and should lead to increased abundance of the species in Washington marine waters (Bargmann 1998).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the Pacific sardine's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. When sardines are abundant they are prey for salmon in marine areas (Emmett et al. 2005). Fisheries for sardines may impact salmon because the purse seine nets used to catch sardines may also result in bycatch of salmon. Thus, salmon are a predation risk to sardines, and sardines pose an indirect risk to salmon from sardine fisheries bycatch. Salmon and steelhead provide no benefit to sardines.

3.2.17 Groundfish

This group of fish encompasses an array of pelagic, benthic, nearshore, and rocky reef-dwelling groundfish species that spend their entire lives in marine waters near or on the bottom. The groundfish species reviewed in this EIS are identified in Table 3.2-23. They are described as a group in this subsection because their relationships with salmon and steelhead are similar.

NMFS completed ESA status reviews for five species of rockfish in Puget Sound (Drake et al. 2010) and determined that the Georgia Basin Bocaccio DPS is endangered, and the Georgia Basin Yelloweye Rockfish DPS and Georgia Basin Canary Rockfish DPS are threatened (75 Fed. Reg. 22276, April 28, 2010). The primary factors responsible for declines in these species include increased commercial and recreational use of marine waters for harvest, habitat degradation, water quality problems including low dissolved oxygen and elevated contaminant levels, and inadequacy of exiting regulatory mechanisms. Other threats include hatchery releases of Chinook salmon and coho salmon because these two species present competition and/or predation risks to groundfish (Drake et al. 2010). NMFS previously determined through a separate species status review (Stout et al. 2001b) that listings of brown, copper, quillback, and yellowtail rockfish were not warranted, although they are Federal species of concern. NMFS subsequently determined that listings for greenstriped rockfish and redstripe rockfish (74 Fed. Reg. 18516, April 23, 2009), and China rockfish and tiger rockfish (75 Fed. Reg. 52928, August 30, 2010) were not warranted. All of the rockfish species discussed above are state candidate species.

After delineating the DPSs for Pacific hake, Pacific cod, and walleye pollock, NMFS determined that listings were not warranted (Gustafson et al. 2000), although Pacific hake and Pacific cod are Federal species of concern (NMFS 2009c, 2011e, respectively) and all three species are state candidate species (WDFW 2014b).

Table 3.2-23. Range in Puget Sound and listing status of groundfish species and their potential interaction with salmon and steelhead.

Species	Range in Puget Sound	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead
Georgia Basin bocaccio DPS (*Sebastes paucispinis*)	Rocky marine habitats south of Tacoma Narrows	Federally listed as endangered, and state candidate species	Young are prey of salmon and steelhead; adults prey on salmon and steelhead; all ages are competitors of salmon and steelhead, and have the potential to be taken incidentally as bycatch in salmon fisheries in marine areas
Georgia Basin yelloweye rockfish DPS *(S. ruberrimus)*	Rocky marine habitats primarily in north Puget Sound, but also occur in south Puget Sound	Federally listed as threatened, and state candidate species	Same as above
Georgia Basin canary rockfish DPS (*S. pinniger*)	Marine areas primarily in north Puget Sound	Federally listed as threatened, and state candidate species	Same as above
Other rockfish (*Sebastes* spp.)	Rocky habitats throughout marine areas	Brown, copper, and quillback rockfish are Federal species of concern; the above species plus black, China, greenstriped, redstripe, tiger, widow, and yellowtail rockfish are state candidate species	Same as above
Pelagic and benthopelagic groundfish (hake, cod, walleye Pollock, lingcod, sablefish)	Deep marine waters	Pacific/Georgia Basin hake and Pacific cod are Federal species of concern and state candidate species; walleye pollock is a state candidate species	Same as above
Flatfish (halibut, sole, flounder)	Sandy, muddy substrates throughout marine areas	None	Same as above
All other groundfish (perch, kelp greenling, sculpin, spiny dogfish, spotted ratfish, skates)	Throughout marine areas	None	Same as above

There is no information to suggest that any groundfish species other than those identified above are at risk of extinction or likely to become so in the foreseeable future.

Groundfish are part of the other fish species group described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, risks and benefits for these fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators). Descriptions of risks and benefits use qualitative evaluations that are generally described using relative terms (i.e., likely, minimal, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish; the reasoning for this is described in Subsection 3.2, Fish.

3.2.17.1 Life Histories

Rockfishes are a diverse group of marine fishes, including at least 20 species in Puget Sound (Drake et al. 2010). The life histories of rockfish described here are summarized from Puget Fishery Management Council groundfish species summaries (PFMC 2008) and from Drake et al. (2010). As a group, rockfish are among the most common of bottom and mid-water dwelling fish on the Pacific coast of North America (Love et al. 2002). In Puget Sound, copper, quillback, and brown rockfish are three of the most common species (Palsson et al. 2009). Adult rockfish can be the most abundant fish in various coastal benthic habitats, such as kelp forests, rocky reefs, and rocky outcrops in submarine canyons at depths greater than 980 feet (300 m) (Yoklavich 1998). Rockfish give birth to live larval young, which are found in surface waters and may be distributed over a wide area extending several hundred miles offshore (Love et al. 2002). Larvae and small juvenile rockfish may remain in open waters for several months.

Larval rockfish feed on diatoms, dinoflagellates, tintinnids, and cladocerans. Juvenile rockfish consume copepods and euphausiids of all life stages (Sumida and Moser 1984). Juvenile and subadult rockfish may be more common than adults in shallow water and are associated with rocky reefs, kelp canopies, and artificial structures, such as piers and oil platforms (Love et al. 2002). Adults generally move into deeper water as they increase in size and age (Garrison and Miller 1982; Love 1996), and many species exhibit strong site fidelity to rocky bottoms and outcrops (Yoklavich et al. 2000). Adults eat bottom and mid-water dwelling invertebrates and small fishes, including other species of rockfish associated with kelp beds, rocky reefs, pinnacles, and sharp drop-offs (Sumida and Moser 1984).

The pelagic species in the groundfish group (Pacific hake, cod, pollock, and sablefish) are also pelagic spawners, inhabiting relatively deep waters for the majority of their life cycles in Puget Sound. Juveniles eat fishes and cephalopods (mainly squids) (Hart 1988), amphipods, and krill (NMFS 2010b). Adults feed on forage fish and rockfishes.

Lingcod are considered top order predators in the areas they inhabit. Adult lingcod are found along slopes of submerged banks 30 to 230 feet (10 to 70 m) below the surface with seaweed and kelp, and eelgrass beds and channels with swift currents that flow around rocky reefs. Juveniles prefer sandy substrates in estuaries and shallow sub-tidal zones. Spawning generally occurs over rocky reefs in areas of swift current. Hatching occurs in April in Washington. Juvenile lingcod eat copepods, shrimps, and other small crustaceans, and when larger, they eat herring and other small fishes. Adults feed primarily on smaller lingcod, squids, octopi, and crabs. Males begin maturing at about 2 years (20 inches [50 cm]), whereas females mature at 3 plus years (30 inches [76 cm]).

Flatfishes mainly inhabit sandy bottom habitats, with several species using intertidal areas extensively for feeding (e.g., starry flounder). All are pelagic spawners, fertilizing their eggs externally and dispersing progeny with the currents to grow through the larval stage, eventually metamorphosing into the bottom-dwelling form that characterizes the group. In general, as subadults and adults, flatfish feed on benthic invertebrates, polycheates, mollusks, and fish.

The other fish species within the groundfish group include perch, kelp greenling, sculpins (cottids), spiny dogfish, spotted ratfish, and skates. Perch inhabit nearshore habitats (particularly those with complex structures like piers) throughout Puget Sound. They feed on a variety of smaller benthic and pelagic organisms, including mollusks, shrimp, larval and juvenile crabs, and invertebrate and fish eggs. Kelp greenlings are found along rocky shore habitats in the project area, feeding on worms, crustaceans, and small fishes (Hart 1988). The marine sculpin species in Puget Sound are characterized as voracious feeders, feeding mainly on invertebrates, but also taking juvenile fish, including salmon, in nearshore areas. Sculpins may be found in marine habitats at moderate depths and in nearshore areas, tide pools, and lower portions of Puget Sound rivers and streams (Hart 1988).

The life histories of the spiny dogfish, ratfish, and skate species are characterized by late maturity, low fecundity, and slow growth to a relatively large body size. Spiny dogfish occur from surface waters to the deepest part of Puget Sound (Hart 1988). They are adaptable in their feeding habits and their diet includes a wide range of fish and invertebrate species, although their principal prey are herring, hake, sand lance, smelts, and euphausiids (Hart 1988). Ratfish are most abundant in deep waters, feeding mainly on clams, crustaceans (such as crab and shrimp), and fishes (Hart 1988). Skates occur at moderate depths, feeding on crustaceans and fish, such as cottids.

3.2.17.2 Distribution and Abundance

Groundfish species are distributed throughout Puget Sound marine waters in habitats ranging from intertidal areas, to rocky reefs, to the deepest portions of Puget Sound.

As noted in Table 3.2-23, listed rockfish (bocaccio, canary, and yelloweye rockfish) are typically associated with rocky habitats. Juveniles and subadults tend to be more common than adults in shallow water and are associated with rocky reefs, kelp canopies, and artificial structures such as piers. Adults generally move into deep water as they increase in size and age but usually exhibit strong site fidelity to rocky bottoms and outcrops just above the bottom of marine waters (Gustafson et al. 2000; Palsson et al. 2009; Drake et al. 2010).

The abundance of most groundfish species in Puget Sound has not been quantified, but many species are generally considered to be at low or depressed levels (Gustafson et al. 2000; Drake et al. 2010), consistent with their listing status.

Currently, the Pacific cod in north Puget Sound is described as depressed, and the southern Puget Sound population is considered critical or near extinct levels (Palsson et al. 1997). The status of Pacific hake in south Puget Sound is also considered critical because of a sharp decline in abundance observed from annual WDFW hydro-acoustic surveys (Palsson et al. 1997). The abundances of other groundfish species in this group are unknown.

3.2.17.3 Relationship with Salmon and Steelhead

Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish. Although most studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish, Drake et al. (2010) describe threats to groundfish that include bycatch from commercial and recreational fisheries. In their assessment, the authors also state that competition and predation with hatchery-origin salmon results in a low to very high risk to specific species of groundfish, as described below. Each applicable risk and benefit is described separately below.

Competition Risks. Species in the groundfish group can be negatively affected by salmon through competition for food if both species groups (groundfish and salmon) feed on the same prey, if both species groups occupy the same habitat, and if the target prey species shared by salmon and groundfish are limiting. Rockfish competition risks (combined with predation risks described below) with hatchery-origin salmon were identified as a concern to threatened and endangered rockfish species by NMFS through its ESA status review process (Drake et al. 2010). These risks are considered high for bocaccio and yelloweye rockfish and low for canary rockfish, redstripe rockfish, and greenstriped rockfish (Drake et al. 2010). Although bocaccio occurrence appears limited to certain areas of Puget Sound, salmon juveniles and adults may compete with bocaccio juveniles and adults for prey, including krill, fish larvae, and juvenile life stages of rockfishes, hake, sablefish, anchovies, lanternfishes, and squid. Salmon may compete with yelloweye rockfish for prey such as juvenile rockfish, sand lance, gadids, flatfishes, shrimps, crabs, and gastropods. Canary rockfish larvae and juveniles are planktivores (Drake et al. 2010).

Drake et al. (2010) summarize feeding habits of rockfish species stating that adult canary rockfish consume crustaceans and small fishes—prey species that are also preferred by Chinook salmon and coho salmon. Greenstriped rockfish adults consume larger crustaceans, fishes, and cephalopods—species also preferred by Chinook salmon and coho salmon. Thus, hatchery-origin Chinook salmon and coho salmon are the primary salmon species that pose competition risks to several species of groundfish. Seaward emigrating sockeye salmon, pink salmon, and chum salmon may compete for shared planktivorous prey items with canary rockfish, but these salmon species migrate seaward soon after out-migrating from fresh water, dispersing into areas removed from rearing groundfish. Thus, these natural-origin and hatchery-origin salmon species do not present competition risks to groundfish. Steelhead disperse into offshore areas for rearing in the ocean and are not likely to present substantial competition risks to any groundfish species in the project area.

Predation Risks. Salmon may prey on groundfish when and where the species interact (Hart 1988). Predation risks from salmon are greatest at the subadult and adult life stages, when the size of salmon is large enough for them to consume smaller juvenile and subadult groundfish. Predation by salmon was identified by Drake et al. (2010) as a threat to the five rockfish species that are listed under the ESA, and was rated as high for bocaccio and yelloweye rockfish and low for canary rockfish, redstripe rockfish, and greenstriped rockfish, although this risk was combined with (not separated from) the competition risk (as noted above).

Chinook salmon and coho salmon are piscivorous as subadults and adults, and tend to rear within Puget Sound and coastal marine waters where they may prey on juvenile rockfish. Hatchery releases of these two salmon species are considered a predation risk to groundfish (Drake et al. 2010). In contrast to hatchery-origin Chinook salmon and coho salmon, pink salmon, chum salmon, and sockeye salmon have a varied, less piscivorous diet (Appendix B, Hatchery Effects and Evaluation Methods for Fish) than groundfish. In addition, pink salmon, chum salmon, and sockeye salmon tend to migrate northward into the ocean to rear and are removed from Puget Sound marine waters where predation on groundfish might otherwise occur. Therefore, risks of predation effects on groundfish species from hatchery-origin pink salmon, chum salmon, and sockeye salmon are considered unsubstantial. Similarly, releases of hatchery-origin steelhead are likely to exert unsubstantial predation risks on juvenile groundfish because steelhead reside offshore for the majority of their life span (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

Bycatch/Incidental Harvest Risks. Commercial and recreational fisheries targeting salmon in marine areas may incidentally harvest groundfish (NMFS 2004a). The potential for bycatch in these fisheries is due to the susceptibility of groundfish to the types of bait used to fish for salmon, the non-selective nature of net gear used in commercial fisheries, and the occurrence of fisheries at locations inhabited by both salmon and rockfish. Estimates of bycatch for groundfish and threatened and endangered rockfish species are not available. Bocaccio, canary rockfish, and yelloweye rockfish are sometimes incidentally caught as bycatch in fisheries targeting salmon. Drake et al. (2010) concluded that rockfish bycatch may be an important source of mortality for some rockfish species, and is rated as a substantial risk for bocaccio, yelloweye rockfish, and canary rockfish, and as an unsubstantial risk for redstripe rockfish and greenstriped rockfish. Ongoing harvest management actions that help to decrease bycatch of groundfish include identifying rockfish conservation areas and then closing these areas for use by specific fishing gear that impacts groundfish (NMFS 2014). In addition, WDFW has also identified preferred fishing methods and techniques to help protect listed groundfish (WDFW 2014c).

Other rockfish species, Pacific hake, sablefish, flatfish, and sculpins are the most abundant of the groundfish species in terms of numbers and biomass, and the status of these species is generally healthy. Salmon harvest management actions have been implemented to minimize bycatch impacts on groundfish from salmon-directed fishery harvest as a means to safeguard threatened and endangered species (as reviewed in Drake et al. 2010).

Benefits to Groundfish. Hatchery-origin juvenile and adult salmon may benefit the viability of groundfish by increasing their available prey base. The five listed rockfish species in Puget Sound reviewed in Drake et al. (2010) rely on fish as food sources. Salmon are prey for spiny dogfish in the Strait of Georgia (north of Puget Sound), and consumption of salmon by dogfish may be a substantial source of salmon mortality (Beamish et al. 1992). Other adult rockfish and groundfish species also rely on fish (including salmon and steelhead) as prey (e.g., black rockfish, lingcod, Pacific hake, Pacific halibut, and sablefish).

3.2.18 Resident Freshwater Fish

This group of fish comprises resident freshwater species that spend their entire life cycle in freshwater habitats in Puget Sound (in ponds, lakes, streams, and rivers) (Table 3.2-24). These species form a diverse group, described in this subsection by individual species or group of species.

Resident freshwater fish are part of the other fish species group described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects. Information on methods used to evaluate risks and benefits for these other fish species is provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Consistent with available information, risks and benefits for these fish species are described in terms of each species' relationships to salmon and steelhead (e.g., as competitors and/or predators). Descriptions of risks and benefits use qualitative evaluations that are generally described using relative terms (i.e., likely, minimal, substantial, unsubstantial).

3.2.18.1 Kokanee

Kokanee are the non-anadromous life history form of *O. nerka* that spend their entire life cycle in fresh water. Sockeye salmon are the anadromous form of the species and are described in Subsection 3.2.12, Sockeye Salmon. The two life history forms of *O. nerka* diverged as a result of isolation over long time periods (Gustafson et al. 1997). After review, the USFWS determined that listing of Lake Sammamish kokanee under the ESA was not warranted (76 Fed. Reg. 192, October 4, 2011); however, kokanee are a Federal species of concern (USFWS 2014d). Kokanee abundance has declined because of habitat loss and degradation, inadequacy of existing regulatory mechanisms, and competition with native and non-native species.

Table 3.2-24. Range in Puget Sound and listing status of resident freshwater fish and their potential interaction with salmon and steelhead.

Species	**Range in Puget Sound**	**Federal/State Listing Status**	**Type of Interaction with Salmon and Steelhead**
Kokanee (*O. nerka*)	Lakes	Federal species of concern (Lake Sammamish)	Competitors, may hybridize with sockeye salmon (e.g., genetic impacts), and may be incidentally caught in fisheries
Whitefish: mountain whitefish *Prosopium williamsi*), pygmy whitefish (*P. coulteri*)	Mountain whitefish occur in Cascade mountain watersheds, pygmy whitefish occur in Lake Chester Morse	Pygmy whitefish are a state sensitive species	Mountain whitefish prey on juvenile salmon and steelhead
Sculpins (*Cottus* spp.), including prickly sculpin (*C. asper*), reticulate sculpin (*C. perplexus*), coastrange sculpin (*C. aleuticus*), shorthead sculpin (*C. confusus*), and torrent sculpin (*C. rhotheus*).	Freshwater streams	Reticulated sculpin is a state monitor species	Sculpins prey on salmon eggs and young and use similar food resources
Suckers: largescale sucker (*Catostomus macrocheilus*), Salish sucker (*Catostomus* sp.)	Largescale suckers occur in freshwater systems; Salish suckers occur in a few lakes and rivers	Salish sucker is a state monitor species	Salmon and steelhead may prey on sucker eggs and young; may occur in similar freshwater habitat, but are bottom feeders and have different ecological niche
Northern Pikeminnow (*Ptychocheilus oregonensis*)	Freshwater lakes and reservoirs	None	Predator of salmon and steelhead
Minnows (*Cyprinus* spp.), including peamouth (*Mylocheilus caurinus*), and dace (*Rhinichthys* spp.), including longnose dace (*Rhinichthys cataractae*) and Nooksack dace (*Rhinichthys sp*.)	Freshwater systems	None	Prey of salmon and steelhead
Olympic mudminnow (*Novumbra hubbsi*)	Lowland fresh waters west of the Nisqually River, Lake Sammamish	State sensitive species	Potential prey of salmon and steelhead and may compete with juvenile coho salmon

Life History. The Lake Washington system harbors runs of kokanee that are separated by spawn timing and geographic location (Berge and Higgins 2003; HDR 2009). Peak spawning times for Lake Washington kokanee are from mid-October to early November for the middle (fall) run and from mid-November to mid-December for the late (winter) run. When they are 2 to 4 years of age, the fish spawn in shallow waters in lake tributary streams or on lake beaches (Roberge et al. 2002; Berge and Higgins 2003). Eggs hatch by spring, and the fry either move down into nursery lakes or reside along shorelines for 1 year of rearing before migrating offshore. Kokanee live in lakes for the majority of their life span, growing to a size of 10 to 15 inches (25 to 38 cm) in the Lake Washington watershed (Wydoski and Whitney 2003). Kokanee feed largely on zooplankton with a preference for *Daphnia*.

Distribution and Abundance. Kokanee are found in two watersheds within the project area that are accessed by anadromous fish—Lake Washington and Baker Lake. Kokanee also occur in some lakes in the project area that lack access by anadromous fish, including Whatcom Lake, Lake Samish, American Lake, and Summit Lake, but kokanee in these lakes are of transplanted origin.

In the Lake Washington-Lake Sammamish system, early (summer) run kokanee rear in Lake Sammamish and spawn in Issaquah Creek. Middle (fall) run kokanee are believed to rear in Lake Washington and spawn in tributaries to the Sammamish River. Late (winter) run kokanee also rear in Lake Sammamish, but spawn in south Lake Sammamish tributaries.

Late (winter) run kokanee are the remaining native and most abundant population. Spawner escapements for that run were highly variable from 1996 to 2010, ranging from 42 in 2008 to 4,591 in 2003 (Jackson 2010). From 2006 to 2009, the average escapement was 315 fish.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. However, for kokanee, the relationships described below are focused on the two locations where kokanee and hatchery-origin salmon or steelhead occur (Baker Lake and Lake Washington). At these locations, there are potential competition, genetic, and incidental harvest risks. Salmon and steelhead may compete with kokanee for food and space as salmon and steelhead migrate downstream through the lake systems. Hatchery-origin sockeye salmon rear for up to 2 years in lakes where they have the potential to compete with kokanee for food and space.

Returning hatchery-origin sockeye salmon from the Baker Lake Hatchery and Cedar River Hatchery in the Lake Washington system (Subsection 3.2.12, Sockeye Salmon) pose genetic risks to natural-origin kokanee from interbreeding. The extent of genetic risk depends on how genetically related the two life history types are in their respective watersheds. In Baker Lake, the sockeye salmon hatchery program is based on fish that originated from natural-origin Baker River sockeye salmon. In the Cedar River, the sockeye salmon hatchery program is based on non-native broodstock that was transferred from Baker Lake in the mid-1930s. These sockeye salmon are reproducing naturally in the watershed and now represent the local stock (Ames 2006).

Genetic risks to kokanee associated with the Baker Lake and Cedar River sockeye salmon hatchery programs are unsubstantial. This is because, for Baker Lake, the hatchery broodstock is genetically indistinguishable from residualizing sockeye salmon that might be considered kokanee, likely because of long-term genetic exchange. In the Cedar River, the adult sockeye salmon produced by the hatchery program have the potential to interbreed with kokanee in the watershed where both *O. nerka* life history forms co-occur. However, genetic risk is unsubstantial because the locations used by the introduced hatchery-origin sockeye salmon for spawning are not kokanee spawning areas (Berge and Higgins 2003). Returning hatchery-origin salmon and steelhead are the target of commercial and recreational fisheries in Baker Lake and Lake Washington. These fisheries may expose kokanee to being incidentally harvested and reduce kokanee abundance. The risk of kokanee to incidental harvest in salmon and steelhead fisheries depends on the location and degree of spatial overlap where fisheries occur, the type of gear used to harvest salmon and steelhead, and the size and life stages of kokanee present during the fisheries. Salmon and steelhead provide no benefit to kokanee.

3.2.18.2 Whitefish

Two species of whitefish inhabit streams, rivers, and lakes within the project area. Mountain whitefish and pygmy whitefish are not federally listed. Pygmy whitefish are a state sensitive species (WDFW 2014b).

Life History. Mountain whitefish are the most common whitefish species in Puget Sound and usually spawn from October through December in stream riffles or on gravel shoals in lakes (Wydoski and Whitney 2003). Juveniles grow to a size of about 5 inches (13 cm) after 1 year, feeding primarily on immature forms of benthic aquatic insects, but also on crayfish, freshwater shrimp, leeches, fish eggs, and small fish (Wydoski and Whitney 2003). In rivers, young-of-the-year juveniles may regularly move between nearshore and offshore areas in search of food and to avoid predators (Roberge et al. 2002).

Older juveniles and adults are most often found in deep, fast moving water over gravel and cobble substrates. Mountain whitefish also occur in lakes.

Pygmy whitefish are a small (5 to 6 inches in length [13 to 15 cm]) freshwater forage fish that occur in deep waters of cool lakes and streams (moderate to swift currents) of mountainous areas. Pygmy whitefish are most often observed at depths from 23 to 300 feet (7 to 91 m) and in water temperatures below 50°F (15°C). They spawn from late summer to early winter and are believed to scatter their eggs over coarse gravel. Pygmy whitefish feed on a variety of benthic organisms, including aquatic insects, crustaceans, mollusks, and zooplankton in lake environments (Hallock and Mongillo 1998).

Distribution and Abundance. Mountain whitefish are considered common in the major watersheds draining the Cascade Mountains, including the Skagit, Nooksack, Stillaguamish, Snohomish, and Green Rivers. In contrast, pygmy whitefish have been eliminated from at least 40 percent of their range in Washington and are considered a relic species, now confined to Lake Chester Morse in the Green River watershed (Hallock and Mongillo 1998; Wydoski and Whitney 2003).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the whitefish's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. However, for pygmy whitefish, this species only occurs in Lake Chester Morse where hatchery releases do not occur. Thus, this species is not considered further in the EIS because hatchery releases would not affect pygmy whitefish. Large mountain whitefish can feed on small juvenile salmon and steelhead, thus providing a benefit to mountain whitefish. Although both whitefish species occupy habitats that are similar to those of juvenile rearing salmon and steelhead and the potential exists for competition for food, the co-evolution of whitefish with salmon and steelhead has probably led to the separation of their ecological niches (size, spawning, and microhabitat preferences) (Hearn 1987; Essington et al. 2000). Thus, competition risks are not likely to occur between whitefish and salmon and steelhead. For mountain whitefish, the primary interaction is likely to be predation of whitefish on juvenile salmon and steelhead because of size differences. There are no hatchery-related predation risks to pygmy whitefish because hatchery-origin fish are not released into Lake Chester Morse, the only place where the species exists in the project area.

3.2.18.3 Sculpins

None of the five species of sculpins described in this subsection are federally listed. The reticulate sculpin is a state monitor species (WDFW 2014b).

Life History. Five species of sculpins may be found in freshwater streams and lakes in Puget Sound (Table 3.2-24). Most of these species inhabit medium or larger sized streams with moderate to rapid current, although some species prefer slow-moving parts of streams or lake habitats. Sculpins are generally bottom-dwelling, preferring a rubble or gravel substrate in stream riffle areas. As a generalized life history, sculpins spawn at 1 or 2 years of age, with peak spawning occurring between March and May. Juvenile sculpins initially feed on plankton during their pelagic life stage, switching to aquatic insects after moving to stream or lake bottoms where they spend the majority of their life cycles. Aquatic insects remain an important food item as the sculpins mature, but at least two species feed on salmon eggs as a large part of their diet during the salmon spawning season (Wydoski and Whitney 2003). Larger coast range and torrent sculpins may also prey on salmon fry. Sculpins may live 4 to 6 years and grow to maximum sizes of 2.7 to 5.9 inches (7 to 15 cm) depending on the species.

Distribution and Abundance. The five species of sculpins are distributed throughout Puget Sound watersheds, from the river mouths to the uppermost reaches of tributaries. The abundance of sculpins is generally unknown.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the sculpins' relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. The food resources of sculpins are similar to those used by rearing juvenile salmon and steelhead, which results in a competition risk to sculpins. Risks of competition effects to sculpins are generally greatest from Chinook salmon, coho salmon, and steelhead that occur relatively high in watersheds. Salmon and steelhead in those locations would have the greatest potential for spatial and temporal overlap with sculpins, and thus have the highest risks. Sculpins are known to prey on salmon and steelhead eggs and young, thus providing a benefit to sculpins. For example, Tabor et al. (1998) found that prickly and torrent sculpin preyed on sockeye salmon. In addition, the coast range sculpin and reticulate sculpin are known to prey on salmon eggs deposited in redds (Wydoski and Whitney 2003). Naturally spawning salmon produce a substantial number of the eggs deposited, thus benefiting the sculpin prey base. Out-migrating juvenile salmon and steelhead that are densely concentrated during their seaward migration also provide prey opportunities for sculpins.

3.2.18.4 Suckers

The sucker species described in this subsection are not federally listed. The Salish sucker is a state monitor species (WDFW 2014b).

Life History. Two species of suckers occur in Puget Sound watersheds (Table 3.2-24). The largescale sucker inhabits lakes and streams. The species is often abundant at the mouths of streams entering lakes, and also prefers backwaters of rivers (Roberge et al. 2002; Wydoski and Whitney 2003). Largescale suckers are mainly bottom dwelling, but they move up within the water column at night (Roberge et al. 2002). The species matures at age 4 to 6 years, and can live up to 11 years and reach a length of 24 inches (61 cm). Spawning takes place during April or May in shallow water near the downstream portions of pools in streams, or occasionally along the shoreline of lakes. Eggs are broadcast along the bottom and hatch in 2 weeks. Fry are initially pelagic, but move to the bottom as they grow. Largescale suckers of smaller size consume aquatic insect larvae, diatoms, and plant material, whereas the diet of larger size suckers includes a variety of bottom-dwelling organisms, including crustaceans, aquatic insect larvae, earthworms, snails, and detritus (Wydoski and Whitney 2003).

The Salish sucker broadcast spawns in March or April in lake tributary streams in fast flowing riffle habitats (Roberge et al. 2002). After hatching, fry prefer areas with abundant cover in habitats such as silt-bottomed pools, long glides, shallow riffles, and ponds (Pearson 2000). Salish suckers have an assumed maximum life span of 4 years, spawning at age 2 for males and age 3 for females. Adult Salish suckers prefer slow flowing deeper pools and glides and possibly off-channel habitat in winter months, where their diet includes benthic species similar to those consumed by largescale suckers.

Distribution and Abundance. Largescale suckers may be found in most major rivers in the project area, including the Lake Washington watershed (Wydoski and Whitney 2003). Salish suckers are present in two lakes, and possibly a few rivers in Puget Sound (Roberge et al. 2002). Pearson (2000) reports Salish suckers in the Nooksack River watershed, Twin Lakes (Stillaguamish watershed), the Green River, and Lake Cushman in the Skokomish River watershed. Although its distribution is limited, the Salish sucker is not imminently threatened in Puget Sound. The abundance of suckers is generally unknown.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the suckers' relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Suckers occur in similar freshwater habitats as rearing juvenile salmon and steelhead, but are bottom feeders and have a different ecological niche; thus, competition risk with salmon and steelhead is unlikely. Predation risks may occur when the salmon and steelhead are large enough to be able to consume small juvenile suckers. Risks of predation effects to suckers are generally greatest from Chinook salmon, coho salmon, and steelhead that migrate downstream from higher areas of watersheds and expend more time in freshwater areas, thus exposing suckers to greater risk of predation. Salmon and steelhead that occur in upstream locations would have the greatest potential for spatial and temporal overlap with suckers, and thus have the highest likelihood for predation. Sucker eggs and young may also be a food resource to salmon and steelhead. Salmon and steelhead provide no benefit to suckers.

3.2.18.5 Pikeminnow

Northern pikeminnow are a common resident freshwater fish species in the project area and are not listed. Northern pikeminnow are described here, separate from the minnow species group (Subsection 3.2.18.6, Minnows), because they are predators of salmon and steelhead, whereas the other minnows are prey.

Life History. Northern pikeminnow are a slow-growing freshwater species with a maximum age of 16 years and an average length of 23 inches (58 cm). Spawning occurs in May through July within tributary streams, mainstem rivers, and lake tributaries of Puget Sound. Newly emerged larvae drift downriver during July and take up residence within rivers, lakes, and reservoirs to spend the rest of their lives. Young northern pikeminnow are generally scavengers, and their diet varies from small insects to sculpins, minnows, and larger fish. As northern pikeminnow mature, they feed on plankton and small fish, such as perch, suckers, salmon, and steelhead. Large northern pikeminnow that live away from shorelines feed only on fish.

Distribution and Abundance. The Northern pikeminnow is found in streams and in most major river systems throughout Puget Sound, including Lake Washington. The species congregates in rocky areas with fast current near dams, islands, stream mouths, points, eddies, rows of pilings, and ledges or bars in rivers in water 7 to 25 feet (2 to 8 m) deep. The abundance of northern pikeminnow in the project area is unknown.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the northern pikeminnow's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Northern pikeminnow are predators of juvenile salmon and steelhead. The importance of northern pikeminnow as predators of salmon and steelhead likely varies depending upon the size of northern pikeminnow and location of co-occurrence. The risk of northern pikeminnow predation on salmon is greatest below dams where pikeminnow can feed on juvenile salmon that out-migrate through the dams (Roberge et al. 2002). After northern pikeminnow mature to a length of approximately 10 inches (250 mm), its predation impact on salmon and steelhead increases substantially (Porter 2007). Thus, salmon and steelhead provide benefits as a food resource to northern pikeminnow.

3.2.18.6 Minnows

None of the minnow species in the project area that are described in this subsection are listed. It is uncertain whether Nooksack dace are a true species distinct from longnose dace, or an isolated sub-species.

Life History. Native minnow species in Puget Sound watersheds (peamouth and daces) have varying life history traits. Most of the species prey on small organisms (zooplankton) or are insectivorous for all or a portion of their life cycles. Peamouth in Lake Washington inhabit very shallow water when young, but move to deeper water in winter, remaining near the bottom when in water less than 60 feet (11 m) deep (Wydoski and Whitney 2003). Spawning occurs in streams and along lake shores in late May and early June, with males maturing at age 3 and females at age 4. Peamouth may live 13 years or longer and reach 14 inches (36 cm) in length. As adults, peamouth feed in the pelagic zone and on the bottom on plankton, aquatic and terrestrial insects, snails and occasionally small fish such as sculpins (Wydoski and Whitney 2003).

Nooksack dace and longnose dace occur in Puget Sound watersheds. Nooksack dace live on the bottom of riffles as adults, preferring water depths of 3.9 to 19.7 inches (10 to19 cm) at fast moving velocities over gravel, cobble, or small boulders (Pearson 2000). Longnose dace prefer running water but are also found in inshore areas of lakes over boulder or gravel bottoms. Dace spawn at night during April and May. Young-of-the-year dace aggregate in shallow, marginal pools over mud or sand substrates near the downstream ends of riffles where they feed on chironomid larvae and ostracods. Adult dace feed primarily on riffle-dwelling insects, including caddisfly and mayfly nymphs, beetle larvae, and adult riffle beetles. Individuals exceeding 3.9 inches (10 cm) fork length are rare.

Distribution and Abundance. Minnow species inhabit most major watersheds in the project area and can be found in mainstem river, tributary, and lake habitats. Peamouth are abundant in the lakes of the Lake Washington system. Longnose dace are found in streams and rivers throughout Puget Sound. Nooksack dace currently inhabit all major watersheds on the east side of Puget Sound (Nooksack River south to the Nisqually River), but are absent from streams on the west side of Puget Sound (Pearson 2000). Minnows are among the most common resident freshwater fish species. The Nooksack dace is common in most of their native streams within Puget Sound (Pearson 2000). The abundances of minnow species are unknown.

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. However, hatchery releases may have a direct effect to minnows where large hatchery releases of salmon and steelhead occur in habitat where minnows are also present. Moyle (2002) concludes that minnows may be prey of salmon and steelhead in watersheds where the species interact. Risks of predation effects to minnows from hatchery-origin fish are generally greatest from hatchery-origin Chinook salmon, coho salmon, and steelhead that are released relatively high in watersheds. Hatchery-origin fish released in those locations would have the greatest potential for spatial and temporal overlap with minnows, and thus have the highest likelihood for predation risks. Salmon and steelhead provide no benefits to minnows.

3.2.18.7 Olympic Mudminnow

The Olympic mudminnow is not federally listed, but is a state sensitive species (WDFW 2014b). Wetlands are the mudminnow’s primary habitat, and because of wetland losses and the limited range of the species, it is vulnerable and likely to become threatened or endangered in a significant portion of its range without cooperative management (Mongillo and Hallock 1999).

Life History. Spawning of Olympic mudminnows begins in late November and ends by mid-June (Mongillo and Hallock 1999). The peak spawning time is April and May. The diet of Olympic mudminnows includes ostracods, isopods, oligochaetes, mysid shrimp, stone flies, mollusks, and dipterans. Mudminnows have an average total length of 2 inches (5.2 cm), with a maximum length of about 3.5 inches (9 cm) and a minimum length of 0.9 inches (2.2 cm).

Distribution and Abundance. Olympic mudminnows are found mainly in the lowland areas of central/south Puget Sound in slow-moving streams (current less than 0.1 ft/sec), wetlands, ponds, and swamps with mud substrate and dense aquatic vegetation (Mongillo and Hallock 1999; Wydoski and Whitney 2003). The only lake in Puget Sound where mudminnows are present is Lake Sammamish. However, mudminnows in Lake Sammamish are thought to be the result of an illegal introduction (Mongillo and Hallock 1999). The abundance of Olympic mudminnows that are monitored appears to be stable (WDFW 2013b).

Relationship with Salmon and Steelhead. Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, summarizes the types of risks and benefits salmon and steelhead provide to other fish, recognizing that most available studies that describe these relationships generally do not differentiate between natural-origin and hatchery-origin fish. As a result, the relationships described below assume that the Olympic mudminnow's relationship with natural-origin salmon and steelhead is the same as with hatchery-origin salmon and steelhead. Olympic mudminnows are not believed to coexist well with other fish species. As numbers of other coexisting fish increase, the presence of the Olympic mudminnow typically declines (Mongillo and Hallock 1999). The food of mudminnow is primarily invertebrates. Juvenile coho salmon are the only salmon species known to inhabit areas where Olympic mudminnow occur because both species reside in slow moving waters, including wetlands. Thus, these coho salmon may result in a competition risk to mudminnow for food. Overall, it is likely that the declines in abundance of mudminnows are to some extent because of fish competition and/or predation (Mongillo and Hallock 1999). Salmon and steelhead provide no benefit to Olympic mudminnows.

3.3 Socioeconomics

3.3.1 Introduction

This socioeconomics subsection describes the affected environment and recent trends in economic activity and economic values associated with commercial and recreational fishing for salmon and steelhead in the socioeconomic analysis area (Subsection 4.3.2, Analysis Area). Provided in this subsection is the following information, including:

- Overview of salmon and steelhead species harvested by commercial and recreational fisheries in marine and fresh water (Subsection 3.3.2, Overview of Puget Sound Fisheries, by Species)
- Harvest of salmon and steelhead and associated economic values of commercial harvests for tribal and non-tribal fisheries (Subsection 3.3.3, Commercial Salmon and Steelhead Fishing)
- Recreational harvest activity and associated economic values (Subsection 3.3.4, Recreational Salmon and Steelhead Fishing)
- Regional and subregional fishing-related economic values for salmon and steelhead (Subsection 3.3.5, Regional and Subregional Economic Conditions)
- Geographic distribution of in-river and marine terminal area harvest activity (Subsection 3.3.6, Fisheries in Major River Systems) and related local economic values (Subsection 3.3.7, Ports and Fishing Communities)

Commercial and recreational salmon and steelhead fisheries in marine waters and associated freshwater areas of Puget Sound are co-managed by the Puget Sound treaty tribes (described in Subsection 3.4.2, Native American Tribes of Concern [Environmental Justice]) and WDFW, under *United States v. Washington*. As described in Subsection 1.7.2, Tribal Treaty Rights and Related Federal Policies and Laws, *United States v. Washington* is the Federal court proceeding that enforces and allocates harvest between the state and treaty tribes while addressing reserved treaty fishing rights with regard to salmon and steelhead returning to Puget Sound. Native American tribes having treaty fishing rights are designated as user groups of concern in Subsection 3.4.1.2, Approach to Identifying Native American Tribes of Concern.

This socioeconomics subsection provides harvest (e.g., numbers harvested) and economic information associated with treaty tribal fisheries and non-tribal fisheries in the socioeconomic analysis area

(Subsection 4.3.2, Analysis Area). This information includes gross economic values for commercial fisheries and net economic values for commercial and recreational fisheries (refer to Box 3-1), and personal income, jobs, and hatchery operations cost values.

Box 3-1. Gross and net economic values. What are these terms?

These are two terms used in the EIS to describe economic conditions associated with commercial and recreational fish harvests. Gross economic value for commercial fishers is also referred to as ex-vessel value (i.e., the price received for the product "at the dock"). Gross economic value is the dollar value that commercial fishers receive for their product once it leaves the fishing vessel. Net economic value for commercial fisheries is the gross economic value received by vessel operators and fish processors minus costs, including wages, operational expenses (such as fuel and equipment), and fixed costs (such as insurance and depreciation). Thus, after the cost of fishing (e.g., equipment, fuel, boats, insurance) that commercial fishers incur is deducted, the resulting net income (gross economic value minus costs) provides a measure of net economic value. Net economic values for commercial fisheries are also defined as the net income or profit (gross economic value minus costs) derived by both commercial fishers and fish processors.

For recreational fisheries, gross economic values are defined in terms of total trip-related expenditures made by recreational fishers, and net economic values are defined as the net willingness to pay by recreational anglers (over and above expenditures) for recreational fishing opportunities.

Economic factors for estimating the gross and net economic values of changes in harvest are derived based on different assumptions and data sources, as described in Appendix I, Socioeconomic Impact Methods. For example, in contrast to commercial fisheries, where data are available to estimate net economic values by species, data are not available to estimate net economic value for recreational fisheries by species. Thus, estimates of net economic value for recreational fishing are for all salmon and steelhead species combined. Hatchery operational cost values represent the economic impacts of hatchery operations, including procurement of goods and services from businesses that directly and indirectly generate economic impacts. These values are estimated based on the basic cost of producing

1,000 juvenile fish for each salmon species. WDFW (2009) is the primary source of the cost information, which includes cost information pertinent to WDFW's hatchery programs that are reviewed in this EIS. An underlying assumption is that operational costs for state and tribal hatcheries are similar, which is considered reasonable because the hatchery facilities operated by the state and tribes use similar protocols and procedures.

This socioeconomic information is also used to characterize the environmental justice affected environment (Subsection 3.4, Environmental Justice). Therefore, data and tables provided in this socioeconomic subsection may also be referred to in Subsection 3.4, Environmental Justice, to reduce redundancy.

Some tabular information is provided in this subsection (i.e., 2002 to 2006 total landings[6] from commercial fisheries, and port and county gross economic value data) as context. This contextual information is presented to illustrate how data can vary from year to year, and is not carried forth in the alternative analysis in Subsection 4.3, Socioeconomics.

3.3.1.1 Regional and Local Socioeconomic Conditions

The affected environment described in this subsection is based on harvest of salmon and steelhead in the 12 counties and 10 major salmon management catch reporting areas (herein referred to as catch areas) that compose the socioeconomics analysis area (Subsection 4.3.2, Analysis Area). The socioeconomic analysis area is similar to but larger than the project and analysis areas described in Subsection 1.4, Project and Analysis Areas, for the reasons described in Subsection 4.3.2, Analysis Area. For socioeconomics, the Puget Sound region is represented by the entire socioeconomic analysis area. Harvest data are primarily from 2002 to 2006 as shown in most tables, supplemented by more recent information (Subsection 3.3.2, Overview of Puget Sound Fisheries, by Species). Economic data are generally from 2002 to 2009 as described in Appendix I, Socioeconomic Impact Methods.

Socioeconomic data are from the area bounded by the 12 counties and catch areas in Puget Sound as designated by Washington State statute (WAC 220-22-030), extending from the U.S./Canadian border to and including the western end of the Strait of Juan de Fuca (Figure 3.3-1). Commercial and recreational salmon fisheries occur in 10 major catch areas (catch area 4B through 13) (Figure 3.3-1), and their subareas (Figure 3.3-2). Socioeconomic information for Clallam, Jefferson, Mason, and Thurston

[6] Landings represent harvested fish, typically brought to shore at locations that include ports, marinas, and boat launches. This EIS generally refers to "harvest" rather than "landings."

Counties includes parts of the counties that extend outside the Puget Sound drainage. Thus, salmon and steelhead harvest data originating from the 12 counties and 10 catch areas are used to describe socioeconomic conditions.

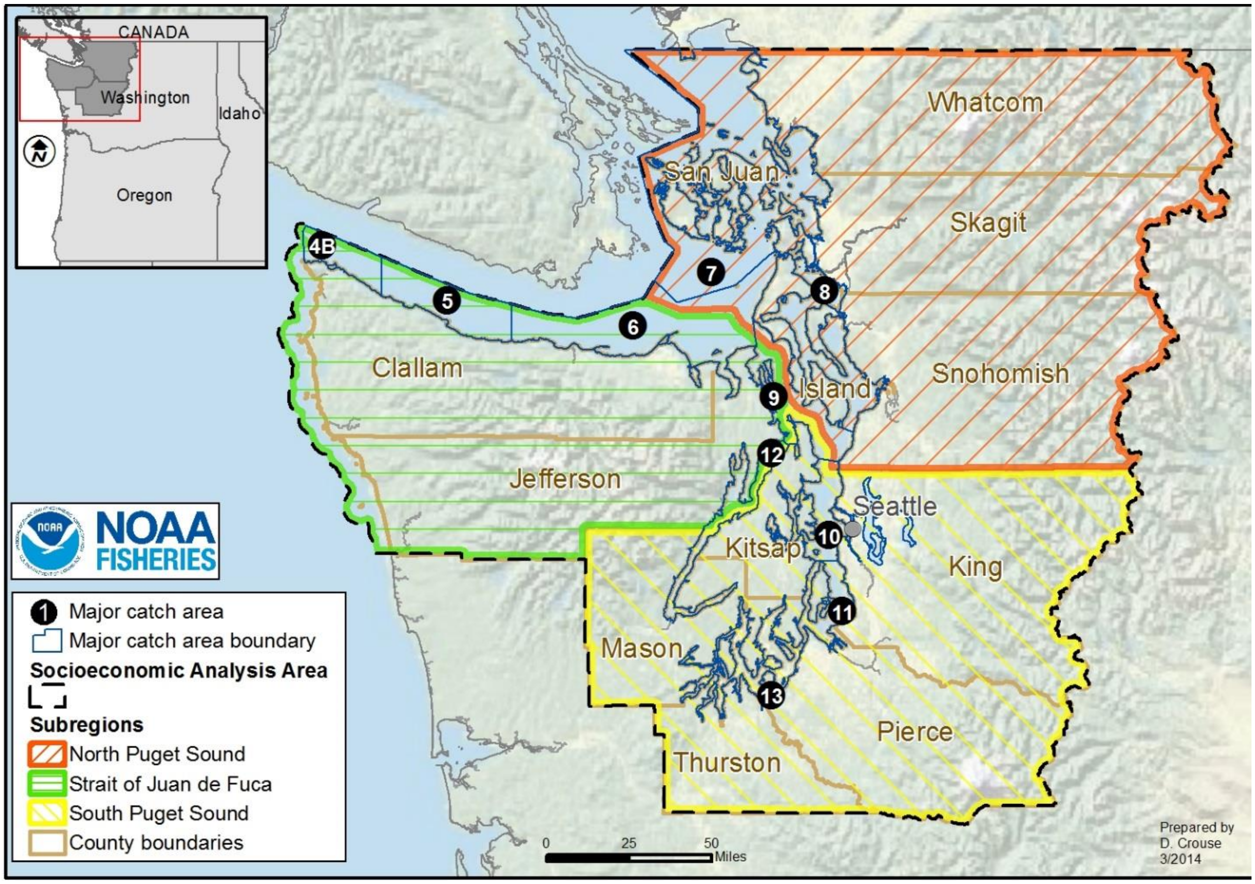


Figure 3.3-1. The geographic area of the 12 counties, 10 major catch areas, and 3 subregions in the socioeconomic analysis area.

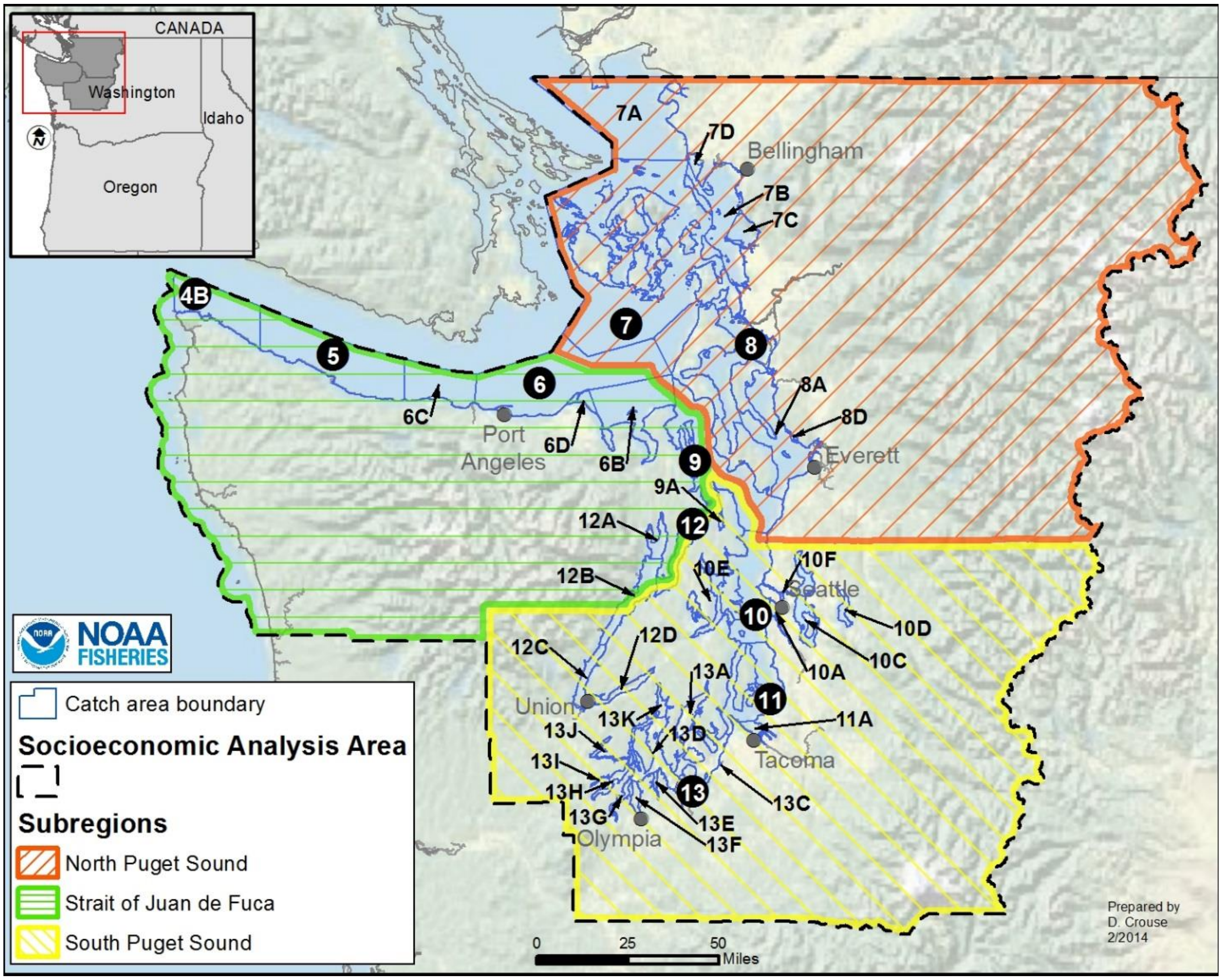


Figure 3.3-2. Catch areas and subareas in the socioeconomic analysis area.

Although salmon produced in the project area may also be harvested along the outer coast of Washington, Oregon, British Columbia, and Alaska, harvest data from those outer areas is generally not used for the analysis (Subsection 4.3.2, Analysis Area), because most of the commercial and recreational harvest of salmon and steelhead produced by hatcheries in the project area occurs in Puget Sound marine and freshwater areas (Appendix I, Socioeconomic Impact Methods) as summarized below. For example, from 2002 to 2006, harvest of hatchery-origin Puget Sound Chinook salmon outside of the socioeconomic analysis area averaged from less than 1 to 9 percent (range less than 1 to 17 percent), and less than 1 to 7 percent (range 0 to 10 percent) for hatchery-origin coho salmon, depending on location and year of harvest (W. Beattie, Northwest Indian Fisheries Commission, memorandum sent to Tom Wegge, April 15, 2010, regarding Puget Sound hatchery production harvested outside of Puget Sound). These percentages likely overestimate the actual contributions of Puget Sound hatchery-origin fish in southeast Alaska and British Columbia fisheries, because all fisheries (e.g., having negligible harvests of Puget Sound fish) are not reflected in the Fishery Regulation Assessment Model (FRAM) estimates (Appendix I, Socioeconomic Impact Methods). These include fisheries inside the southeast Alaska archipelago, and fisheries associated with terminal areas in British Columbia tidewater areas. Other salmon species produced in Puget Sound (pink salmon, sockeye salmon, and chum salmon) are also harvested along the outer coast of Alaska, British Columbia, Washington, and Oregon, but most of the commercial and recreational harvest of these species occurs in Puget Sound marine and freshwater areas. Finally, although there are limits on the harvest impacts to listed Puget Sound Chinook salmon from certain fisheries in southeast Alaska and British Columbia, harvest and harvest rate targets vary largely independently of Puget Sound hatchery production. Thus, changes in production under the alternatives analyzed in this EIS would not be expected to have substantial effects on fisheries outside of the socioeconomic analysis area. Hatchery-origin steelhead from Puget Sound are not targeted in fisheries outside the socioeconomic analysis area.

For more detailed information on Puget Sound salmon and fisheries outside of the socioeconomic analysis area, refer to Appendix I, Socioeconomic Impact Methods.

3.3.1.2 Subregion Socioeconomic Conditions

Socioeconomic information for the entire socioeconomic analysis area (region) is subdivided into three subregions: 1) north Puget Sound subregion, 2) south Puget Sound subregion, and 3) Strait of Juan de Fuca subregion. The subregions encompass counties, river systems, and catch areas as shown in Figure 3.3-1, Figure 3.3-2, Table 3.3-1, and Table 3.3-2.

The following subsections describe salmon and steelhead commercial and recreational fishing, and related economic conditions for the 12 counties and 10 catch areas, and for each of the three subregions. For context, an overview of Puget Sound fisheries by species is presented first.

Table 3.3-1. Counties and their associated major river systems, and catch areas by subregion.

Subregion	County(ies)	Major River System(s)	Catch Areas
North Puget Sound	Whatcom, Skagit	Nooksack River	7, 7A, 7B, 7C, 7D, 8, 8A, 8D
	Skagit	Samish River	
	Skagit, Whatcom	Skagit River	
	Snohomish, Skagit	Stillaguamish River	
	Snohomish	Snohomish River, Skykomish River	
	San Juan Island	None	
South Puget Sound	King	Lake Washington (Cedar and Sammamish Rivers), Snoqualmie River	10, 10A-F, 11, 11A, 12C, 12D, 13, 13A, 13C-K, 13H
	King	Green	
	Pierce	Puyallup River, White River	
	Thurston, Pierce	Nisqually River	
	Mason	Skokomish River	
	Kitsap	None	
Strait of Juan de Fuca	Jefferson	Mid-Hood Canal rivers (Hamma Hamma, Dosewallips, Duckabush, and Quilcene Rivers)	4B, 5, 6C, 6D, 9A, 12, 12A, 12B
	Clallam	Dungeness River	
	Clallam	Elwha River	

Table 3.3-2. Important commercial fisheries by subregion and catch area.

Subregion	Major Fisheries: Target Species and Gears	Treaty Tribe and Non-tribal Involvement
North Puget Sound		
Catch areas 7, 7A, 7B, 7C, 7D, 8, 8A, 8D Nooksack, Skagit Rivers	Fraser River[1] sockeye salmon and pink salmon, Chinook salmon, pink salmon, coho salmon, and chum salmon – gillnet and purse seine	Treaty tribe and non-tribal in all marine areas; treaty tribal only in rivers
South Puget Sound		
Catch areas 10, 10A-F, 11, 11A Lake Washington, and Duwamish, Puyallup, and Nisqually Rivers Catch areas 12C, 12D, 13, 13A, 13C-K, 13H Skokomish River	Lake Washington sockeye salmon, and Chinook salmon, coho salmon, and chum salmon – gillnet and purse seine	Treaty tribe, all marine and river areas; non-tribal chum salmon in catch areas 10 and 11
Strait of Juan de Fuca		
Catch areas 4B, 5, 6C, 6D	Fraser River sockeye salmon and pink salmon – gillnet; Chinook salmon – troll and setnet	Treaty tribe only, except for non-tribal fishery in catch area 6D
Catch areas 9A, 12, 12A, 12B	Chinook salmon, coho salmon, and chum salmon – gillnet and purse seine	Treaty tribe, all marine and river areas; non-tribal marine chum salmon

[1] Fraser River sockeye salmon originate in the Fraser River but migrate through Puget Sound and are caught in Puget Sound fisheries.

3.3.2 Overview of Puget Sound Fisheries, by Species

Commercial and recreational salmon fisheries in marine waters of Puget Sound (including the United States waters of the Strait of Juan de Fuca, Rosario Strait, Georgia Strait, embayments of Puget Sound, and Hood Canal) and in associated freshwater areas, are co-managed by Puget Sound treaty tribes (described in Subsection 3.4.2, Native American Tribes of Concern) and WDFW.

In many Puget Sound areas, commercial and recreational fisheries target hatchery-origin salmon and steelhead. The specific contributions of hatchery-origin fish to marine and freshwater fisheries, however, vary greatly by species and catch area. The following information on Puget Sound fisheries is largely based on information from the Puget Sound Chinook Harvest Plan (PSIT and WDFW 2004) and is complemented by information from the latest harvest management plan (PSIT and WDFW 2010). The information in this subsection includes average total commercial harvests of salmon and steelhead originating from Puget Sound waters (Table 3.3-3). These averages include Puget Sound-origin fish brought to ports located within the Puget Sound region, as well as those brought to ports located outside the Puget Sound region (e.g., coastal ports). Information used in this EIS to characterize economic conditions associated with commercial salmon and steelhead fishing focuses on fish brought to ports in Puget Sound. Fisheries are regulated to achieve conservation guidelines for listed salmon and steelhead populations.

3.3.2.1 Chinook Salmon Fisheries

Because of conservation concerns, commercial fisheries targeting Chinook salmon are limited to protect listed fish and are mostly directed at abundant hatchery production in marine terminal areas (marine areas near locations where fish returning from the ocean enter their home streams and/or spawn), including Bellingham/Samish Bay and the Nooksack River, Tulalip Bay, Elliot Bay and the Duwamish River, Lake Washington, Puyallup River, Nisqually River, Budd Inlet, Carr Inlet, Chambers Bay, Sinclair Inlet, southern Hood Canal, and the Skokomish River. Non-tribal marine terminal area Chinook salmon fisheries occur only in Bellingham Bay and Samish Bay. Total commercial harvest of Chinook salmon in Puget Sound has fallen from levels in excess of 200,000 fish in the 1980s, to an average of 89,500 fish from 1998 to 2002 (PSIT and WDFW 2004). Total commercial catch from 2002 to 2006 averaged 78,390 fish (range 51,320 to 106,927 fish) (Table 3.3-3), and was over 100,000 fish from 2006 through 2008 (PSIT and WDFW 2010).

Commercial net fisheries directed at Chinook salmon occur in some Puget Sound marine areas, and in the lower reaches of larger rivers. These fisheries are regulated to achieve conservation guidelines for natural-origin Chinook salmon populations. In each catch area, harvest is focused on the target species or stock according to its migration timing through that catch area. Because the migration timings of different species overlap, the actual fishing schedules may be constrained during the early and late portion of the management period to reduce impacts on non-target species. Incidental harvest of Chinook salmon also occurs in net fisheries directed at sockeye salmon, pink salmon, and coho salmon.

Table 3.3-3. Commercial salmon harvest from catch areas in the socioeconomic analysis area from 2002 through 2006.

Catch Area and Species	Number of Fish					
	2002	**2003**	**2004**	**2005**	**2006**	**Annual Average**
Areas 5 and 6 (including 4B, marine subareas for catch areas 5 and 6, and rivers)						
Chinook salmon	4,264	1,335	28,372	10,005	4,450	9,685
Coho salmon	15,810	5,859	28,515	7,532	3,741	12,291
Sockeye salmon	45,108	36,334	16,977	5,139	23,393	25,390
Pink salmon	NA	50,103	NA	5,863	NA	27,983
Chum salmon	1,331	421	5,332	1,990	4,730	2,761
Steelhead	115	155	196	164	394	205
Total	**66,628**	**94,207**	**79,392**	**30,693**	**36,708**	**78,315**
Area 7 (including marine subareas for catch area 7, and rivers)						
Chinook salmon	40,601	22,270	14,820	16,288	28,226	24,441
Coho salmon	56,384	51,385	110,907	38,521	22,428	55,925
Sockeye salmon	398,733	230,974	175,902	196,300	677,234	335,829
Pink salmon	NA[1]	799,022	NA	299,585	NA	549,302
Chum salmon	125,759	100,426	196,424	96,051	145,830	132,898
Steelhead	2	2	7	7	0	4
Total	**621,477**	**1,204,079**	**498,061**	**647,018**	**873,718**	**1,098,395**
Areas 8 and 9 (including marine subareas for catch areas 8 and 9, and rivers)						
Chinook salmon	1,975	7,074	4,461	8,307	4,263	5,216
Coho salmon	56,276	26,988	112,737	54,996	35,496	57,299
Sockeye salmon	0	0	2,009	315	887	642
Pink salmon	NA	353,292	NA	38,676	NA	195,984
Chum salmon	319,743	49,421	127,877	60,649	312,005	173,939
Steelhead	0	12	388	394	280	215
Total	**377,994**	**436,787**	**247,472**	**163,337**	**352,931**	**433,295**
Areas 10, 11, and 13 (including marine subareas for catch areas 10, 11, and 13, and rivers)						
Chinook salmon	18,429	15,461	25,898	26,073	51,184	27,409
Coho salmon	118,507	115,901	217,682	138,825	141,283	146,440
Sockeye salmon	26,844	0	17,524	0	51,235	19,121
Pink salmon	NA	2,861	NA	1,769	NA	2,315
Chum salmon	568,087	385,944	708,173	312,532	603,185	515,584
Steelhead	436	91	129	135	113	181
Total	**732,303**	**520,258**	**969,406**	**479,334**	**847,000**	**711,050**

Table 3.3-3. Commercial salmon harvest from catch areas in the socioeconomic analysis area from 2002 through 2006, continued.

Catch Area and Species	Number of Fish					
	2002	**2003**	**2004**	**2005**	**2006**	**Annual Average**
Area 12 (including 9A, marine subareas for catch area 12, and rivers)						
Chinook salmon	3,936	5,180	11,324	18,949	18,804	11,639
Coho salmon	7,464	30,654	79,414	53,533	62,208	46,655
Sockeye salmon	0	0	0	0	0	0
Pink salmon	NA	0	NA	0	NA	0
Chum salmon	305,639	466,965	682,731	238,695	598,928	458,592
Steelhead	0	0	0	0	0	0
Total	**317,039**	**502,799**	**773,469**	**311,177**	**679,940**	**516,886**
Puget Sound Region						
Chinook salmon	69,205	51,320	84,875	79,622	106,927	78,390
Coho salmon	254,441	230,787	549,255	293,407	265,156	318,609
Sockeye salmon	470,685	267,308	212,412	201,754	752,749	380,982
Pink salmon	NA	1,205,278	NA	345,890	NA	775,584 (odd years only)
Chum salmon	1,320,559	1,003,177	1,720,537	709,917	1,664,678	1,283,774
Steelhead	553	260	720	700	787	604
TOTAL	**2,115,443**	**2,758,130**	**2,567,799**	**1,631,290**	**2,790,297**	**2,837,943 (odd years) 2,062,359 (even years)**

Source: Data compiled by W. Beattie (Northwest Indian Fisheries Commission) from TOCAS-LIFT database (file = 2002-06 comm catch 5-04-09.xls) for Puget Sound.

[1] NA = pink salmon harvest is very low in even-numbered years and is excluded.

Note: Includes commercial tribal and non-tribal harvest from marine and freshwater areas. Also includes Puget Sound harvest landed in ports located outside of Puget Sound, including ports along the Washington and Oregon coasts. Therefore, annual average harvest totals do not match those in Table 3.3-4 and Table 4.3-1.

Tribal commercial troll fisheries directed at Chinook salmon occur in the Strait of Juan de Fuca. Most of the effort occurs in winter and early spring, with annual closure from mid-April to mid-June to protect maturing spring-run Chinook salmon. In the early 2000s, annual troll harvest ranged from 1,000 to 2,000 fish (PSIT and WDFW 2004).

Chinook salmon are one of the principal target species of recreational fisheries in marine waters of Puget Sound. Recreational Chinook salmon harvest in marine areas of Puget Sound has fallen since the late 1980s, when harvest levels were in excess of 100,000 fish (PSIT and WDFW 2004), but has been relatively stable in recent years, with the 2000 to 2007 average of approximately 30,000 fish (PSIT and

WDFW 2010). Recreational harvest of Chinook salmon in freshwater areas of Puget Sound has shown an increasing trend since the early 1990s, ranging from 5,000 to 17,000 fish from 2000 to 2007 (PSIT and WDFW 2010). This trend is likely in response to reduced harvest limits and more restrictive harvest seasons in marine areas in conjunction with increasing abundance of some populations.

3.3.2.2 Coho Salmon Fisheries

Commercial fisheries directed at coho salmon occur in some Puget Sound marine areas and rivers. Coho salmon commercial harvests from 2002 to 2006 averaged 318,609 fish (range 230,797 to 549,255 fish) (Table 3.3-3), and remained over 200,000 fish through 2008 (PSIT and WDFW 2010). These harvest levels are substantially below levels of the early 1990s when the total annual harvest exceeded 1 million fish (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, April 23, 2009). Non-tribal coho salmon fisheries occur in Bellingham/Samish Bay, Saratoga Passage, and Possession Sound, and small-scale beach seine fisheries for coho salmon also occur in Quilcene Bay and Dungeness Bay.

The coho salmon harvest in marine recreational fisheries in Puget Sound has varied widely since 2000, ranging from approximately 30,000 to 193,000 fish (PSIT and WDFW 2004, 2010). Since 2000, the recreational coho salmon harvest in fresh water averaged about 45,000 fish (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, August 2, 2007). Coho salmon fisheries are structured to harvest surplus hatchery production in some areas, but are managed to achieve conservation guidelines for natural-origin populations in most areas of Puget Sound. The late-year timing of coho salmon migration overlaps with Chinook salmon; consequently, during the early weeks of coho salmon returns, coho salmon fisheries in some areas are limited to conserve Chinook salmon.

3.3.2.3 Chum Salmon Fisheries

Commercial chum salmon fisheries occur in Bellingham/Samish Bay, Saratoga Passage, Possession Sound, central Puget Sound, and Hood Canal. The number of commercially harvested chum salmon in Puget Sound surpassed that of other species, averaging 1,283,774 chum salmon (range from 709,917 to 1,664,774) from 2002 to 2006 (Table 3.3-3), and remained over 1 million through 2008 (PSIT and WDFW 2010). Chum salmon are commercially harvested primarily in marine areas, but the tribal commercial harvest of chum salmon in rivers is substantial in some areas. Because of rising demand and increased prices for roe, commercial fishing for chum salmon has increased in recent years.

Relatively few chum salmon are caught in recreational fisheries. From 2002 to 2006, the average recreational harvest of chum salmon was 3,703 fish in marine waters of Puget Sound and 11,144 fish in fresh water (E. Kraig, pers. comm., WDFW, Catch Record Card Data Manager, March 4, 2014). The popularity of recreational fishing for chum salmon has increased in some areas, however. Generally, chum salmon fisheries in Puget Sound (both recreational and commercial) are managed to achieve escapement goals for natural-origin populations, but hatchery production is substantial and targeted in some areas (e.g., Hood Canal) by commercial and recreational fishers.

3.3.2.4 Pink Salmon Fisheries

Commercial fisheries directed at Puget Sound-origin pink salmon occur only in the Skagit and Stillaguamish-Snohomish marine terminal areas (i.e., Skagit Bay and Skagit River, and Possession Sound/Port Gardner). Returns of fish originating in other Puget Sound rivers are inconsistent and not at high enough abundance levels to support directed fisheries. Because the run timing of pink salmon and Chinook salmon in Puget Sound overlap considerably, pink salmon are taken in Chinook salmon-directed commercial fisheries. Most Puget Sound pink salmon return only in odd-numbered years, with the even-year run in the Snohomish River being the principal exception. The average commercial harvest of pink salmon was 775,584 fish from 2003 and 2005 (range 345,890 to 1,205,278 fish) (Table 3.3-3), and harvest in 2007 was similar to 2005 (PSIT and WDFW 2010). Commercial fisheries directed at Fraser River-origin pink salmon occur in catch areas 7 and 7A. The average pink salmon harvest in those fisheries was over 450,000 fish in odd-numbered years from 2001 to 2007 (PSIT and WDFW 2010).

The recreational harvest of Fraser River-origin pink salmon occurs primarily in the Strait of Juan de Fuca and catch area 8, and averaged 107,000 fish during 2001, 2003, and 2005; the average recreational harvest of Fraser River-origin pink salmon in freshwater areas of Puget Sound was 60,000 fish during those years (PSIT and WDFW 2004).

Relatively small numbers of pink salmon are reared in Puget Sound hatcheries. Because the run timing of pink salmon and Chinook salmon in Puget Sound overlaps, fisheries directed at pink salmon can be modified to reduce incidental harvests of Chinook salmon.

3.3.2.5 Sockeye Salmon Fisheries

Commercial and recreational fisheries targeting Puget Sound sockeye salmon populations are very limited, occurring sporadically (2002 and 2006) in central Puget Sound and Lake Washington (on the Cedar River population), and in the Skagit River (on the Baker River population). Hatchery production enhances the sockeye salmon fisheries. Net fisheries directed at sockeye salmon returning to the Fraser River are conducted annually in the Strait of Juan de Fuca (catch areas 4B, 5, and 6C), and Georgia Strait/Rosario Strait (catch areas 7 and 7A). Although the Fraser River sockeye salmon harvest annually exceeded two million fish from 1994 to 2004, the fishery has been constrained in recent years because of lower survival and pre-spawning mortality of sockeye salmon (PSIT and WDFW 2010). Sockeye salmon harvest averaged 380,982 fish from 2002 to 2006 (range 201,754 to 752,749 fish) (Table 3.3-3), with lower numbers in 2007 and 2008 (PSIT and WDFW 2010).

3.3.2.6 Steelhead Fisheries

Natural-origin winter-run and summer-run steelhead are distributed throughout Puget Sound (Subsection 3.2.7, Puget Sound Steelhead DPS), but their abundance is generally not sufficient to support harvest of natural-origin fish. Steelhead fisheries in Puget Sound target hatchery production (primarily winter-run steelhead), with the exception of summer-run steelhead in the Stillaguamish River and Snohomish River systems. The run timing of winter-run hatchery-origin steelhead is earlier than natural-origin steelhead, enabling fisheries to target hatchery-origin fish with low incidental mortality to natural-origin steelhead.

Recreational fishing for steelhead that targets hatchery-origin fish is very popular in Puget Sound rivers. The average recreational harvest of steelhead in Puget Sound rivers was about 11,000 fish in 1999 and 2000. Two river systems, the Snohomish River and Stillaguamish Rivers, accounted for more than half of this harvest (Manning and Smith 2004). In the late 1970s, the WDFW implemented conservation measures requiring fishers to release natural-origin steelhead.

Tribal commercial incidental steelhead harvest averaged 604 fish from 2002 to 2006 (range 260 to 787 fish) (Table 3.3-3). Most tribal steelhead fisheries occur in freshwater areas. Tribal fishers also harvest steelhead in commercial, ceremonial, and subsistence fisheries (primarily using set nets).

3.3.3 Commercial Salmon and Steelhead Fishing

Tribal and non-tribal commercial fishing for salmon and steelhead occurs throughout the 12 counties and 10 catch areas, although tribal fishers typically fish in designated usual and accustomed areas. Tribal salmon fishing (including ceremonial and subsistence fishing), which is in addition to commercial fisheries, is distributed in space and time throughout all marine waters and major rivers of Puget Sound, but occurs within defined usual and accustomed areas for each tribe. Non-tribal commercial salmon fishing in Puget Sound marine areas occurs on a more limited spatial scale, targeting local hatchery production with gillnet and purse seine gear. Non-tribal commercial fishing does not occur in rivers; all commercial harvests in rivers are by tribal fishers. In addition, there is no non-tribal commercial fishing for steelhead. Tribal and non-tribal commercial fishers use similar fishing gear, although certain types of gear are used for targeting different species and can change from year to year.

Harvest estimates for commercial fisheries were developed from species-specific harvest averages for marine catch areas and freshwater areas in the socioeconomics analysis area over the 2002 to 2006 period, using state and tribal data and modeling. This information is used to describe the affected environment. Estimates of harvest and associated gross and net economic values are presented below for the 12 counties and 10 catch areas, followed by estimates for each of the three subregions: north Puget Sound, south Puget Sound, and Strait of Juan de Fuca. Information at the regional and subregional level is provided to characterize differences within and between the subregions in the context of the 12 counties and 10 catch areas.

Not all salmon and steelhead harvested from Puget Sound waters are brought to ports in the project area. A small percentage (about 6 percent) of the average annual harvest of fish from the project area is brought to ports along the Washington and Oregon coast (Table A-3 in Appendix I, Socioeconomic Impact Methods).

3.3.3.1 Puget Sound Region

Commercial harvest of salmon and steelhead originating from the project area is reported for 10 catch areas and respective sub-areas (catch areas 4B to 13H), and in major rivers (fresh water) that terminate in these catch areas (Table 3.3-2). The distribution of total commercial harvest of salmon and steelhead in catch areas from 2002 to 2006 is shown in Table 3.3-3. Overall, including fish brought to ports outside Puget Sound, commercial salmon and steelhead harvests from these areas range from 1,631,290 to 2,790,297 fish (Table 3.3-3). On average, harvests of chum salmon account for 45 percent of this total commercial harvest, followed by pink salmon at 27 percent. Sockeye salmon, coho salmon, and Chinook salmon landings account for 13, 11, and 3 percent, respectively, of the total commercial harvest.

The commercial harvest of Puget Sound salmon and steelhead in catch area 7 accounts for 39 percent of the total commercial harvest, followed by combined catch areas 10, 11, and 13 in the south Puget Sound subregion (25 percent), catch area 12 also representing the south Puget Sound subregion (18 percent), catch areas 8 and 9 representing the north Puget Sound subregion and Strait of Juan de Fuca subregions (15 percent), and catch areas 5 and 6 representing the Strait of Juan de Fuca subregion (3 percent) (Table 3.3-3). Chum salmon was the most frequently caught species in catch areas 10, 11, 12, and 13, whereas pink salmon were the most frequently caught species in catch areas 5 and 6, catch area 7, and catch areas 8 and 9 (pink salmon are only harvested in large numbers in Puget Sound fisheries in odd-numbered years) (Table 3.3-3).

Total commercial harvests of salmon and steelhead originating in the project area and brought to ports within the 12 counties and 10 catch areas are used to describe economic conditions associated with commercial harvest. From 2002 to 2006, this total commercial harvest averaged 2,679,392 fish, with 49 percent of the harvest by tribal fishers and 51 percent by non-tribal fishers (Table 3.3-4). Average harvest of chum salmon (1,190,995 fish, or 44 percent of total harvest) is larger than any other species (Table 3.3-4). The combined harvest of pink salmon, sockeye salmon, and coho salmon account for 53 percent of the total harvest, while Chinook salmon and steelhead harvest account for 3 percent and less than 1 percent of the total harvest, respectively. Harvests in freshwater areas are described in Subsection 3.3.6, Fisheries in Major River Systems.

Based on the total commercial harvest of salmon and steelhead originating in the project area and brought to ports and other locations in the 12 counties and 10 catch areas, the average annual gross economic value totals $15,577,897, including $9,148,467 (59 percent) for tribal fishers and $6,429,430 (41 percent) for non-tribal fishers (Table 3.3-4). The total net economic values associated with the average annual harvest (tribal and non-tribal) of salmon and steelhead brought to ports and other locations in the 12 counties and 10 catch areas is estimated to be $10,346,702 (Table 3.3-4). Chum salmon represent the highest total net economic value ($4,418,591) of any species harvested in the 12 counties and 10 catch areas (Table 3.3-4).

3.3.3.2 North Puget Sound Subregion

An average total of 1,712,653 salmon and steelhead originating in the project area are harvested by tribal and non-tribal fishers and brought to ports and other locations in the north Puget Sound subregion (Table 3.3-4). The gross economic value of these harvests annually averages $8,545,496, or 55 percent of the gross economic value of total harvest brought to ports in the 12 counties and 10 catch areas (Table 3.3-4). Note that gross economic values for subregions do not include the value of harvest brought to ports outside of the 12 counties and 10 catch areas. Harvest from each catch area is assigned to ports, and then to counties, based on the average proportion of harvest for each species from each catch area brought to the different port areas (Appendix I, Socioeconomic Impact Methods). As would be expected, the commercial harvest in catch area 7 (north Puget Sound) is primarily brought to ports in Whatcom and Skagit Counties (Table A-3 in Appendix I, Socioeconomic Impact Methods).

Table 3.3-4. Average annual (2002 to 2006) commercial harvest, gross economic values, and net economic values from treaty tribe and non-tribal salmon and steelhead commercial harvests brought to ports, by fish species and subregion.

Subregion and Species	Treaty Tribe		Non-Tribal		Total		Net Economic Value ($)[3]
	Average Harvest (Number of Fish)[1]	Gross Economic Value ($)[2]	Average Harvest (Number of Fish)[1]	Gross Economic Value ($)[2]	Average Harvest (Number of Fish)[1]	Gross Economic Value ($)[2]	
North Puget Sound							
Chinook salmon	17,810	452,012	8,495	215,596	26,305	667,608	462,959
Coho salmon	100,671	979,324	15,010	146,016	115,681	1,125,340	747,296
Sockeye salmon	199,454	1,715,882	108,471	933,163	307,925	2,649,045	1,758,254
Pink salmon	281,434	228,300	345,001	279,865	626,435	508,165	332,011
Chum salmon	190,811	1,077,787	445,278	2,515,128	636,089	3,592,915	2,359,890
Steelhead	218	2,425	0	0	218	2,425	1,607
Total	**790,399**	**4,455,730**	**922,254**	**4,089,767**	**1,712,653**	**8,545,496**	**5,662,016**
South Puget Sound							
Chinook salmon	40,203	1,020,363	143	3,637	40,346	1,024,000	710,103
Coho salmon	169,771	1,651,531	4,741	46,118	174,512	1,697,649	1,127,345
Sockeye salmon	30,937	266,149	6,520	56,092	37,457	322,241	213,881
Pink salmon	29,809	24,181	34,739	28,180	64,548	52,361	34,210
Chum salmon	164,034	926,539	380,300	2,148,104	544,334	3,074,643	2,019,480
Steelhead	181	2,007	0	0	181	2,007	1,331
Total	**434,935**	**3,890,770**	**426,443**	**2,282,131**	**861,378**	**6,172,902**	**4,106,350**
Strait of Juan de Fuca							
Chinook salmon	11,169	283,478	26	670	11,195	284,148	197,045
Coho salmon	23,144	225,140	724	7,047	23,868	232,187	154,187
Sockeye salmon	28,349	243,880	1,541	13,258	29,890	257,138	170,671
Pink salmon	28,726	23,303	905	734	29,631	24,037	15,704
Chum salmon	4,230	23,891	6,342	35,823	10,572	59,714	39,221
Steelhead	205	2,274	0	0	205	2,274	1,507
Total	**95,822**	**801,967**	**9,539**	**57,532**	**105,361**	**859,499**	**578,336**

Table 3.3-4. Average annual (2002 to 2006) commercial harvest, gross economic values, and net economic values from treaty tribe and non-tribal salmon and steelhead commercial harvests brought to ports, by fish species and subregion, continued.

Subregion and Species	**Treaty Tribe**		**Non-Tribal**		**Total**		**Net Economic Value ($)[3]**
	Average Harvest (Number of Fish)[1]	**Gross Economic Value ($)[2]**	**Average Harvest (Number of Fish)[1]**	**Gross Economic Value ($)[2]**	**Average Harvest (Number of Fish)[1]**	**Gross Economic Value ($)[2]**	
Puget Sound Region							
Chinook salmon	69,183	1,755,853	8,664	219,904	77,847	1,975,757	1,370,107
Coho salmon	293,585	2,855,995	20,475	199,181	314,060	3,055,176	2,028,827
Sockeye salmon	258,740	2,225,912	116,532	1,002,512	375,272	3,228,424	2,142,806
Pink salmon	339,969	275,783	380,644	308,779	720,613	584,562	381,925
Chum salmon	359,075	2,028,218	831,920	4,699,055	1,190,995	6,727,273	4,418,591
Steelhead	604	6,706	0	0	604	6,706	4,445
Total	**1,321,156**	**9,148,467**	**1,358,235**	**6,429,430**	**2,679,392**	**15,577,897**	**10,346,702**

Sources: Gross economic value estimates are from the Economics Impact Model developed by TCW Economics for this EIS. Net economic value estimates are derived by TCW Economics using harvest estimates provided by the EIS Technical Work Group and net economic value factors identified in Appendix I, Socioeconomic Impact Methods.

[1] Harvest does not include harvest landed in ports outside of Puget Sound. Therefore, average harvest totals do not match those in Table 3.3-3.

[2] All values are expressed in 2007 dollars.

[3] Net economic value totals do not include the value of fish caught in Puget Sound marine waters but landed in ports outside of Puget Sound.

For non-tribal fishers, an average of 922,254 salmon are annually harvested in the north Puget Sound subregion, generating $4,089,767 in gross economic value (Table 3.3-4). This harvest represents 68 percent of the average annual non-tribal salmon harvest of 1,358,235 fish for the region. Chum salmon are the greatest contributor to total non-tribal harvest and total gross economic values in the north Puget Sound subregion (Table 3.3-4).

For tribal fishers, the commercial harvest of salmon and steelhead brought to ports in the north Puget Sound subregion averages 790,399 fish, or 60 percent of the total tribal harvest of 1,321,156 fish for the region (Table 3.3-4). Tribal harvests account for 52 percent of the total average gross economic value of $4,455,730 within the north Puget Sound subregion, with pink salmon contributing the largest shares to total tribal harvest and sockeye salmon and chum salmon contributing the largest shares of tribal gross economic value within the subregion (Table 3.3-4).

The overall net economic value of the annual harvest of salmon and steelhead in the north Puget Sound subregion is $5,662,016, with most of the net economic value attributable to chum salmon and sockeye salmon (Table 3.3-4).

3.3.3.3 South Puget Sound Subregion

An average total of 861,378 salmon and steelhead are harvested by tribal and non-tribal fishers in the south Puget Sound subregion (Table 3.3-4). The gross economic value of these harvests annually average $6,172,902, or 40 percent of the value of total landings at all Puget Sound ports (Table 3.3-4). As would be expected, the commercial harvest in catch area 12 (south Puget Sound) is primarily brought to ports in Mason County (Appendix I, Socioeconomic Impact Methods, Table A-3).

For non-tribal fishers, an average of 426,443 salmon are annually harvested in the south Puget Sound subregion, generating $2,282,131 in gross economic value (Table 3.3-4). This harvest represents 31 percent of the average annual non-tribal salmon harvest of 1,358,235 fish for the region. Chum salmon are the greatest contributor to total non-tribal harvest and total gross economic values in the south Puget Sound subregion (Table 3.3-4).

For tribal fishers, the commercial harvest of Puget Sound salmon and steelhead brought to ports in the south Puget Sound subregion averages 434,935 fish, or 33 percent of the total tribal harvest of 1,321,156 fish for the region (Table 3.3-4). Tribal harvests account for 63 percent of the total average gross economic value of $6,172,902 within the south Puget Sound subregion, with coho salmon contributing the largest share to total tribal harvest and total gross economic value in the south Puget Sound subregion (Table 3.3-4).

The net economic value of the annual harvest of salmon and steelhead brought to ports and other locations in the south Puget Sound subregion was $4,106,350, with most of the net economic value attributable to pink salmon and coho salmon (Table 3.3-4).

3.3.3.4 Strait of Juan de Fuca Subregion

An average total of 105,361 salmon and steelhead are harvested by tribal and non-tribal fishers and brought to ports and other locations in the Strait of Juan de Fuca subregion (Table 3.3-4). The gross economic value of these harvests annually averages $859,499, or about 6 percent of the value of total landings at all Puget Sound ports (Table 3.3-4). As would be expected, the commercial harvest in catch areas 5 and 6 (the Strait of Juan de Fuca and western Puget Sound) are primarily brought to ports in Clallam and Jefferson Counties (Table A-3 in Appendix I, Socioeconomic Impact Methods).

For non-tribal fishers, an average of 9,539 salmon are annually harvested in the Strait of Juan de Fuca subregion, generating $57,532 in gross economic value (Table 3.3-4). This harvest represents less than 1 percent of the average annual non-tribal salmon harvest of 1,358,235 fish. Chum salmon are the greatest contributor to total non-tribal harvest and gross economic values in the Strait of Juan de Fuca subregion (Table 3.3-4).

For tribal fishers, commercial harvest of salmon brought to ports and other locations in the Strait of Juan de Fuca subregion averages 95,822 fish, or 7 percent, of the total tribal harvest of 1,321,156 fish for the region (Table 3.3-4). Tribal harvest accounts for 93 percent of the total gross economic value of $859,499 in the Strait of Juan de Fuca subregion, with pink salmon contributing the largest share to total tribal harvest, and Chinook salmon contributing the greatest share to total tribal gross economic values in the Strait of Juan de Fuca subregion.

The net economic value of the total average annual harvest of salmon and steelhead in the Strait of Juan de Fuca subregion is $578,336, with most of the net economic value attributable to Chinook salmon, coho salmon, and sockeye salmon (Table 3.3-4).

3.3.4 Recreational Salmon and Steelhead Fishing

Recreational fishing trips are used to estimate the economic effects of recreational salmon and steelhead fisheries, as described in Appendix I, Socioeconomic Impact Methods. Gross and net economic values for recreational fishing are described, with gross economic values for recreational fisheries defined in terms of total trip-related expenditures made by recreational fishers, and net economic values defined as fishers' willingness to pay over and above expenditures for these fishing opportunities. The gross economic value of salmon and steelhead recreational fisheries is the value that the fisheries generate for businesses and economies supported by the fisheries (including guides, charter boat operators, and other businesses such as bait and tackle stores, lodging, food stores and restaurants, and miscellaneous retail stores).

3.3.4.1 Puget Sound Region

The total number of recreational fishing trips for salmon and steelhead averages 997,380 trips annually in the Puget Sound region (Table 3.3-5). Based on an average of $70.43 per day in trip-related expenditures (e.g., purchases of bait, tackle, lodging, food, guide fees, boat-related expenses, travel expenses), recreational fishers generate an estimated $70,245,440 in trip-related expenditures (Table 3.3-5). Based on an average value per angler day of $59.12, recreational fishers are estimated to accrue $58,965,077 in net economic value (Table 3.3-5). In contrast to economic data for commercial fisheries, limitations in economic data for recreational fisheries preclude species-specific estimates of net economic values.

Table 3.3-5. Average annual (2002 through 2006) recreational trips, trip expenditures, and net economic values for recreational salmon and steelhead fisheries by subregion.

Subregion	Number of Trips	Trip Expenditures ($)[1]	Net Economic Value ($)
North Puget Sound	430,757	30,338,222	25,466,359
South Puget Sound	512,878	36,121,982	30,321,334
Strait of Juan de Fuca	53,745	3,785,236	3,177,384
Puget Sound Region	997,380	70,245,440	58,965,077

Source: Trips estimated by the EIS Technical Work Group, and expenditures and net economic values estimated by TCW Economics (Appendix I, Socioeconomic Impact Methods).
[1] Values are expressed in 2007 dollars.

3.3.4.2 North Puget Sound Subregion

Within the north Puget Sound subregion, the total number of recreational trips annually averages 430,757 trips, representing 43 percent of all salmon and steelhead trips (Table 3.3-5). Annual trip-related expenditures by fishers in the subregion averages $30,338,222 (Table 3.3-5). Based on an average value per angler day of $59.12, recreational fisheries are estimated to accrue a total of $25,466,359 in net economic value in the south Puget Sound subregion (Table 3.3-5).

3.3.4.3 South Puget Sound Subregion

Within the south Puget Sound subregion, the total number of recreational trips annually averages 512,878 trips, representing 51 percent of all salmon and steelhead trips (Table 3.3-5). Annual trip-related expenditures by fishers in the subregion averages $36,121,982 (Table 3.3-5). Based on an average value per angler day of $59.12, recreational fisheries are estimated to accrue a total of $30,321,334 in net economic value in the south Puget Sound subregion (Table 3.3-5).

3.3.4.4 Strait of Juan de Fuca Subregion

Within the Strait of Juan de Fuca subregion, the total number of recreational trips annually averages 53,745 trips, representing 5 percent of all salmon and steelhead trips (Table 3.3-5). Annual trip-related expenditures by fishers in the subregion averages $3,785,236 (Table 3.3-5). Based on an average value per angler day of $59.12, recreational fisheries are estimated to accrue a total of $3,177,384 in net economic value in the Strait of Juan de Fuca subregion (Table 3.3-5).

3.3.5 Regional and Subregional Economic Conditions

Commercial and recreational fisheries generate personal income and support jobs throughout the 12 counties and 10 catch areas. For example, commercially harvested salmon and steelhead are frequently sold directly or after processing to persons or businesses located outside the Puget Sound economy. This transfer of money supports payments to labor (jobs), which are then re-spent within the 12 counties (i.e., multiplier effect). Similarly, non-local recreational fishers (i.e., fishers who live outside the local area) spend money on guide services, lodging, and other goods and services that generate household and job income for local communities. Lastly, money spent on hatchery operations (e.g., goods and services) provides an additional infusion of income to local economies.

Salmon processors and buyers include persons who purchase salmon from tribal and non-tribal commercial fishers, and either process the product themselves (e.g., cleaning and icing operations, or smoking and curing), or sell it to a third party for processing. Although most salmon processors and buyers are believed to be non-tribal individuals and companies, some Puget Sound treaty tribes buy salmon directly from tribal commercial fishers, and a few tribes also process salmon (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, August 2, 2007).

Descriptions of regional and subregional economic conditions involve estimating the amount of personal income and number of jobs generated by harvest and hatchery-related activities. In terms of harvest, economic impacts (personal income and jobs) are generated by commercial fishing activity of tribal and non-tribal fishers, and by recreational fishing activities. In terms of hatchery production, estimates of personal income and number of jobs are based on the direct and indirect effects associated with hatchery operational cost values. These hatchery operational cost values represent the economic impacts of hatchery operations, including procurement of goods and services from businesses that directly and indirectly generate economic impacts. These hatchery operations cost values are estimated using the cost of producing 1,000 juvenile fish for each salmon species reported in WDFW (2009). The hatchery operations cost values in WDFW (2009) pertain to WDFW's hatchery programs that are reviewed in this EIS, and are assumed to apply to other hatcheries as well. Additional details concerning the methods used to estimate hatchery operational cost values are described in Appendix I, Socioeconomic Impact Methods.

3.3.5.1 Puget Sound Region

As shown in Table 3.3-6, the total economic effect from Puget Sound hatchery operations and associated harvest, including income in the salmon processing and buying sectors described above, is $106,888,559. Of that total, the amount of personal income and number of jobs supported by commercial and recreational fisheries and related hatchery operations is $94,249,982 and 2,060 jobs, respectively (Table 3.3-6). Commercial and recreational fisheries alone annually generate an estimated $84,544,409 in harvest-related personal income and 1,851 jobs, whereas hatchery operations generate $9,705,573 in personal income and 209 jobs (Table 3.3-6).

Of the total personal income of $94,249,982, $55,755,262 (59 percent) is generated from recreational fishing, $28,789,147 (30 percent) is from commercial fishing, and $9,705,573 (11 percent) is from hatchery operations (Table 3.3-6). Of the 2,060 jobs related to harvest and hatchery operations, 1,195 jobs (58 percent) are attributable to recreational fishing, 656 jobs (32 percent) are attributable to commercial fishing, and 209 jobs (10 percent) are attributable to hatchery operations (Table 3.3-6). The goods and services procured to support hatchery operations contributed $12,638,777 (Table 3.3-6).

1 Table 3.3-6. Economic effects from hatchery operation and harvest-related costs, personal income, and jobs by subregion.

Subregion[1]	Hatchery Operations Cost Values, Personal Income, and Jobs			Harvest-related Personal Income and Jobs		Totals		
	Operations Cost Value ($)[2]	Personal Income ($)[3]	Number of Jobs[4]	Personal Income ($)[3]	Number of Jobs[4]	Personal Income ($)[3]	Number of Jobs[4]	Total Personal Income Plus Hatchery Operations Cost Value ($)
North Puget Sound								
Tribal commercial	1,471,992	1,051,468	24	7,707,370	192	8,758,838	216	10,230,830
Non-tribal commercial	2,390,901	1,707,860	38	9,008,170	224	10,715,730	262	13,106,931
Recreational	-[5]	-[5]	-[5]	22,249,969	497	22,249,969	497	22,249,969
Total	**3,862,893**	**2,759,328**	**62**	**38,965,509**	**913**	**41,724,837**	**975**	**45,587,730**
South Puget Sound								
Tribal commercial	2,574,548	2,104,988	44	5,925,841	117	8,030,829	161	10,605,377
Non-tribal commercial	5,017,291	4,102,209	85	5,123,617	92	9,225,826	177	14,243,117
Recreational	-[5]	-[5]	-[5]	29,581,949	574	29,581,949	574	29,581,949
Total	**7,591,839**	**6,207,197**	**129**	**40,631,407**	**783**	**46,838,604**	**912**	**54,430,443**
Strait of Juan de Fuca								
Tribal commercial	411,747	257,001	6	932,398	29	1,189,399	35	1,601,146
Non-tribal commercial	772,297	482,047	12	91,750	3	573,797	15	1,346,094
Recreational	-[5]	-[5]	-[5]	3,923,344	123	3,923,344	123	3,923,344
Total	**1,184,044**	**739,048**	**18**	**4,947,492**	**155**	**5,686,540**	**173**	**6,870,584**

Table 3.3-6. Economic effects from hatchery operation and harvest-related costs, personal income, and jobs by subregion, continued.

	Hatchery Operations Cost Values, Personal Income, and Jobs			Harvest-related Personal Income and Jobs		Totals		
Subregion[1]	**Operations Cost Value ($)**[2]	**Personal Income ($)**[3]	**Number of Jobs**[4]	**Personal Income ($)**[3]	**Number of Jobs**[4]	**Personal Income ($)**[3]	**Number of Jobs**[4]	**Total Personal Income Plus Hatchery Operations Cost Value ($)**
Puget Sound Region								
Tribal commercial	4,458,287	3,413,457	74	14,565,610	338	17,979,067	412	22,437,354
Non-tribal commercial	8,180,490	6,292,116	135	14,223,537	318	20,515,653	453	28,696,143
Recreational	-[5]	-[5]	-[5]	55,755,262	1,195	55,755,262	1,195	55,755,262
Total	**12,638,777**	**9,705,573**	**209**	**84,544,409**	**1,851**	**94,249,982**	**2,060**	**106,888,559**

Source: Economics Impact Model developed by TCW Economics for this EIS.

[1] Information on tribal and non-tribal commercial fisheries is included here for environmental justice.
[2] Includes economic values from hatchery operations including goods and services such as fish food and other supplies, administration, and required services including routine mass-marking. Occasional capital costs and coded-wire tagging are not included.
[3] Includes direct and indirect personal income effects.
[4] Jobs are expressed in full- and part-time jobs. Includes direct and indirect employment effects.
[5] Dashes mean not applicable, because hatchery operation cost values are not separable into commercial and recreational harvest sectors.
Note: all values are expressed in 2007 dollars.

3.3.5.2 North Puget Sound Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the north Puget Sound subregion are intermediate among the three subregions. As shown in Table 3.3-6, the total economic effect from hatchery operations and associated harvest in the north Puget Sound subregion, including income in the salmon processing and buying sectors described above, is $45,587,730. Of that total, the amount of personal income and number of jobs supported by the north Puget Sound subregion commercial and recreational fisheries and hatchery operations is $41,724,837 and 975 jobs, respectively (Table 3.3-6). Commercial and recreational fisheries alone annually generate an estimated $38,965,509 in personal income and 913 jobs within the north Puget Sound subregion, whereas hatchery operations generate $2,759,328 in personal income and 62 jobs (Table 3.3-6). Of the total personal income of $41,724,837, $22,249,969 (52 percent) is generated from recreational fishing, $16,715,540 (40 percent) is from commercial fishing, and $2,759,328 (8 percent) is from hatchery operations (Table 3.3-6).

Of the total of 975 jobs generated in the north Puget Sound subregion, 497 jobs (51 percent) are attributable to recreational fishing, 416 jobs (43 percent) are attributable to commercial fishing, and 62 jobs (6 percent) are attributable to hatchery operations (Table 3.3-6).

The north Puget Sound subregion accounts for about 43 percent of the $106,888,559 in total harvest-related and hatchery operations income, and 47 percent of the total jobs in the 12 counties and 10 catch areas (Table 3.3-6). The goods and services procured to support hatchery operations contribute $3,862,893 (Table 3.3-6).

3.3.5.3 South Puget Sound Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the south Puget Sound subregion are the largest among the three subregions. As shown in Table 3.3-6, the total economic effect from hatchery operations and associated harvest in the south Puget Sound subregion, including income in the salmon processing and buying sectors, is $54,430,443. Of that total, the amount of personal income and number of jobs supported by the south Puget Sound subregion for commercial and recreational fisheries and hatchery operations is $46,838,604 and 912 jobs, respectively (Table 3.3-6). Commercial and recreational fisheries alone annually generate an estimated $40,631,407 in personal income and 783 jobs within the south Puget Sound subregion, whereas hatchery operations generate $6,207,197 in personal income and 129 jobs (Table 3.3-6). Of the total personal income of

$46,838,604, $29,581,949 (64 percent) is generated from recreational fishing, $11,049,458 (23 percent) is from commercial fishing, and $6,207,197 (13 percent) is from hatchery operations (Table 3.3-6).

Of the 912 jobs generated in the south Puget Sound subregion, 574 jobs (63 percent) are attributable to recreational fishing, 209 jobs (23 percent) are attributable to commercial fishing, and 129 jobs (14 percent) jobs are attributable to hatchery operations (Table 3.3-6).

The south Puget Sound subregion accounts for about 51 percent of the $106,888,559 in total harvest-related and hatchery operations income, and 44 percent of the total number of jobs (Table 3.3-6). The goods and services procured to support hatchery operations contribute $7,591,839 (Table 3.3-6).

3.3.5.4 Strait of Juan de Fuca Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the Strait of Juan de Fuca subregion are the smallest of the subregions. As shown in Table 3.3-6, the total economic effect from hatchery operations and associated harvest in the Strait of Juan de Fuca subregion, including income in the salmon processing and buying sectors described above, is $6,870,584. Of that total, the amount of personal income and number of jobs supported by the Strait of Juan de Fuca subregion commercial and recreational fisheries and hatchery operations is $5,686,540 and 173 jobs, respectively (Table 3.3-6). Commercial and recreational fisheries alone annually generate an estimated $4,947,492 in personal income and 155 jobs within the Strait of Juan de Fuca subregion, whereas hatchery operations generate $739,048 in personal income and 18 jobs (Table 3.3-6). Of the total personal income, $3,923,344 (67 percent) is generated from recreational fishing, $1,024,148 (17 percent) is from commercial fishing, and $739,048 (16 percent) is from hatchery operations (Table 3.3-6).

Of the 173 jobs generated in the Strait of Juan de Fuca subregion, 123 jobs (71 percent) are attributable to recreational fishing, 32 jobs (19 percent) are attributable to commercial fishing, and 18 jobs (10 percent) are attributable to hatchery operations (Table 3.3-6). The Strait of Juan de Fuca subregion accounts for about 7 percent of the $106,888,559 in total harvest-related and hatchery operations income, and 8 percent of the total number of jobs (Table 3.3-6). The goods and services procured to support hatchery operations contribute $1,184,044 (Table 3.3-6).

3.3.6 Fisheries in Major River Systems

Affected environment conditions are characterized in this subsection in terms of marine and in-river terminal area fisheries. Terminal area fisheries are generally associated with commercial salmon fisheries located in marine areas immediately adjacent to river mouths, but are also associated with in-river (recreational) fisheries in major rivers. Major river systems and corresponding counties where they are located are identified in Table 3.3-1. The relative contribution of hatchery-origin salmon and steelhead to local in-river fisheries and harvest is identified in Table 3.3-7.

Table 3.3-7. Relative contribution of hatchery-origin salmon and steelhead to commercial (treaty tribes) and recreational in-river fisheries by subregion, river, and species.

Subregion and River	**Chinook Salmon**	**Coho Salmon**	**Chum Salmon**	**Pink Salmon**	**Sockeye Salmon**	**Steelhead**
North Puget Sound						
Nooksack	High [1]	High	Low	Natural		High
Samish	High	High	Low	Natural		High
Skagit	Low	Moderate	Low	Natural	Moderate	High
Stillaguamish	High	Moderate	Natural	Natural		High
Snohomish	High	Moderate				High
Skykomish	High	Moderate				High
South Puget Sound						
Lake Washington	High	Moderate	Natural	Natural	Moderate	
Snoqualmie						
Green	High	Moderate	Low	Natural		High
Puyallup	High	High	Moderate	Natural		High
White						
Nisqually	High	Moderate	Natural	Natural		
Skokomish	High	Moderate	High			
Strait of Juan de Fuca						
Mid-Hood Canal Rivers		High	Moderate			
Dungeness		Moderate				
Elwha[2]		Moderate				

Source: EIS Technical Work Group (via W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, June 17, 2010).
[1] Blank cell = no or insignificant incidental contribution of hatcheries to fisheries associated with the river.
Natural = no contribution from hatchery programs; fisheries associated with the river are from natural production only.
Low = minor or intermittent contribution from hatcheries to local commercial or recreational fisheries in marine or freshwater areas associated with the river.
Moderate = moderate contribution from hatcheries to local or more expansive commercial and/or recreational fisheries in marine and/or freshwater areas associated with the river.
High = major contribution of hatcheries to extensive commercial and/or recreational fisheries in marine and/or freshwater areas associated with the river.
[2] A moratorium on harvest began in 2012 and will continue through 2017 to protect salmon and steelhead during removal of the mainstem dam. With the exception of coho salmon, all programs are conservation programs. The moderate contribution to coho salmon fisheries may occur after the harvest moratorium ends.

Substantial commercial and recreational fisheries are conducted in most major rivers. A review of the largest commercial fisheries in major rivers (which are conducted only by treaty tribes) showed the Green River accounted for 31 percent of the total commercial harvest (in total pounds of salmon and steelhead landed) from 1997 to 2006, the Skagit River accounted for 19 percent, the Nisqually River accounted for 12 percent, and the Puyallup River accounted for 12 percent of the total commercial harvest (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, August 2, 2007). Note that there is no non-tribal commercial harvest of salmon in freshwater areas.

Considering hatchery contributions by species, the most substantial hatchery contributions are for Chinook salmon and steelhead, followed by coho salmon, chum salmon, and sockeye salmon. Relative to other species, hatchery programs for pink salmon generally do not make substantial contributions to fisheries; most of those pink salmon fisheries harvest natural-origin fish.

The descriptions of the affected environment in this subsection associated with marine and in-river terminal area fisheries associated with major river systems differ from descriptions of the affected environment in other socioeconomic subsections of this EIS. This is because, in contrast to other subsections for which quantitative data are available, this subsection relies on qualitative information and inferences (e.g., best professional judgments). Correspondingly, analyses of the alternatives in Subsection 4.3.7, Fisheries in Major River Systems, also rely on qualitative information because quantitative data for the alternatives analyses are not available.

3.3.6.1 North Puget Sound Subregion

Major river systems in the north Puget Sound subregion having marine and in-river terminal area fisheries affected by hatchery production include the Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers (Table 3.3-1). Hatcheries that enhance fisheries in the Nooksack River and Samish River and the nearby marine terminal area include the Samish Hatchery, Lummi Bay Hatchery, Skookum Creek Hatchery, Kendall Creek Hatchery, and Whatcom Creek Hatchery; hatcheries in the Skagit River system include the Marblemount Hatchery, Upper Skagit Hatchery, and Baker Lake and Barnaby Slough facilities; hatcheries in the Stillaguamish River system include Harvey Creek Hatchery and Whitehorse Pond; and in the Snohomish River and Skykomish River systems include the Wallace River Hatchery and Tokul Creek Hatchery (Appendix A, Puget Sound Hatchery Programs and Facilities). The relative contribution, by species, that hatchery-origin salmon and steelhead provide to important in-river commercial (treaty tribal) and recreational fisheries in the north Puget Sound subregion is identified in Table 3.3-7 and described by major river below.

3.3.6.1.1 Nooksack and Samish Rivers

The Nooksak River and Samish River local area comprises two major rivers, the Nooksack and Samish Rivers, and the adjacent marine waters of Bellingham Bay (catch area 7B), Lummi Bay (catch area 7D), and Samish Bay (catch area 7C). Hatchery production contributes to Chinook salmon, coho salmon, chum salmon, and steelhead fisheries in the Nooksack River and Samish River (a tributary to the Nooksack River) (Table 3.3-7). Natural-origin pink salmon are also harvested (Table 3.3-7).

Local treaty tribes operate commercial fisheries in the Nooksack River and adjacent marine areas. Recreational fisheries operate in both rivers, but the adjacent marine area is managed as part of the much larger catch area 7. Chinook salmon, coho salmon, and steelhead harvests in freshwater and marine terminal areas are enhanced by hatchery production from the Samish, Lummi Bay, Skookum Creek, Kendall Creek, and Whatcom Creek Hatcheries. The harvest of steelhead by treaty tribes is currently low. In summary, hatchery programs make high contributions to Chinook salmon, coho salmon, and steelhead fisheries, moderate contributions to sockeye salmon fisheries, low contributions to chum salmon fisheries, and no contribution to the pink salmon fisheries associated with the Nooksack River and Samish Rivers (Table 3.3-7).

3.3.6.1.2 Skagit River

The Skagit River local area includes only the Skagit River, but not the adjacent marine waters of Skagit Bay and Saratoga Passage (catch area 8). Hatchery production at Marblemount and Upper Skagit Hatcheries, and Baker Lake and Barnaby Slough facilities contributes to Chinook salmon, coho salmon, chum salmon, sockeye salmon, and steelhead fisheries in the Skagit River; natural-origin pink salmon are also harvested (Table 3.3-7). Salmon fisheries in this area are primarily supported by natural-origin populations because hatchery programs are relatively small in scale; thus, the relative contribution to salmon fisheries from hatchery programs is generally low to moderate (Table 3.3-7).

Three treaty tribes operate commercial salmon and steelhead fisheries in the Skagit River. Substantial recreational fishing opportunity is available in the Skagit River. Recreational fisheries for Chinook salmon, coho salmon, and pink salmon are distributed from the mouth up the mainstem and into the major tributary systems of the Cascade and Sauk Rivers. Fisheries on natural-origin pink salmon occur only in odd-numbered years. Steelhead fisheries are widely distributed in the Skagit River system (Table 3.3-7). In summary, hatchery programs make high contributions to steelhead fisheries, moderate contributions to coho salmon and sockeye salmon fisheries, low contributions to chum salmon fisheries, and no contribution to pink salmon fisheries associated with the Skagit River (Table 3.3-7).

3.3.6.1.3 Stillaguamish River

The Stillaguamish River local area includes the Stillaguamish River and the Stillaguamish-Snohomish marine terminal area that includes Possession Sound, Port Gardner, Port Susan (catch area 8A), and Tulalip Bay (catch area 8D). Hatchery production from the Harvey Creek Hatchery and Whitehorse Pond contributes to Chinook salmon, coho salmon, and steelhead fisheries; natural-origin chum salmon and pink salmon also are harvested (Table 3.3-7). Treaty tribal and non-tribal commercial fisheries operate in catch area 8A in the Stillaguamish-Snohomish marine terminal area. The Stillaguamish Tribe conducts small-scale fisheries, but there is no in-river commercial harvest of Chinook salmon in the Stillaguamish River.

Chinook salmon, coho salmon, and chum salmon production at the Bernie Kai-Kai Gobin Hatchery and Tulalip Hatchery supports the tribal commercial and recreational fisheries in Tulalip Bay (catch area 8D). Production of summer-run Chinook salmon at Whitehorse Pond is intended for conservation purposes (as opposed to fisheries enhancement) (Appendix A, Puget Sound Hatchery Programs and Facilities), so production does not directly affect local fisheries. Fisheries in nearby marine areas, including commercial fisheries in Possession Sound (catch area 8A) and recreational fisheries in catch area 8, are supported by many populations that commingle in these areas. In summary, hatchery programs make high contributions to Chinook salmon and steelhead fisheries, moderate contributions to coho salmon fisheries, and no contributions to chum salmon and pink salmon fisheries associated with the Stillaguamish River system (Table 3.3-7).

3.3.6.1.4 Snohomish and Skykomish Rivers

The Snohomish River and Skykomish River local area comprises two major rivers, the Snohomish River and the Skykomish River (a Snohomish River tributary), and adjacent marine terminal areas (catch area 8A). Hatchery production at the Wallace River Hatchery, Tokul Creek Hatchery, and Reiter Pond contributes to Chinook salmon, coho salmon, and steelhead fisheries in the Snohomish River and Skykomish River (Table 3.3-7). Tribal commercial fisheries do not operate in the Snohomish River, but recreational fishing occurs in the Snohomish River and Skykomish River.

Chinook salmon and coho salmon production at the Wallace River Hatchery on the Skykomish River contributes to recreational fisheries in the Snohomish River system (Appendix A, Puget Sound Hatchery

Programs and Facilities). Fisheries in nearby marine areas, including commercial fisheries in Possession Sound (catch area 8A) and recreational fisheries in catch area 8, are supported by commingled populations in these areas. In summary, hatchery programs make high contributions to Chinook salmon and steelhead fisheries, and moderate contributions to coho salmon fisheries associated with the Snohomish and Skykomish Rivers (Table 3.3-7).

3.3.6.2 South Puget Sound Subregion

Major river systems in the south Puget Sound subregion having in-river or marine terminal area fisheries that are affected by hatchery production include one lake and four river systems. These are, from north to south, Lake Washington, and the Green, Puyallup, Nisqually, and Skokomish Rivers (Table 3.3-1). As described in Appendix A, Puget Sound Hatchery Programs and Facilities, hatcheries that enhance fisheries in the Lake Washington system include Issaquah Hatchery and Cedar River Hatchery; hatcheries in the Green River system and nearby marine terminal areas include Crisp Creek Rearing Ponds, Soos Creek Hatchery, Keta Creek Hatchery, Palmer Ponds, Icy Creek Hatchery, and Flaming Geyser Pond; hatcheries in the Puyallup River system include Voights Creek Hatchery, Clarks Creek Hatchery, Diru Creek Hatchery, and White River Hatchery; hatcheries in the Nisqually River system include Clear Creek Hatchery and Kalama Creek Hatchery; hatcheries in the deep south Puget Sound area include a system of south Puget Sound net pens (Agate Pass, Ballard, Elliot Bay, Laebugton, Squaxin Island), Hupp Springs Hatchery, Minter Creek Hatchery, Garrison Springs Hatchery, Chambers Creek Hatchery, and Tumwater Falls Hatchery; and hatcheries in the Skokomish River system include George Adams Hatchery, Rick's Pond Hatchery, Hoodsport Hatchery, Enetai Hatchery, and McKernan Hatchery. Harvest of salmon and steelhead does not occur in the White and Snoqualmie Rivers; thus, hatcheries do not contribute to fisheries in those rivers.

In addition to the hatchery programs on south Puget Sound subregion river systems, hatchery production associated with marine waters of the south Puget Sound subregion supports marine commercial and recreational fisheries. These fisheries are directed at Chinook salmon and coho salmon in the marine areas south of the Tacoma Narrows Bridge (commercial catch areas 13, 13A through 13K, and recreational catch area 13). Chinook salmon production at the Garrison Springs Hatchery affects the commercial fishery in Chambers Bay (catch area 13C), and Chinook salmon production at Tumwater Falls affects the commercial fishery in Budd Inlet (catch area 13F). Coho salmon production at the south Puget Sound net pens affects the commercial fishery in Peale Passage and vicinity (catch area 13D).

The relative contribution, by species, that hatchery-origin salmon and steelhead provide to important in-river commercial (treaty tribal) and recreational fisheries in the south Puget Sound subregion is identified in Table 3.3-7 and described by major river below.

3.3.6.2.1 Lake Washington

The Lake Washington local area comprises the Lake Washington system, including the Lake Sammamish system and the Cedar River. Hatchery production contributes to Chinook salmon, coho salmon, and sockeye salmon fisheries, and natural-origin chum salmon and pink salmon fisheries in the Lake Washington system (including the Cedar River) (Table 3.3-7). The limited Chinook salmon and coho salmon fisheries that occur in these areas (particularly Chinook salmon) depend on production at the Issaquah Creek Hatchery. There is no harvest of steelhead in the Lake Washington system. In summary, hatchery programs make high contributions to Chinook salmon fisheries, moderate contributions to coho salmon and sockeye salmon fisheries, and no contribution to chum salmon, pink salmon, and steelhead fisheries associated with the Lake Washington system (Table 3.3-7).

3.3.6.2.2 Green River

The Green River local area comprises the Green River (including the Duwamish River, which is the lower mainstem of the Green River) and the adjacent marine waters of Elliott Bay (catch areas 10 and 11). Hatchery production from the Crisp Creek Rearing Ponds, Soos Creek Hatchery, Keta Creek Hatchery, Palmer Ponds, Icy Creek Hatchery, and Flaming Geyser Pond contributes to fisheries in the Green River that are directed at Chinook salmon, coho salmon, chum salmon, and steelhead, and is particularly important to Chinook salmon and steelhead fisheries. Natural-origin pink salmon are also harvested (Table 3.3-7). Treaty tribes' commercial Chinook salmon, coho salmon, and steelhead fisheries occur in the Green River (and Duwamish River) and in Elliott Bay. Recreational salmon fisheries also occur in the marine waters of Elliott Bay and in the Green River up to the City of Tacoma's diversion dam (RM 61), but is more concentrated in the lower river up to RM 34. Much of the hatchery production that supports these fisheries is from the Soos Creek Hatchery.

The recreational harvest of Chinook salmon in the Green River is small relative to the commercial harvest. The tribal commercial harvest of steelhead is currently low. In summary, hatchery programs make high contributions to Chinook salmon and steelhead fisheries, moderate contributions to coho salmon fisheries, low contributions to chum salmon fisheries, and no contribution to pink salmon fisheries associated with the Green River (Table 3.3-7).

3.3.6.2.3 Puyallup River

The Puyallup River local area comprises the Puyallup River and the adjacent marine waters of Commencement Bay (catch area 11A). Hatchery production from the Voights Creek Hatchery, Clarks Creek Hatchery, Diru Creek Hatchery, White River Hatchery, and Minter Creek Hatchery (and associated acclimation ponds in the upper White River), contributes to Chinook salmon, coho salmon, chum salmon, and steelhead fisheries in the Puyallup River. Natural-origin pink salmon are also harvested (Table 3.3-7). Treaty tribal commercial fisheries are directed at Chinook salmon, coho salmon, pink salmon, and chum salmon in the Puyallup River. Recreational salmon and steelhead fisheries also occur. Recreational fishing is distributed primarily from the river mouth through the lower mainstem and into the Carbon River (a Puyallup River tributary). The tribal commercial harvest of steelhead in the Puyallup River is low, involving steelhead incidentally caught during the tribal chum salmon fishery. Puyallup River fisheries are substantially dependent on hatchery production of Chinook salmon, coho salmon, and chum salmon at Voights Creek Hatchery and Clarks Creek Hatchery. The tribal harvest of salmon in Commencement Bay (catch area 11A) is relatively small. In summary, hatchery programs make high contributions to Chinook salmon, coho salmon, and steelhead fisheries, and moderate contributions to chum salmon fisheries associated with the Puyallup River system (Table 3.3-7).

Chinook salmon and steelhead hatchery production occurs in the White River, a tributary of the Puyallup River. However, the hatchery production at the White River Hatchery and associated acclimation ponds in the upper White River (a tributary of the Puyallup River), produce spring-run Chinook salmon intended to conserve and rebuild the White River population (Appendix A, Puget Sound Hatchery Programs and Facilities). Therefore, hatchery programs do not contribute to commercial or recreational fisheries in the White River (Table 3.3-7).

3.3.6.2.4 Nisqually River

The Nisqually River local area comprises the Nisqually River and the adjacent marine waters of catch area 13. Hatchery production from the Clear Creek Hatchery and Kalama Creek Hatchery contributes to Chinook salmon and coho salmon fisheries in the Nisqually River. Natural-origin chum salmon and pink salmon are also harvested (Table 3.3-7). A tribal commercial net fishery and a recreational fishery on the Nisqually River target hatchery-origin Chinook salmon and, to a lesser extent, coho salmon. These fisheries substantially depend on production at the Clear Creek Hatchery and Kalama Creek Hatchery. Steelhead fisheries do not currently occur in the Nisqually River; the hatchery program that previously supported harvest has been discontinued and natural-origin steelhead are insufficiently abundant to support harvest.

Chinook salmon production at the Garrison Springs Hatchery affects the commercial fishery in nearby marine waters of Chambers Bay (catch area 13C), and Chinook salmon production at Tumwater Falls affects the commercial fishery in marine waters of Budd Inlet (catch area 13F). Coho salmon production at the south Puget Sound net pens affects the commercial fishery in Peale Passage and vicinity (catch area 13D).

Recreational fishing in the Nisqually River, which is concentrated in the lower 4 miles of the river, targets primarily Chinook salmon. Commercial and recreational fisheries also occur in the adjacent marine portion of catch area 13, but other Chinook salmon and coho salmon hatchery programs in the south Puget Sound subregion contribute to these fisheries. In summary, hatchery programs make high contributions to Chinook salmon fisheries, moderate contributions to coho salmon fisheries, and no contribution to chum salmon and pink salmon fisheries associated with the Nisqually River (Table 3.3-7).

3.3.6.2.5 Skokomish River

The Skokomish River local area comprises the Skokomish River and the adjacent marine waters of catch areas 12C and 12H, and southern catch area 12. Hatchery production from the George Adams Hatchery, Rick’s Pond Hatchery, Hoodsport Hatchery, Enetai Hatchery, and McKernan Hatchery contributes to Chinook salmon, coho salmon, chum salmon, and pink salmon commercial (tribal) salmon fisheries in the Skokomish River and marine waters of nearby Hood Canal (Table 3.3-7). Recreational salmon fishing also occurs in fresh waters of southern Hood Canal. Chinook salmon fisheries, particularly the tribal commercial fishery in southern Hood Canal (catch areas 12C and 12H), the recreational fishery in southern catch area 12, and commercial and recreational fisheries in the Skokomish River, are substantially dependent on production of Chinook salmon from the George Adams Hatchery. There is a relatively small recreational fishery in the nearby marine catch area 12, but commercial fisheries directed at pink salmon have not occurred in recent years. In summary, hatchery programs make high contributions to Chinook salmon and chum salmon fisheries, and moderate contributions to coho salmon fisheries associated with the Skokomish River (Table 3.3-7).

3.3.6.3 Strait of Juan de Fuca Subregion

Major river systems in the Strait of Juan de Fuca subregion having in-river or marine terminal area fisheries that are affected by hatchery production include mid-Hood Canal rivers and the Dungeness and

Elwha Rivers (Table 3.3-1). As described in Appendix A, Puget Sound Hatchery Programs and Facilities, hatcheries that enhance fisheries in mid-Hood Canal rivers and/or nearby marine terminal areas include the McKernan Hatchery, Hamma Hamma Hatchery, Lilliwaup Hatchery, Quilcene National Fish Hatchery, Hurd Creek Hatchery, Little Boston Hatchery, and Port Gamble and Quilcene Bay net pens; hatcheries in the Dungeness River system include the Dungeness Hatchery; and hatcheries in the Elwha River include the Lower Elwha Hatchery, Elwha Channel Hatchery, and Morse Creek Hatchery.

In addition to the hatchery programs on Strait of Juan de Fuca subregion river systems, hatchery operations in marine waters of the northern Strait of Juan de Fuca subregion support commercial and recreational fisheries for chum salmon and coho salmon in nearby marine areas (Port Gamble, Quilcene and Dabob Bays, and catch area 12).

The relative contribution, by species, that hatchery-origin salmon and steelhead provide to important in-river commercial (tribal) and recreational fisheries in the Strait of Juan de Fuca subregion is identified in Table 3.3-7 and described by major river below.

3.3.6.3.1 Mid-Hood Canal Rivers

The mid-Hood Canal rivers local area comprises the Quilcene, Hamma Hamma, Duckabush, and Dosewallips Rivers, and adjacent marine waters of Hood Canal. Hatchery production contributes to coho salmon and chum salmon fisheries in mid-Hood Canal rivers (Table 3.3-7). The Quilcene River is the only river in this local area where commercial and recreational salmon fisheries operate; no fisheries occur in the Hamma Hamma, Duckabush, or Dosewallips Rivers because of the critical status of the ESA-listed mid-Hood Canal Chinook salmon population. Coho salmon fisheries in marine waters of nearby Quilcene Bay, Port Gamble, and catch area 12 depend substantially on hatchery production at Quilcene National Fish Hatchery, and on the Port Gamble and Quilcene Bay net pens. In summary, hatchery programs make high contributions to coho salmon fisheries, and moderate contributions to chum salmon fisheries associated with mid-Hood Canal Rivers (Table 3.3-7).

3.3.6.3.2 Dungeness River

The Dungeness River local area includes the Dungeness River and marine terminal area that includes Dungeness Bay (catch area 6D). Hatchery production contributes to coho salmon fisheries (Table 3.3-7). Coho salmon production at the Dungeness Hatchery affects the recreational harvest in the Dungeness River, and the tribal and non-tribal commercial harvest in nearby Dungeness Bay (catch area 6D). Production of Chinook salmon at hatcheries on the Dungeness River is intended for conservation purposes only because of the critical status of the natural-origin Chinook salmon and chum salmon populations (Appendix A, Puget Sound Hatchery Programs and Facilities), and does not contribute to fisheries. Relative to other species, steelhead hatchery production at the Dungeness Hatchery contributes insubstantially to fisheries in the Dungeness River. Tribal steelhead harvest in the Dungeness River is minimal. In summary, hatchery programs make moderate contributions to coho salmon fisheries associated with the Dungeness River (Table 3.3-7).

3.3.6.3.3 Elwha River

The Elwha River local area includes the Elwha River. A harvest moratorium to protect Elwha River fishery resources will be in place during dam removal operations (from 2012 through 2017). An exception to the moratorium is a temporary tribal steelhead fishery targeting non-local hatchery-origin stock (the stock is no longer being released). After the harvest moratorium ends in 2017, the coho salmon hatchery program is expected to contribute to coho salmon fisheries (Table 3.3-7). Coho salmon production at the Lower Elwha Hatchery will affect tribal commercial fisheries and recreational fisheries. Hatchery production of Chinook salmon, chum salmon, pink salmon, and steelhead in the Elwha River is intended for conservation purposes only (Appendix A, Puget Sound Hatchery Programs and Facilities), and does not contribute to local fisheries. Coho salmon fisheries are not substantially enhanced by coho salmon hatchery production from the Elwha River because stocks from many other Puget Sound and British Columbia systems contribute to harvests that occur in the adjacent marine waters of the Strait of Juan de Fuca. In summary, hatchery programs currently do not contribute to fisheries associated with the Elwha River, but coho salmon hatchery programs may make a moderate contribution to coho salmon fisheries once the current moratorium on harvest ends (Table 3.3-7).

3.3.7 Ports and Fishing Communities

Fisheries generate economic activity that affects ports and fishing communities. This subsection describes local economic conditions in terms of personal income and jobs for fishing activities and hatchery operations, is compiled at the county level for each of the three subregions, and identifies ports and other fishing communities likely to be vulnerable to changes in commercial and recreational fishing activity in response to changes in hatchery production and associated harvest. For the purposes of this EIS, fisheries-related personal income and job information at the county level is used to describe economic conditions of ports and fishing communities based on factors described in Appendix I, Socioeconomic Impact Methods. In addition, various fishing communities are vulnerable to changes in commercial and recreational fishing activity that would be associated with changes in hatchery production levels. These communities are identified within the following subregion subsections.

Harvested salmon and steelhead are brought to 17 major ports in the 12 counties (Table 3.3-8). These ports and counties include eight major ports and five counties in the north Puget Sound subregion, six major ports and five counties in the south Puget Sound subregion, and three major ports and two counties in the Strait of Juan de Fuca subregion (Table 3.3-8). Harvest from each catch area was assigned to ports, and then to counties, based on the average proportion of harvest for each species from each catch area brought to the different port areas (Appendix I, Socioeconomic Impact Methods).

To provide additional context, about 90 percent of the gross economic value of salmon landed in the 12 counties and 10 catch areas occurred at five ports, three of which are in the north Puget Sound subregion. The ports in the north Puget Sound subregion and average gross economic values associated with fishing activities are Bellingham in Whatcom County ($3,004,000), Everett in Snohomish County ($1,596,000), and LaConner in Skagit County ($967,000). The Port of Seattle in King County ($1,975,000) and Shelton in Mason County ($920,000) are in the south Puget Sound subregion (Table 3.3-8). Altogether, from 2002 to 2006, salmon fishing generated $9,416,000 of average gross economic value at the 17 major ports associated with the 12 counties evaluated in this EIS (Table 3.3-8).

Gross economic value information for ports and counties (Table 3.3-8) is provided for context to show the relative range of fishing-related gross economic values, and to show how values can vary from year to year. Personal income and jobs at the county level are used to describe economic conditions of ports and fishing communities in the subregions below.

3.3.7.1 North Puget Sound Subregion

In the north Puget Sound subregion, fishing activities (plus hatchery facility operations) generated an average of $41,724,837 in total personal income and 975 jobs from 2002 to 2006 (Table 3.3-9).

Table 3.3-8. Estimated gross economic value of salmon brought to counties and ports from 2002 to 2006 (in thousands of nominal dollars), by subregion.

Subregion	Major Port and County	Gross Economic Value ($ in thousands)					
		2002	2003	2004	2005	2006	Annual Average
North Puget Sound	Blaine	658	538	519	469	1,227	692
	Bellingham	2,597	1,563	3,302	2,137	5,422	3,004
	Whatcom County	3,255	2,101	3,821	2,606	6,725	3,902
	Friday Harbor	19	31	34	17	32	27
	San Juan County	19	32	35	18	37	28
	Anacortes	16	7	12	111	27	35
	LaConner	514	704	1,136	628	1,851	967
	Skagit County	530	711	1,148	739	1,878	1,001
	Everett	128	101	697	424	1,229	1,596
	Snohomish County	128	101	697	424	1,229	1,596
	Coupeville	7	5	5	8	4	6
	Whidbey Island	14	10	11	9	8	10
	Island County	21	15	16	17	12	16
South Puget Sound	Seattle	1,317	1,362	2,390	1,520	3,286	1,975
	King County	1,317	1,362	2,390	1,520	3,286	1,975
	Tacoma	602	388	653	290	607	508
	Pierce County	602	388	653	290	607	508
	Olympia	23	32	92	43	793	197
	Thurston County	23	32	92	43	793	197
	Shelton	1,177	492	1,036	933	963	920
	Mason County	1,177	492	1,036	933	963	920
	Poulsbo	23	14	40	30	89	39
	Bremerton	--[1]	--[1]	--[1]	--[1]	--[1]	--[1]
	Kitsap County	23	14	40	30	89	39
Strait of Juan de Fuca	Port Townsend	27	27	94	66	234	90
	Jefferson County	27	28	94	66	234	90
	Port Angeles	328	218	183	46	126	180
	Neah Bay	55	104	619	262	181	244
	Clallam County	383	322	802	308	307	424
PUGET SOUND REGION	**TOTAL**	**7,505**	**5,598**	**10,824**	**6,994**	**16,160**	**9,416**

Source: Washington Department of Fish and Wildlife, License and Fish Ticket database (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, August 2, 2007).

[1] Not reported for confidentiality reasons (fewer than 3 buyers).

Table 3.3-9. Estimated average annual (2002 to 2006) total (direct and indirect) personal income and jobs generated by commercial and recreational fishing and hatchery operations, by subregion and county.

Subregion and County	Commercial		Recreational		Total	
	Personal Income ($)[1]	**Number of Jobs[2]**	**Personal Income ($)[1]**	**Number of Jobs[2]**	**Personal Income ($)[1]**	**Number of Jobs[2]**
North Puget Sound						
Whatcom	11,558,897	297	2,472,992	64	14,031,890	361
Skagit	3,619,539	87	4,188,423	100	7,807,961	187
Snohomish	1,435,076	2	12,053,537	243	13,488,613	271
Island	39,581	1	2,948,297	69	2,987,878	70
San Juan	62,447	2	586,719	3	649,166	25
Hatchery Facility Operations [3]	---	---	---	---	2,759,382	62
Total	**16,715,540**	**416**	**22,249,969**	**497**	**41,724,837**	**975**
South Puget Sound						
King	7,410,819	115	13,429,734	208	20,840,553	323
Pierce	956,496	20	7,413,041	153	8,369,537	172
Thurston	632,471	15	2,609,945	61	3,242,415	75
Mason	1,977,397	58	2,946,716	87	4,924,113	145
Kitsap	72,277	2	3,182,512	67	3,254,789	68
Hatchery Facility Operations	---	---	---	---	6,207,197	129
Total	**11,049,458**	**209**	**29,581,949**	**575**	**46,838,604**	**912**
Strait of Juan de Fuca						
Clallam	831,210	25	2,868,872	87	3,700,082	112
Jefferson	192,938	7	1,054,472	36	1,247,410	43
Hatchery Facility Operations	---	---	---	---	739,048	18
Total	**1,024,148**	**32**	**3,923,344**	**123**	**5,686,540**	**173**
Puget Sound Region						
Total	**28,789,146**	**657**	**55,765,262**	**1,195**	**94,249,981**	**2,060**

Source: Economics Impact Model developed by TCW Economics for this EIS.
[1] All values are expressed in 2007 dollars.
[2] Includes full- and part-time jobs.
[3] Personal income and jobs for hatchery facility operations were estimated for each subregion, but not by individual county.

Of the total personal income and jobs in the north Puget Sound subregion from fishing activities, the largest contribution is from Whatcom County (with $14,031,890 [34 percent] of the total personal income and 361 jobs [37 percent]) (Table 3.3-9), and is where the ports of Blaine and Bellingham are located (Table 3.3-8). The next largest contribution to total personal income and jobs in the subregion occurred in Snohomish County (with $13,488,613 [32 percent] of the total personal income and 271 jobs [28 percent]) (Table 3.3-9), and is where the Port of Everett is located (Table 3.3-8). Commercial and recreational fishing also are important to Skagit County, which contributed $7,807,961 (19 percent) in annual personal income and 187 jobs (19 percent) (Table 3.3-9).

In all counties but Whatcom County, recreational fishing activities generated more personal income and jobs than commercial fishing activities (Table 3.3-9). Overall, recreational fishing activity accounts for over half ($22,249,969 or 53 percent) of the total personal income and 497 (51 percent) of the total jobs in the north Puget Sound subregion (Table 3.3-9).

Other counties within the north Puget Sound subregion that are less dependent on fishing but are economically vulnerable to changes in fishing activity include Island County and San Juan County (Table 3.3-9). Other than the ports already mentioned, communities in the north Puget Sound subregion that depend on commercial and recreational fishing activities include La Conner and Anacortes in Skagit County, and Friday Harbor in San Juan County. In addition to the ports identified in Table 3.3-8, commercial and recreational fishing in the north Puget Sound subregion supports economic activity in the community of Mount Vernon, as well as in more rural areas of Skagit and Snohomish Counties, such as Concrete, Rockport, Darrington, Sedro Wooley, and Burlington. Rural communities in Snohomish County that are likely affected by treaty tribes' commercial fishing and by recreational fishing include Monroe, Snohomish, Carnation, and Sultan.

3.3.7.2 South Puget Sound Subregion

In the south Puget Sound subregion, fishing activities (plus hatchery facility operations) generated an average of $46,838,604 in total personal income and 912 jobs from 2002 to 2006 (Table 3.3-9).

Of the total personal income and jobs in the south Puget Sound subregion from fishing activities, the largest contribution occurred in King County (with $20,840,553 [44 percent] of the total personal income and 323 jobs [35 percent]) (Table 3.3-9), and is where the Port of Seattle is located (Table 3.3-8). The next largest contributions to total personal income and jobs in the subregion occurred in Pierce County and Mason County. Pierce County contributes $8,369,537 (18 percent) of the total personal income, and

172 (19 percent) of the total jobs (Table 3.3-9), and is where the Port of Tacoma is located (Table 3.3-8). Mason County contributed $4,924,113 (10 percent) of the total personal income, and 145 (16 percent) of the total jobs (Table 3.3-9), and is where the Port of Shelton is located (Table 3.3-8). Fishing activities are also important in Thurston and Kitsap Counties, which together contributed $6,497,204 in annual personal income and 143 jobs (Table 3.3-9).

In all counties in the south Puget Sound subregion, recreational fishing activities generated more personal income and jobs than commercial fishing activities (Table 3.3-9). Overall, recreational fishing activity accounted for $29,581,949 (63 percent) of the total personal income and 575 (63 percent) of the total jobs in the south Puget Sound subregion (Table 3.3-9).

Communities in the south Puget Sound subregion other than the ports already mentioned are also economically affected by fishing activities. These include rural towns in King County that are affected by treaty tribes' commercial fisheries and by recreational fisheries. Puyallup benefits from nearby treaty tribes' commercial salmon fisheries and from recreational fisheries, and rural communities in Pierce County that also benefit from fisheries activities include Orting and Buckley. Recreational salmon fishing (e.g., Nisqually River) benefits the rural communities of Yelm, Tenino, and McKenna in Pierce County. Recreational fishing (e.g., Skokomish River) also supports economic activity in the Mason County community of Hoodsport. Fishing also supports economic activity in the Kitsap County communities of Poulsbo and Bremerton.

3.3.7.3 Strait of Juan de Fuca Subregion

In the Strait of Juan de Fuca subregion, fishing activities (plus hatchery facility operations) generated an average of $5,686,540 in total personal income and 173 jobs from 2002 to 2006 (Table 3.3-9).

Of the total personal income and jobs in the Strait of Juan de Fuca subregion from fishing activities, the largest contribution is from Clallam County (with $3,700,082 [65 percent] of the total personal income and 112 jobs [65 percent]) (Table 3.3-9), and is where the Ports of Port Angeles and Neah Bay are located (Table 3.3-8). The contribution to total personal income and jobs in Jefferson County is $1,247,410 (22 percent) of the total personal income, and 43 (25 percent) of the jobs (Table 3.3-9), and is where the Port of Port Townsend is located (Table 3.3-8).

In both counties in the Strait of Juan de Fuca subregion, recreational fishing activities generated more personal income and jobs than commercial fishing activities (Table 3.3-9). Overall, recreational fishing activity accounts for $3,923,344 (69 percent) of the total personal income and 123 (71 percent) of the total jobs in the Strait of Juan de Fuca subregion (Table 3.3-9).

Other than the ports already mentioned, communities in the Strait of Juan de Fuca subregion that are most dependent on commercial and recreational fishing activities include the mostly rural communities in northern Hood Canal and along the Strait of Juan de Fuca (e.g., Sequim). A moratorium on fishing in the Elwha River was imposed in 2012 and will continue through 2017 to protect salmon and steelhead until after the Elwha dam removal operations are completed.

3.4 Environmental Justice

3.4.1 Introduction

The United States Environmental Protection Agency (EPA) defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA 1998). Under Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 Fed. Reg. 32, February 11, 1994), the EPA states that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." Further, EPA guidance recommends that the environmental justice analysis should also determine whether such populations or communities have been sufficiently involved in the decision-making process (EPA 1998, 2010).

This environmental justice subsection was prepared in compliance with Executive Order 12898 (59 Fed. Reg. 32, February 11, 1994) and Title VI of the Civil Rights Act of 1964 to ensure that minority and low-income populations do not receive disproportionately high or adverse human health or environmental effects from the Proposed Action. Generally, minority and low income target populations are defined as:

- **Minority**—All people of the following origins: Black, Asian, American Indian and Alaskan Native, Native Hawaiian or Other Pacific Islander, and Hispanic (considered an ethnic and cultural identity and not the same as race)

- **Low income**—Persons whose household income is at or below the U.S. Department of Health and Human Services poverty guidelines (EPA 1998)

This subsection includes an overview of policy and regulatory considerations; existing conditions for the environmental justice analysis in Subsection 4.4, Environmental Justice, including the approach for identifying environmental justice user groups and communities of concern and existing demographic data used to establish thresholds for selecting these groups and communities of concern; and a summary of the public outreach process.

Demographic information used in this subsection relies on the 2000 census. Fish harvest and fishery economic data are described in Subsection 3.3, Socioeconomics. Those data are largely from 2002 to 2006. Identification of environmental justice user groups of concern and communities of concern relies on 2000 census information. NMFS used data for quantitative (socioeconomic) modeling that was available up to the time the modeling was conducted (mid-2000s).

For consistency in the EIS, Subsection 3.4, Environmental Justice and Subsection 4.4, Environmental Justice, use the term "Native American" when referring in general to indigenous peoples, "Indian tribe" when referring in general to federally recognized tribes, and "Puget Sound treaty tribes" when referring to tribes in the project area whose fishing rights are reserved under *United States v. Washington* as described in Subsection 1.9.3, Puget Sound Treaty Tribes.

This affected environment subsection describes groups and communities within the Puget Sound region and three multi-county subregions (Figure 3.3-1) that may be affected by the alternatives (Subsection 4.4.2, Analysis Area [Environmental Justice]). The three subregions are the north Puget Sound subregion (consisting of Whatcom, Skagit, Snohomish, Island, and San Juan Counties); the south Puget Sound subregion (consisting of King, Pierce, Thurston, Mason, and Kitsap Counties); and the Strait of Juan de Fuca subregion (consisting of Clallam and Jefferson Counties) (Table 3.4-1).

3.4.1.1 Steps to Identify Environmental Justice User Groups and Communities of Concern

This EIS identifies environmental justice groups and communities of concern using the six steps outlined below.

Step 1: Establish the Target Area. A target area is the geographic area that is potentially affected by the project alternatives. For this assessment, the target area is the Puget Sound region and three subregions described above (Table 3.4-1).

Table 3.4-1. Counties within subregions.

Subregion	County
North Puget Sound	Island, San Juan, Skagit, Snohomish, Whatcom
South Puget Sound	King, Kitsap, Mason, Pierce, Thurston
Strait of Juan de Fuca	Clallam, Jefferson

Step 2: Identify the Population Areal Unit. A population areal unit is the geopolitical unit containing populations that, in aggregate, define the target area. At the subregional scale, the population areal unit used is the county. However, when assessing distinct user groups, other areas within subregions are considered. For commercial fishers and processors, the population

areal units are the affected fishing ports and communities where these user groups are concentrated, including Anacortes, Bellingham Bay, Blaine, Everett, and La Conner in the north Puget Sound subregion; Olympia, Poulsbo, Seattle, Shelton, and Tacoma in the south Puget Sound subregion; and Port Townsend, Port Angeles, and Neah Bay in the Strait of Juan de Fuca subregion. For Indian tribes, the population areal unit is the reservation.

Step 3: Identify the Target Population. The target population includes the potentially affected residents of each county, port community, or reservation. Because this EIS analyzes the effects of alternative hatchery production levels that may affect fish harvests, the primary target populations for environmental justice analysis are non-tribal commercial and sport fishers, and tribal members harvesting these fish. Once salmon and steelhead are harvested and brought to shore (landed), there are secondary effects on people within the target area, such as fish processors and businesses that support recreation.

Step 4: Identify the Reference Area. A reference area is the area used as a benchmark of comparison when identifying whether a target population that may be subject to disproportionate environmental and economic impacts has a substantially larger minority or low-income population, thereby warranting further consideration in the context of environmental justice. The reference area for environmental justice in the EIS is the State of Washington.

Step 5: Establish Thresholds to Identify Environmental Justice User Groups and Communities of Concern. Quantitative thresholds were established to determine whether a target population has a substantially higher proportion of minority or low-income population relative to the population of the reference area. The environmental justice thresholds are described in Subsection 3.4.1.5, Environmental Justice Thresholds for Identifying Groups and Communities of Concern.

Step 6: Identify Environmental Justice User Groups and Communities of Concern. In this step, socio-demographic data for target populations and for populations in the reference area are compared to the thresholds established in Step 5 and, if the affected population within a target area has minority or low-income populations exceeding the thresholds, the population is defined as an environmental justice user group or community of concern. The environmental justice user groups and communities of concern are then evaluated in more detail in the impact analysis (Subsection 4.4, Environmental Justice), to determine if, and to what extent, they would experience disproportionate effects.

3.4.1.2 Approach to Identifying Native American Tribes of Concern

EPA guidance regarding environmental justice extends beyond use of statistical thresholds to explicitly consider environmental justice effects on Native American tribes. EPA (1998) indicates:

> *Federal duties under the Environmental Justice EO (Executive Order), the Presidential directive on government-to-government relations, and the trust responsibility to Indian tribes may merge when the action proposed by a Federal agency or EPA potentially affects the natural or physical environment of a tribe. The natural or physical environment of a tribe may include resources reserved by treaty or lands held in trust; sites of special cultural, religious, or archaeological importance, such as sites protected under the National Historic Preservation Act or the Native American Graves Protection and Repatriation Act; other areas reserved for hunting, fishing, and gathering (usual and accustomed), which may include "ceded" lands that are not within reservation boundaries. Potential effects of concern . . . may include ecological, cultural, human health, economic, or social impacts when those impacts are interrelated to impacts on the natural or physical environment.*

Salmon are important to the way of life of Indian tribes in the Puget Sound region (Box 3-2). Most of the tribes in Puget Sound have federally reserved treaty fishing rights and could be potentially affected by the alternatives considered in this EIS (Subsection 1.1, Introduction). Therefore, all potentially affected treaty tribes that have federally reserved treaty fishing rights in the Puget Sound region and three subregions are environmental justice groups of concern, and accordingly, tribal effects are a specific focus of the environmental justice analysis.

3.4.1.3 Approach to Identifying Non-tribal User Groups of Concern

In determining whether potential user groups are environmental justice groups of concern, the demographic characteristics specific to these groups are considered. Non-tribal user groups affected by hatchery production are commercial and recreational fishers. Describing the prevalence of minority and low-income populations among commercial fishers requires demographic data for these groups that are not readily available. Consequently, relevant demographic data are available for ports which are used as a proxy for the demographics of these user groups, and are compared to the environmental justice thresholds presented in Subsection 3.4.1.5, Environmental Justice Thresholds for Identifying Groups and Communities of Concern.

Box 3-2. Why are Salmon and Steelhead Important to Puget Sound Treaty Tribes?

Salmon and steelhead are important to Puget Sound treaty tribes for many reasons. Salmon fishing has been a focus for tribal economies, cultures, lifestyles, and identities for over 1,000 years (Gunther 1950; Stein 2000). Beyond generating jobs and income for contemporary commercial tribal fishers, salmon are regularly eaten by individuals and families, and are served at gatherings of elders at traditional dinners and other ceremonies. To Indian tribes, salmon are a core symbol of tribal and individual identity. The survival and well-being of salmon are seen as inextricably linked to the survival and well-being of Indian people and their cultures (Meyer Resources Inc. 1999). Salmon evoke sharing, gifts from nature, responsibility to the resource, and connection to the land and the water. Puget Sound treaty tribes use salmon in various ways, including personal and family consumption, informal and formal distribution and community sharing, and ceremonial uses (Amoss 1987).

Salmon are strongly associated with the use and knowledge of water, use and knowledge of appropriate harvesting techniques, and knowledge of traditional processing techniques. Salmon facilitate the transfer of tribal fishing culture to young tribal members (Deloria 1977). This education includes teaching young tribal members to use traditional and modern methods of fishing and to cook and preserve salmon. See NMFS (2004) for a summary of the cultural relationship of Puget Sound treaty tribes to salmon.

For recreational fishers, demographic and personal income data also are limited and available only at the state-wide level. Demographic data for recreational fishers were obtained from USFWS (2006). Based on these data, two minority groups can be recognized as recreational fishers: non-white and Hispanic. The percentages of recreational fishers within these minority groups are compared to the corresponding values for the reference population, to determine if these groups are environmental justice groups of concern. Personal income-related data are presented on the basis of income brackets rather than poverty rates or per-capita income levels. Using the organization of the income data in USFWS (2006), the determination of whether recreational fishers are classified as low-income populations is based on comparing the percentages of recreational fishers in the two lowest income brackets (less than $10,000, and $10,000 to $20,000) relative to the reference area. If the percentage of recreational fishers in these two low-income brackets is higher than in the reference area, then the group is identified as an environmental justice group of concern.

3.4.1.4 Approach to Identifying Communities of Concern

In addition to user groups that are directly affected by hatchery production and associated harvests, other persons and businesses (such as fish processors and businesses supporting recreation) in their communities are indirectly affected. In determining whether potential communities are an environmental justice community of concern, the demographic characteristics specific to these communities must be considered. Available socio-demographic data on the prevalence of minority and low-income populations for counties in the three subregions are used as a proxy for these persons and businesses. These data are compared to the environmental justice thresholds presented in Subsection 3.4.1.5, Environmental Justice Thresholds for Identifying Groups and Communities of Concern, to identify communities of concern at the county level.

3.4.1.5 Environmental Justice Thresholds for Identifying Groups and Communities of Concern

Guidance on defining minority and low income areas was established by the Council on Environmental Quality (CEQ). This guidance (CEQ 1997) states:

> *Minority populations should be identified where either (a) the minority population of the affected area exceeds 50 percent or (b) the population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis… The selection of the appropriate unit of geographical analysis may be a governing body's jurisdiction, a neighborhood, a census tract, or other similar unit that is chosen so as not to artificially dilute or inflate the affected minority population.*

These CEQ guidelines do not specifically state the percentage considered meaningful in the case of low income populations.

For this assessment, criteria to identify environmental justice groups and communities of concern are based on the determination of whether the number of minority and low-income people in affected user groups is substantially greater than for the reference population. Five categories of minority and low-income indicators are used: 1) percent non-white population; 2) percent Native American population; 3) percent Hispanic population; 4) per-capita income; and 5) poverty rate. Thresholds for each of the minority and low-income categories were established using data from the United States Census Bureau (2000).

Thresholds for minority groups of concern are based on reference area percentages of non-white, Native American, and Hispanic persons above the minimum of the highest quintile (top twentieth percentile) for percent non-white, percent Native American, and percent Hispanic people. The thresholds range from 3.0 percent for Native American populations to 18.4 percent for non-white populations (Table 3.4-2). The threshold for identifying low-income populations of concern is the Federal poverty rate (17.7 percent), and for per-capita income the threshold is the maximum of the bottom quintile for the reference area ($15,829) (Table 3.4-2).

Table 3.4-2. Threshold criteria for identifying minority groups and low-income populations of concern in the environmental justice reference area (Washington State).

		Minority			Income	
Total Population Size	**Number of Counties**	**Percentage Non-white**	**Percentage Native American**	**Percentage Hispanic**	**Poverty Rate Percentage**	**Per Capita Income ($)**
5,894,121	39	18.4	3.0	13.4	17.7	15,829

Source: U.S. Census Bureau (2000).

As indicated in Subsection 3.4.1.2, Approach to Identifying Native American Tribes of Concern, all 17 Native American tribes with federally recognized treaty fishing rights have an interest in fishery management in Puget Sound and qualify as environmental justice groups of concern (see Figure 3.4-1 for the location of these tribes). Consequently, thresholds are not used to determine if any individual tribe qualifies as an environmental justice group of concern.

3.4.2 Native American Tribes of Concern

The information in this subsection on Native American tribes of concern is provided as context for the description of the environmental justice affected environment and Subsection 4.4, Environmental Justice.

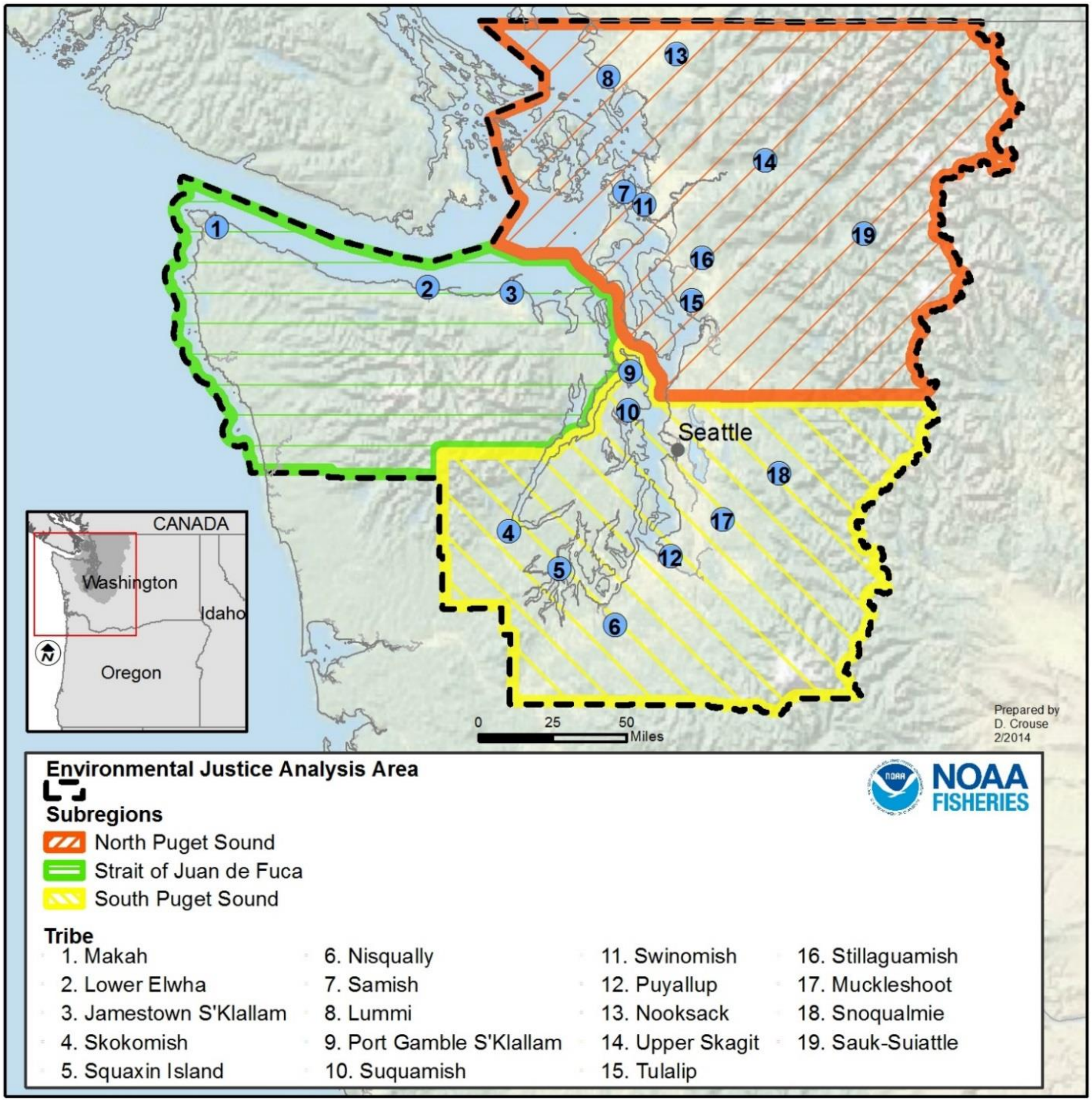


Figure 3.4-1. Location of federally recognized Puget Sound Indian tribes in the Puget Sound region and three subregions. Note the Samish and Snoqualmie tribes are federally recognized, but do not have federally recognized treaty fishing rights.

As described in Subsection 1.7.2.2, *United States v. Washington*, there are 17 treaty tribes with adjudicated fishing rights pursuant to *United States v. Washington* within the environmental justice analysis area. These tribes are the Native American tribes of concern for the purposes of this environmental justice analysis (Subsection 3.4.1.2, Approach to Identifying Native American Tribes of Concern). The tribes are the Jamestown S'Klallam, Lower Elwha Klallam, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Port Gamble S'Klallam, Skokomish, Suquamish, Puyallup, Sauk-Suiattle, Squaxin Island, Stillaguamish, Swinomish, Tulalip, and Upper Skagit Tribes. The Samish and Snoqualmie Tribes also are federally recognized within the project area but they are not parties to *United States v. Washington* (Subsection 1.7.2.2, *United States v. Washington*) and do not have federally recognized treaty fishing rights at the present time.

Of the Native American tribes of concern in the Puget Sound region and three subregions, per capita income ranges from about $5,500 for the Upper Skagit Tribe to about $13,600 for the Suquamish Tribe (Table 3.4-3). The average per capita income for the 17 tribes is $10,233, a per capita income level that is well below the state-wide level of $23,973. Tribal per capita income is lowest in the Strait of Juan de Fuca subregion ($9,462) and highest in the south Puget Sound subregion ($10,788) (Table 3.4-3).

The percentage of people in Native American tribes of concern in the Puget Sound and three subregions with incomes below the Federal poverty level ranges from 5 percent for the Sauk-Suiattle Tribe to 60 percent for the Upper Skagit Tribe (Table 3.4-3). An average of 28 percent of the people in the Native American tribes of concern live below the Federal poverty level, compared to 11 percent of all residents in the reference area. The percentage of people in these tribes with incomes below the Federal poverty level is highest in the Strait of Juan de Fuca subregion (31 percent) and lowest in the south Puget Sound subregion (25 percent) (Table 3.4-3).

The number of people in the Native American tribes of concern labor force that reside on- or off-reservation totals 4,228 people, ranging from 16 people for the Jamestown S'Klallam Tribe to 727 people for the Lummi Tribe (Table 3.4-4). The average unemployment rate for Native American tribes of concern and all residents in the reference area (Washington State) is 17 percent and 6 percent, respectively (Table 3.4-4). The unemployment rate for tribal members ranges from a low of 14 percent in the south Puget Sound subregion to a high of 26 percent in the Strait of Juan de Fuca subregion (Table 3.4-4).

Table 3.4-3. Per capita income and percent below the Federal poverty level for Native American residents on or near designated reservations.

Subregion and Tribe	Population Size (Number)	Per Capita Income ($)	Percentage Below Federal Poverty Level
North Puget Sound			
Lummi	2,208	10,142	28
Nooksack	348	9,695	29
Sauk-Suiattle	41	8,127	5
Stillaguamish	78	7,609	13
Swinomish	611	8,712	36
Tulalip	1,875	10,623	29
Upper Skagit	139	5,523	60
Total	**5,300**	**9,944**	**30**
South Puget Sound			
Muckleshoot	1,029	9,914	29
Nisqually	314	11,072	18
Port Gamble S'Klallam	461	8,539	18
Puyallup	1,386	12,439	26
Skokomish	518	8,500	32
Squaxin Island	325	8,698	33
Suquamish	503	13,613	13
Total	**4,536**	**10,788**	**25**
Strait of Juan de Fuca			
Jamestown S'Klallam	16	NA	NA
Lower Elwha Klallam	256	8,082	33
Makah	1,076	9,835	31
Total	**1,348**	**9,462**	**31**
Tribal Totals	**11,184**	**10,233**	**28**
Reference Area (entire population of Washington State)	5,894,121	22,973	11
Native American Population Relative to the Reference Area (Washington State) (%)	Less than 1 percent	45 percent	---

Source: U.S. Census Bureau (2000).

[1] Many enrolled tribal members do not live on the reservation http://www.npaihb.org/member_tribes/tribe/jamestown_sklallam_tribe/

[2] NA = not available.

Note: The tribal data presented in this table may include some Native American residents on or near designated reservations who are not members of the 17 Puget Sound treaty tribes in the environmental justice analysis area. In addition, population numbers may include enrolled members that do not live on designated reservations and trust lands.

Table 3.4-4. Labor force (numbers) and unemployment for Indian tribes residing on Puget Sound reservation and off-reservation Trust lands.

Subregion and Tribe	Number in Labor Force	Number Unemployed	Percentage Unemployed
North Puget Sound			
Lummi	727	146	20
Nooksack	144	22	15
Sauk-Suiattle	17	5	29
Stillaguamish	29	0	0
Swinomish	220	46	21
Tulalip	703	92	13
Upper Skagit	39	2	5
Total	**1,879**	**313**	**17**
South Puget Sound			
Muckleshoot	361	49	14
Nisqually	149	24	16
Port Gamble S'Klallam	182	16	9
Puyallup	565	80	14
Skokomish	166	43	26
Squaxin Island	106	20	19
Suquamish	244	25	10
Total	**1,773**	**257**	**14**
Strait of Juan de Fuca			
Jamestown S'Kallam	16 [1]	0	0
Lower Elwha Klallam	96	18	19
Makah	464	128	28
Total	**576**	**146**	**26**
Tribal Total	**4,228**	**716**	**17**
Reference Area (entire population of Washington State)	3,027,734	186,102	6
Native American Population Relative to the Reference Area (Washington State) (%)	Less than1	Less than 1	---

Source: U.S. Census Bureau (2000).

[1] Many enrolled tribal members do not live on the reservation http://www.npaihb.org/member_tribes/tribe/jamestown_sklallam_tribe/

Note: The tribal data presented in this table may include some Native American residents on or near designated reservations who are not members of the 17 Puget Sound treaty tribes in the environmental justice analysis area. In addition, population numbers may include enrolled members that do not live on designated reservations and trust lands.

To evaluate if, and to what extent, hatchery production could have environmental justice impacts on Native American tribes of concern, three indicators of impacts are described: tribal commercial salmon and steelhead harvests, tribal ceremonial and subsistence uses, and economic values to tribes from harvest and hatchery operations. Existing conditions pertaining to these indicators are described in the following subsections.

3.4.2.1 Tribal Commercial Salmon and Steelhead Harvests

As described in Subsection 3.3.1, Introduction (Socioeconomics), Puget Sound treaty tribes with fishing rights are entitled to up to 50 percent of the available harvest at usual and accustomed grounds and stations (pursuant to *United States v. Washington*). Subsection 3.3, Socioeconomics, provides harvest information for treaty tribal and non-tribal fisheries. The information for treaty tribes' fisheries provides the existing harvest conditions for Native American tribes of concern addressed in this subsection. Thus, to reduce redundancy, harvest data and tables in Subsection 3.3, Socioeconomics are referred to in this subsection and are not repeated.

Between 2002 and 2006, tribal commercial harvest of salmon and steelhead averaged 1,321,156 fish annually (Table 3.3-4). On average, 790,399 (about 60 percent of the total tribal harvest of salmon and steelhead) occurred in the north Puget Sound subregion, 434,935 (about 33 percent) occurred in the south Puget Sound subregion, and 95,822 (about 7 percent) occurred in the Strait of Juan de Fuca subregion (Table 3.3-4). Only Puget Sound treaty tribes are permitted to commercially harvest salmon and steelhead in freshwater areas in the project area. From 2002 to 2006, an estimated 17 percent (or 224,596) of the total tribal commercial harvest occurred in Puget Sound rivers. Additional details pertaining to tribal fishing in freshwater areas are described in Subsection 3.3.6, Fisheries in Major River Systems.

3.4.2.2 Ceremonial and Subsistence Uses

Ceremonial and subsistence uses pertain to fish that are caught non-commercially by members of Puget Sound treaty tribes. Salmon and steelhead harvested for ceremonial and subsistence purposes are important to maintaining cultural viability, and provide a valuable food resource, among other traditional foods, in tribal ceremonies. Examples of ceremonies that use traditional foods include winter ceremonies, first salmon ceremonies (Amoss 1987), naming ceremonies, giveaways, feasts, and funerals (Meyer Resources Inc. 1999). Subsistence refers to ways in which Native Americans use environmental resources like salmon and steelhead to meet the nutritional needs of tribal members.

Members of the Puget Sound treaty tribes prioritize their ceremonial and subsistence needs over commercial sales. Tribes may fish for ceremonial and subsistence uses when there are no concurrent commercial fisheries, and may use some of their commercial harvest for ceremonial and subsistence purposes. Many tribes feel their subsistence needs are not met by the current abundances of natural-origin and hatchery-origin fish (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, April 6, 2010).

3.4.2.3 Economic Value to Tribes from Harvest and Hatchery Operations

Tribal commercial harvest of salmon and steelhead and tribal operation of hatchery facilities provide economic value to tribes. The gross economic value (see Subsection 3.3.1, Introduction (Socioeconomics), for a description of gross economic value) to tribes from salmon and steelhead harvest annually averaged $9,148,467 from 2002 to 2006 (Table 3.3-4). As shown in Table 3.3-4, tribal harvest of salmon and steelhead in the north Puget Sound subregion generated the highest gross economic value ($4,455,730), followed by the south Puget Sound subregion ($3,890,770), and the Strait of Juan de Fuca subregion ($801,967).

Operation of tribal salmon and steelhead hatcheries involves $3,413,457 in tribal personal income and 74 tribal jobs (Table 3.3-6). As shown in Table 3.3-6, tribal hatchery operations in the south Puget Sound subregion generated the highest personal income ($2,104,988) and number of jobs (44 jobs), followed by the north Puget Sound subregion ($1,051,468 and 24 jobs) and Strait of Juan de Fuca subregion ($257,001 and 6 jobs).

In addition to harvest-related and hatchery operations-related personal income to tribes, tribes also receive funds for routine operation of hatcheries (i.e., fish food and other supplies, administration, and required services such as mass-marking). These hatchery operation cost values total $4,458,287, and are highest in the south Puget Sound subregion ($2,574,548), followed by the north Puget Sound subregion ($1,471,992), and Strait of Juan de Fuca subregion ($411,747) (Table 3.3-6).

3.4.3 Income to Non-tribal User Groups of Concern

As indicated in Subsection 3.4.1.3, Approach to Identifying Non-tribal User Groups of Concern, hatchery production of salmon and steelhead and associated harvests may affect potential user groups of concern (commercial and recreational fishers). Socio-demographic data is considered in determining if a user group is an environmental justice user group of concern. Because socio-demographic data specific to non-tribal user groups of concern are generally not available, the analysis of non-tribal user groups focuses on the 13 ports where commercial fishers are based (Table 3.4-5). Based on data available for the 13 ports, commercial fishers based at 7 ports meet minority and/or low-income criteria found in Table 3.4-2, and are an environmental justice group of concern (Table 3.4-5). The environmental justice group of concern includes commercial fishers based at three ports in the south Puget Sound subregion (Seattle, Shelton, and Tacoma), two in the north Puget Sound subregion (Bellingham Bay and Everett), and two in the Strait of Juan de Fuca subregion (Neah Bay and Port Angeles) (Table 3.4-5).

Table 3.4-5. Identification of non-tribal environmental justice user groups of concern (ports) by subregion.

Subregion and Commercial Fishing Port (County)	Minority			Income	
	Percentage Non-white	**Percentage Native American**	**Percentage Hispanic**	**Percentage in Poverty**	**Per Capita Income ($)**
North Puget Sound					
Anacortes (Skagit)	7.3	1.1	3.2	7.7	22,297
Bellingham Bay (Whatcom)	12.1	1.5	4.6	20.6[1]	19,483
Blaine (Whatcom)	12.3	1.1	4.4	15.5	20,333
Everett (Snohomish)	18.9[1]	1.6	7.1	12.9	20,577
La Conner (Skagit)	9.2	1.7	6.2	11.8	24,308
South Puget Sound					
Olympia (Thurston)	14.7	1.3	4.4	12.1	22,590
Poulsbo (Kitsap)	11.9	1.0	4.8	9.1	20,649
Seattle (King)	29.9[1]	1.0	5.3	11.8	30,306
Shelton (Mason)	14.2	2.7	10.9	18.9[1]	16,303
Tacoma (Pierce)	30.9[1]	2.0	6.9	15.9	19,130
Strait of Juan de Fuca					
Neah Bay (Clallam)	85.8[1]	78.2[1]	5.4	29.9[1]	11,338[1]
Port Angeles (Clallam)	8.6	3.3[1]	2.3	13.2	17,903
Port Townsend (Jefferson)	6.7	1.2	2.3	14.0	22,395

Source: U.S. Census Bureau (2000).

[1] Gray shading in boxes represents environmental justice user groups of concern (ports) whose minority and/or income levels exceed threshold criteria provided in Table 3.4-2.

Net revenues (profits minus losses) from harvest of salmon by non-tribal commercial fishers are shown in Table 3.4-6. Net revenues for the commercial fishers based at the seven ports total $3,335,926, and are highest in the north Puget Sound subregion ($1,850,497), followed by the south Puget Sound subregion ($1,473,806), and Strait of Juan de Fuca subregion ($11,623) (Table 3.4-6).

Table 3.4-6. Net revenues for non-tribal environmental justice user groups of concern (ports) by subregion from commercial salmon brought to ports.

Subregion and Commercial Fishing Port of Concern[1]	**Net Revenue ($)**
North Puget Sound	
Bellingham Bay	1,581,951
Everett	268,546
Total	**1,850,497**
South Puget Sound	
Seattle	1,166,822
Shelton	222,005
Tacoma	84,979
Total	**1,473,806**
Strait of Juan de Fuca	
Neah Bay	1,621
Port Angeles	10,002
Total	**11,623**
Grand Total	**3,335,926**

Source: Estimates of non-tribal commercial fishing net revenues were derived by the Puget Sound Hatcheries EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Environmental justice user groups of concern are identified in Table 3.4-5.

Based on socio-demographic data, recreational fishers are not an environmental justice group of concern. As described in Subsection 3.4.1.3, Approach to Identifying Non-tribal User Groups of Concern, the assessment of recreational fishers as a potential user group of concern focuses on two minority categories (percentage of non-white and Hispanic) and income thresholds to determine low-income status. The assessment is conducted using statewide data because comprehensive socio-demographic data are not available at the local (county) or subregion level. As shown in Table 3.4-7, the percentages of Washington's recreational fishers that are non-white or Hispanic and the percentage of Washington recreational fishers in low-income households are less than the percentages for the overall statewide population. Thus, recreational fishers are not an environmental justice group of concern, and recreational fishers are not analyzed further in the EIS for environmental justice.

Table 3.4-7. Comparison of demographic characteristics of recreational fishers in Washington State compared to the statewide population.

Category	Race or Ethnicity		Annual Household Income	
	Percentage Non-white	**Percentage Hispanic**	**Percentage <$10,000**	**Percentage $10,000-$20,000**
Washington recreational fishers	4	3	2	3
Washington statewide population	14	7	3	6

Source: U.S. Fish and Wildlife Service (2006).

3.4.4 Income to Communities of Concern

As indicated in Subsection 3.4.1.4, Approach to Identifying Communities of Concern, hatchery production of salmon and steelhead and associated commercial and recreational harvests indirectly affects persons and businesses that conduct business with commercial and recreational fishers. Included in community-level effects are direct income to fish harvesters and hatchery employees, and indirect income to fish processors, businesses providing support to recreational fishing, and businesses that provide materials and services to hatchery operations. To identify potential environmental justice communities of concern, socio-demographic characteristics of affected counties in the target area are evaluated. Counties are designated as environmental justice communities of concern if poverty levels or the percentage of minority population(s) in these target areas exceeds the reference area thresholds for either of these indicators (Table 3.4-2).

Based on low-income criteria, counties are communities of concern if their poverty rate is above, or per capita income is below, threshold levels established for the environmental justice analysis area (Federal poverty rate of 17.7 percent and per capita income of $15,829) (Table 3.4-2), or if criteria for minority populations are exceeded (Table 3.4-2). No counties qualify as communities of concern based on low-income criteria, but four counties qualify as communities of concern based on minority criteria (Table 3.4-8). Of these four counties, three are located in the south Puget Sound subregion (King, Mason, and Pierce Counties), and one county (Clallam County) is in the Strait of Juan de Fuca subregion (Table 3.4-8). The per capita income for all four counties representing communities of concern is above the threshold criteria for per capita income ($29,521, $18,056, and $20,948 for King, Mason and Pierce Counties, respectively, in the south Puget Sound subregion, and $19,517 for Clallam County in the Strait of Juan de Fuca subregion) (Table 3.4-8).

Table 3.4-8. Identification of environmental justice communities of concern (counties) by subregion and county.

Subregion and County	Minority			Income	
	Percentage Non-white	Percentage Native American	Percentage Hispanic	Percentage in Poverty	Per Capita Income ($)
North Puget Sound					
Island County	12.8	1.0	4.0	7.0	21,472
San Juan County	5.0	0.8	2.4	9.2	30,603
Skagit County	13.5	1.9	11.2	11.1	21,256
Snohomish County	14.4	1.4	4.7	6.9	23,417
Whatcom County	11.6	2.8	5.2	14.2	20,245
South Puget Sound					
King County	24.3[1]	0.9	5.5	8.4	29,521
Kitsap County	15.7	1.6	4.1	8.8	22,317
Mason County	11.5	3.7[1]	4.8	12.2	18,056
Pierce County	21.6[1]	1.4	5.5	10.5	20,948
Thurston County	14.3	1.5	4.5	8.8	22,415
Strait of Juan de Fuca					
Clallam County	10.9	5.1[1]	3.4	12.5	19,517
Jefferson County	7.8	2.3	2.1	11.3	22,211

Source: U.S. Census Bureau (2000).

[1] Gray shading in boxes represents environmental justice communities of concern whose minority and/or income levels exceed threshold criteria provided in Table 3.4-2.

3.4.5 Public Outreach

Throughout the EIS process, NMFS will ensure that the requirements of EO 12898 (59 Fed. Reg. 32, February 11, 1994) regarding environmental justice are implemented, including appropriate tribal consultation activities. As part of the public scoping process for this EIS (Subsection 1.6, Scoping and Relevant Issues), NMFS attempted to directly notify the potential environmental justice user groups and communities of concern considered in this assessment: non-tribal commercial and recreational fishers, and tribal fishers. NMFS sent letters to Puget Sound Indian tribes notifying them about EIS scoping meetings and activities. Non-tribal commercial and recreational fishers were contacted through phone calls and/or emails to invite them to participate in EIS scoping meetings. Additional notices were published in local newspapers and electronic newsletters. In addition, emails were sent to individuals identified by NMFS as non-tribal commercial and recreational fishers, and tribal fishers. All groups notified during scoping are included on the EIS distribution list and will receive direct information about commenting on the draft and final EISs.

3.5 Wildlife

3.5.1 Introduction

Hatchery facilities and their operation, and hatchery-origin fish after release, have the potential to affect wildlife. Topics discussed in this subsection are the:

- Potential transfer of toxic contaminants from fish to wildlife
- Potential for hatchery weirs to impede movements of wildlife
- Effects to wildlife from salmon and steelhead carcasses
- Potential effects to water quality and quantity from hatchery operations
- Predator-prey interactions between wildlife and salmon and steelhead

Predator-prey interactions dominate the relationships between wildlife and salmon and steelhead. Numerous wildlife species prey on hatchery-origin and natural-origin salmon and steelhead. Other species, such as marine and freshwater invertebrates, are the prey of salmon and steelhead. Key wildlife groups associated with salmon and steelhead predator-prey interactions are: 1) ESA-listed freshwater, marine, and terrestrial wildlife species; 2) non-listed fish-eating birds; 3) non-listed marine mammals; and 4) other non-listed freshwater, marine, and terrestrial wildlife species.

Salmon and steelhead have intrinsic relationships to wildlife species (dominated by predator-prey dynamics) reflecting how dependent or adaptable the wildlife species are to variations in the availability of the fish for food. These relationships are described as strong or recurrent by Cederholm et al. (2000) who explain that a strong relationship is one in which salmon and steelhead provide an important role in the distribution, abundance, viability, and/or population status of the wildlife species, especially at particular life stages or specific seasons. These authors describe a recurrent relationship as one that may affect some populations of a given wildlife species, but in general does not affect the distribution, abundance, viability, or population status of the species.

Information in this subsection is organized by topic and by wildlife species, and some species are grouped when appropriate. For key wildlife species and groups, the discussion is focused on the general relationships between wildlife and salmon and steelhead. For the purposes of the EIS, wildlife relationships with hatchery-origin salmon and steelhead are described to the extent possible. Studies are not available indicating whether or not wildlife differentiate or prefer hatchery-origin from natural-origin fish (e.g., as sources of food or prey). Therefore, relationships between wildlife and natural-origin and hatchery-origin salmon and steelhead are assumed to be the same.

3.5.2 Hatchery Operations and Wildlife

Hatchery operations that affect the abundance of salmon and steelhead in freshwater and marine environments influence wildlife typically through predator and prey interactions. In addition, hatcheries could affect wildlife through transfer of toxic contaminants or pathogens from hatchery-origin fish to wildlife, predator control programs (which may harass or kill wildlife preying on juvenile salmon at hatchery facilities), operation of hatchery structures or weirs (which could block or entrap wildlife), distribution of hatchery salmon carcasses into the environment (which provides food and nutrients for wildlife), or other aquatic habitat changes that occur from hatchery operations.

3.5.2.1 Transfer of Toxic Contaminants and Pathogens

Wildlife species that consume salmon and steelhead are susceptible to toxic contaminants and/or pathogens that may be within the fish they consume. There is evidence of bioaccumulation in fish-eating birds and mammals of persistent organic pollutants, including polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethanes (DDTs) and other pesticides, polycyclic aromatic hydrocarbons (PAHs), fire retardants (such as polybrominated diphenyl ethers [PDBEs]) and other compounds that may cause a range of deleterious health effects (Anthony et al. 1993; Ross et al. 2000; Tabuchi et al. 2006; review in PSAT 2007; Cullon et al. 2009; O’Neill and West 2009). One study noted that adult Puget Sound Chinook salmon had nearly three to five times the PCB levels compared to Chinook salmon from the Georgia Basin, Alaska, British Columbia, and Oregon. Available information does not indicate that fish hatchery operations contribute to introducing these contaminants into the environment (Subsection 3.7, Human Health), but hatchery-origin fish (as well as natural-origin fish) may pass contaminants on to wildlife predators, as described in this subsection.

There is some potential for elevated contaminant loads in hatchery-origin fish prior to their release as juveniles if they were to consume contaminated fish feed (Maule et al. 2006). However, there is no evidence documenting contaminant loading in hatchery-origin fish from the consumption of fish feed (Johnson et al. 2007) (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish). Uptake of organic contaminants directly from water to fish is considered to be a minor accumulation pathway, and the major source of contamination in salmon is probably their diet (Johnson et al. 2007).

The amount of time spent within Puget Sound appears to be an important factor in contaminant loading for Chinook salmon. Thus, the longer the time expended in Puget Sound, the greater the likelihood for increased contaminant loading. Natural-origin and hatchery-origin Chinook salmon (Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon, and Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon, respectively) occur at various times year-round in Puget Sound estuaries (e.g., as juveniles, and to a lesser extent as immature resident salmon [locally referred to as blackmouth salmon] that may remain in Puget Sound without migrating to the ocean).

In general, Chinook salmon appear to have the highest PCB loads of all salmon species in Puget Sound (O'Neill et al. 2005; O'Neill and West 2009). Heavy contaminant loads in Puget Sound Chinook salmon likely contribute to contaminant loads in Southern Resident killer whales (O'Neill et al. 2005; Cullon et al. 2009), because the main prey source for the whales is Chinook salmon during some months of the year (Ford and Ellis 2006; Hanson et al. 2010). Krahn et al. (2007, 2009) found that tissue samples from Southern Resident killer whales, with the exception of three recent mothers, had PCB levels that exceeded thresholds for health effects in marine mammals (Kannan et al. 2000). Southern Resident killer whales prefer to capture older (i.e., larger) adult Chinook salmon prey (Ford and Ellis 2006), which would be expected to carry greater contaminant loads than juvenile Chinook salmon.

The relatively small numbers of resident natural-origin and hatchery-origin Chinook salmon that occur in Puget Sound may have a greater potential for elevated contaminant loads, relative to the much more common ocean-going salmon that spend less time in Puget Sound. Most resident salmon are sexually immature, and thus are younger and smaller in size than their ocean-going adult counterparts. Because of their longer exposure to the degraded marine waters of Puget Sound, these fish would be expected to accumulate more toxic contaminates in their bodies than hatchery-origin and natural-origin fish that rear in the ocean. Hatchery-origin, yearling fall-run Chinook salmon releases that may produce resident Chinook salmon compose about 4 percent of the total number of Chinook salmon releases in the project area, and survival of salmon from those programs has declined in recent years (Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon). Because of their scarcity and smaller relative size (compared to ocean-going Chinook salmon adults), it is unlikely that resident Chinook salmon substantially contribute to the prey base and contaminant loading in Southern Resident killer whales. Thus, the source of contaminant loading in Southern Resident killer whales is likely primarily from returns of the more abundant and larger ocean-going Chinook salmon prey.

Chemical and drug use at hatcheries is regulated by the Food and Drug Administration (FDA) and EPA and subject to permit approval. As described in Subsection 3.6.1, Water Quality, state and tribal hatcheries must obtain National Pollutant Discharge Elimination System (NPDES) permits for the discharge of chemicals and other pollutants used in hatchery operations. These potential pollutants include antibiotics, fungicides, disinfectants, nutrients (phosphorus and nitrogen from salmon carcasses), ammonia, and particulates (e.g., food, fecal material, dead fish). Hatchery programs are regulated by the terms of NPDES permits. Ecology routinely monitors hatchery compliance with these regulations to ensure continual compliance, and most hatchery non-compliances are associated with brief and episodic flooding events (Subsection 3.6.1, Water Quality).

The controls on pollutant discharges from hatcheries and the chemical content of food fed to hatchery-origin fish suggest that hatchery operations are not the likely contributor to contaminant loads in wildlife species. Contaminant loading of hatchery-origin fish is expected to occur after release from hatchery facilities and both hatchery-origin fish and natural-origin fish are likely to contribute to contaminant loads in wildlife species that consume these fish. This conclusion is based on the expectation that both hatchery-origin and natural-origin salmon and steelhead acquire contaminants while they reside in streams and marine waters in the project area, and that wildlife species consume both hatchery-origin and natural-origin salmon and steelhead.

Operation of state and tribal hatcheries in Puget Sound is governed by guidelines established in fish health policy manuals to minimize disease transmission from hatchery-origin fish to aquatic organisms (NWIFC and WDFW 2006). Diseases of hatchery-origin fish are caused by viral, bacterial, and parasitic pathogens that are also present in natural-origin salmon and steelhead populations (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Available information in the literature does not indicate that fish diseases injure or kill wildlife, although some fish diseases or parasites use wildlife as intermediate disease hosts or vectors (McVicar et al. 2006). One exception is salmon poisoning disease, a rickettsial disease borne by salmon and steelhead that sickens or kills dogs and wild canids that ingest infected fish (Ettinger and Feldman 1995). Another exception is the potential for pathogen transfer from fish to amphibians, which has been cited by Blaustein and Kiesecker (2002) as a potential contributor to the decline of amphibian populations. Amphibians have permeable skin, making them susceptible to similar pathogens as fish, and hatchery-reared salmon may infect amphibians with pathogens (Kiesecker et al. 2001). In a recent California Department of Fish and Game (CDFG) EIS (Final Hatchery and Stocking Program Environmental Impact Report/EIS) prepared in 2010, CDFG recommended that hatcheries managed by CDFG implement best management practices that minimize risk of disease transmission to native amphibian populations (CDFG and USFWS 2010). Altogether, relatively few diseases of fish affect wildlife species, and the operation of hatcheries is designed to minimize the potential transmission of disease from hatchery-origin salmon and steelhead to wildlife.

3.5.2.2 Hatchery Predator Control Programs and Weirs

The primary avian predators associated with operation of hatchery facilities are bald eagles, great blue herons, kingfishers, gulls, mergansers, and cormorants (ODFW 1992; Price and Nickum 1995; USDA 1997). To minimize predation on fish at hatcheries, operators employ techniques to deter and control predators. These techniques include non-lethal, passive, exclusionary-type devices (such as bird netting, electric wires, and fencing). In some cases, harassment of birds using pyrotechnics or a trained falcon is also employed. These control programs are used at hatchery rearing ponds and net pens when predator control is needed. These programs are generally effective and can limit wildlife predation to times when hatchery-origin fish are released from rearing ponds and net pens (Senn et al. 1984).

In addition to avian predators, river otters and mink are common predators at hatchery facilities (J. Kerwin, pers. comm., WDFW, Wildlife Biologist, February 18, 2004). For these species, hatcheries may also employ trapping to inhibit or prevent these predators from taking hatchery salmon. The predator control devices at hatcheries result in lost foraging opportunities for individual predators at the hatcheries, but it has not been demonstrated that these devices impact overall wildlife populations in the project area. Similar to avian predator control programs, the predator control programs for river otter and mink can be effective in limiting their distribution at and near hatcheries; however, during periods when hatchery-origin fish are released, river otter and mink may increase their use of areas where hatchery-origin fish are out-migrating.

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, weirs and fish ladder trap combinations associated with barriers, such as dams, are used to block upstream migration for the purpose of collecting hatchery broodstock and separating hatchery-origin from natural-origin fish to meet management objectives. Weirs and traps used for broodstock collection may be temporary or permanent, and their effects on non-target fish and aquatic species would depend on the timing of their use in streams. For example, weirs may delay migration or block the movements of other aquatic wildlife species, isolating formerly connected areas and potentially fragmenting populations.

The distribution of predators may be affected by changes in the occurrence of aquatic prey populations in streams affected by weirs and traps. Weirs may alter stream flow and streambed and riparian habitat and affect habitat availability for non-target fish, amphibians, and aquatic invertebrates. Weirs may facilitate predation by mammals and birds on salmon and steelhead by blocking fish passage and concentrating fish into confined areas. The effects of weirs and traps on non-target aquatic wildlife species may be advantageous to those wildlife predators that prey on fish and a detriment to those aquatic wildlife species that travel along the stream corridor where the weirs are located. However, no studies have been conducted to date demonstrating that weirs are negatively impacting wildlife populations.

3.5.2.3 Nutrients from Salmon and Steelhead Carcasses

Research in Pacific Northwest streams indicates the importance of anadromous salmon and steelhead to freshwater and terrestrial food webs and ecosystem function (Kline et al. 1990; Cederholm et al. 2000; Hilderbrand et al. 2004). In addition to live salmon and steelhead consumed by wildlife predators, salmon carcasses provide a carrion food source to wildlife and a source of nutrients to other aquatic and terrestrial species through the decomposition of carcasses. Carcasses in streams result from natural-origin and hatchery-origin spawners and from hatchery-origin fish that return to hatchery facilities to spawn and then are placed out into streams by hatchery operators.

Birds (such as wintering bald eagles), mammals, and aquatic invertebrates feed directly on salmon and steelhead carcasses, and the decomposer communities (i.e., organisms, including bacteria, fungi, and invertebrates, that decompose organic material) that develop on carcasses are, in turn, consumed by other aquatic invertebrate species (Willson et al. 1998). The input of marine-derived nutrients, such as phosphorus and nitrogen, into streams is thought to substantially enhance productivity of many nutrient-poor coastal streams (reviewed by Willson et al. 1998) and riparian vegetation communities (reviewed by Hilderbrand et al. 2004).

As described in Subsection 3.2.3.7, Benefits - Marine-derived Nutrients, about 23 million pounds of salmon and steelhead carcasses, including both hatchery-origin and natural-origin fish, are deposited in the project area. Eighty percent of this biomass is contributed by chum salmon and pink salmon, which are predominantly natural-origin fish and, therefore, not greatly influenced by hatchery production. However, distribution of hatchery-origin salmon carcasses to upstream river reaches via naturally spawning hatchery-origin fish and placement of carcasses by hatchery operators can replace some of the nutrients in nutrient-deficient areas where spawning salmon and steelhead are limited or lacking. Hatcheries obtain permits, as required, to place salmon carcasses in streams, the amount of which is based on hatchery production and other factors. An annual average of 28,850 salmon carcasses was distributed into Puget Sound rivers and streams from WDFW hatcheries from 2007 to 2011 (Appendix B, Hatchery

Effects and Evaluation Methods for Fish). In general, the distribution of hatchery-origin carcasses is a benefit to wildlife and can provide an important food resource to wintering bald eagles, which is described in greater detail in Subsection 3.5.3.2.1, Bald Eagle.

3.5.2.4 Other Hatchery Operations

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, hatchery facilities may indirectly alter water quality and quantity in streams where hatchery facilities are located. Hatchery operations may affect water volume and flow, particularly in bypass areas. Depending on existing habitat, and timing and degree of water flow alterations, habitat availability for stream-breeding amphibians (e.g., giant salamanders), crustaceans, and aquatic insects could be influenced by hatchery operations. Water diversions and water quality are regulated by water rights permits, NMFS screening criteria, and Hatchery Scientific Review Group operational guidelines designed to minimize the risk of harming natural-origin fish and other aquatic fauna. Appendix B, Hatchery Effects and Evaluation Methods for Fish, identified four hatcheries with the potential to affect aquatic organisms by dewatering of stream reaches downstream from their water intake structures. Water diversions at these hatcheries are located near the stream mouths, and the hatcheries are no more than 0.5 RM upstream of the mouths, limiting the extent of the areas affected by these operations. Relative to the much larger areas occupied by aquatic fauna populations, the effects of these water diversions in bypass reaches are minimal. Thus, hatchery operation effects relative to water quality and quantity in the project area have not been shown to affect wildlife populations.

Most hatchery facilities contain ponds for fish rearing or other purposes that use asphalt or other materials for lining walls; these materials do not provide amphibian habitat. While amphibians are able to enter these ponds, in some instances the animals may not be able to escape from the ponds, which would be based on the facility configuration. However, the presence of dense concentrations of fish makes these ponds generally unsuitable for breeding amphibians because of predation on larval amphibians. Other potential sources of amphibian mortality at the hatchery facilities could include entrapment in fish screens and other exclusionary devices. Apart from ponds, hatcheries generally do not create slow-moving or still-water areas that could support pond-breeding amphibians that are either native (e.g., rough-skinned newt, red-legged frog), and/or non-native (i.e., bullfrog). In evaluating amphibian population declines, hatchery facilities were not considered a contributing factor (Blaustein et al. 2011); thus, effects from hatchery facilities on amphibians are considered negligible.

3.5.3 Predator-prey Relationships between Wildlife and Salmon and Steelhead

Hatcheries in the project area contribute substantially to the total number of adults of most salmon species returning to the project area (Table 3.2-1). Hatchery-origin Chinook salmon compose a substantial majority (74 percent) (Table 3.2-1) of the total number of returning adult Chinook salmon, thereby supporting wildlife species that feed on this species. Hatchery-origin coho salmon compose nearly half (47 percent), and hatchery-origin chum salmon and sockeye salmon each compose nearly a third (29 and 30 percent, respectively), of the total number of returning adults, thus benefiting wildlife that feed on salmon. Most pink salmon returning to the project area are of natural origin. This subsection focuses on the predator-prey interactions between salmon and steelhead and specific wildlife species or wildlife groups.

3.5.3.1 ESA-listed Species

Six wildlife species occur in the project area that are federally listed as endangered or threatened under the ESA. Four of these species (spotted owl, Canada lynx, grizzly bear, and humpback whale) have no relationship with salmon or steelhead in Puget Sound, or with salmon and steelhead hatcheries and operations as described in Subsection 3.5.2, Hatchery Operations and Wildlife. Thus, these species are not discussed further in this EIS. The spotted owl and Canada lynx do not consume salmon or steelhead. While the grizzly bear consumes salmon in other areas, the species' distribution in the project area is limited to the North Cascades where it feeds primarily on plants with less than 10 percent of its diet as meat (winter-killed deer and elk) (Western Wildlife Outreach 2014). Humpback whales occur occasionally in the project area (Falcone et al. 2005), but rarely feed on salmon (NMFS 1991). These four species are also not found near hatcheries within the analysis area. The remaining three ESA-listed species (Southern Resident killer whale, Steller sea lion, and marbled murrelet) are discussed below.

Salmon and steelhead distribution and abundance (including hatchery-origin and natural-origin fish) could affect distribution and abundance of Southern Resident killer whale and marbled murrelet through effects on prey abundance and distribution as shown in Table 3.5-1. Most of the consumption of salmon and steelhead by these two ESA-listed species in the project area occurs in marine waters.

Table 3.5-1. Status, distribution, association, and trends for ESA-listed wildlife potentially affected by the alternatives.

Species[1]	**Federal (F) and State (S) Status**	**Distribution and Habitat Associations within the Project Area**	**Association with Hatchery and Wild Salmon in the Project Area**[2]	**Life Stage and/or Habitat where Interactions Occur**	**Population Trends**
Killer whale, Southern Resident	F: Endangered S: Endangered in WA	Puget Sound, Strait of Juan de Fuca, Strait of Georgia; occurs in inland marine deep-water habitats	Forage on salmon in project area	Adult salmon and steelhead; marine habitats	Variable over the last several decades; decline from 2005 to 2008, almost unchanged through 2011 (Carretta et al. 2013)
Marbled murrelet	F: Threatened S: Threatened	Widespread in nearshore waters of project area, with the exception of the vicinity of metropolitan areas	Known to forage on salmon and steelhead in nearshore marine areas and freshwater rearing areas; may forage on salmon in project area	Smolt; marine and freshwater habitats	Declining in Washington (McShane et al. 2004; Nelson et al. 2006; Pearson et al. 2011)

[1] **Bold** species name indicates species with strong, consistent relationship with salmon and steelhead; non-bold species name indicates species with recurrent relationship, as determined by Cederholm et al. (2000).
[2] Refers to entire project area, including, but not limited to, fish rearing areas and release sites.

3.5.3.1.1 Killer Whale

Eight distinct stocks of killer whales are recognized within the United States Exclusive Economic Zone, four of which may occur in the project area: 1) the Eastern North Pacific Southern Resident stock, occurring from southern Southeast Alaska to central California and including inland waters of British Columbia and Washington State; 2) the Eastern North Pacific Northern Resident stock, occurring from Alaska through British Columbia; 3) the Eastern North Pacific Transient stock, occurring from Alaska through California; and 4) the Eastern North Pacific Offshore stock, occurring from Southeast Alaska through California (Carretta et al. 2013). All stocks are protected under the Marine Mammal Protection Act (MMPA), but only the Southern Resident killer whale is listed under the ESA (endangered) (Table 3.5-1). A combination of natural and anthropogenic factors (including reduction of quantity and quality of prey, disturbance from sound and vessels, the presence of toxic chemicals that accumulate in top predators, and oil spills) were identified as potential limiting factors to their recovery (NMFS 2008a). Threats to the Southern Resident killer whale include habitat deterioration, changes in food availability, increased exposure to pollutants, and human disturbance (NMFS 2008a). The relative importance of these threats to killer whales within Puget Sound is unknown.

The project area (excluding Hood Canal) is included as critical habitat for the Southern Resident stock. Approximately 2,500 square miles of Puget Sound, including the entire Strait of Juan de Fuca, are critical habitat, with the exception of waters less than 20 feet deep. Regulations (50 CFR 424.12(b)) state that the agencies "shall consider those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection." Based on the natural history of the Southern Resident killer whales and their habitat needs, the physical or biological features of Southern Resident killer whale critical habitat are: 1) water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging (71 Fed. Reg. 69054, November 29, 2006). Considering observations from this region, salmon are preferred prey of Southern Resident killer whales and are likely consumed in large amounts, as indicated by the estimates of total salmon consumed by the Southern Resident killer whale DPS. "Sufficient prey abundance is necessary to support individual growth to reach sexual maturity and reproduction, including lactation and successful rearing of calves" (71 Fed. Reg. 69054, November 29, 2006).

Southern Resident killer whales occur in the Georgia Basin (the Strait of Georgia, the Strait of Juan de Fuca, and Haro Strait), Puget Sound, and coastal waters from Vancouver Island to Monterey Bay, California (Ford et al. 2000; NMFS 2008a; Black 2011). Northern resident killer whales occur primarily in inland and coastal British Columbia and southeast Alaska marine waters, and rarely enter Washington State marine waters (Ford et al. 2000; Krahn et al. 2004). Transient killer whales occur primarily in coastal marine waters, where they feed on marine mammals, but occasionally forage in inland Washington marine waters within the core ranges of the two resident stocks (Ford et al. 1994; Krahn et al. 2002; Balcomb 2006). Offshore killer whales are thought to consume fish and do not occur in inland waters of Washington (Ford et al. 1994; Krahn et al. 2002). Thus, only the Southern Resident killer whale is discussed in the following subsections because the other stocks either do not occur in the project area or do not consume salmon and steelhead.

The total estimated population of Southern Resident killer whales was 80 individuals comprising three pods as of June 23, 2014 (E. Heydenreich, pers. comm., Center for Whale Research, Senior Staff/Field

Biologist, June 23, 2014). Population censuses from 1974 to the present show variations from 71 individuals in 1974 to 96 individuals in 1994 (Carretta et al. 2013).

Southern Resident killer whales have seasonal patterns of occurrence in inland marine waters of Washington and British Columbia that have been documented since 1976, although there is variability between years and among the three pods of killer whales (McCluskey 2006; Hauser et al. 2007; Hanson and Emmons 2011). All three pods are detected in inland marine waters (including the vicinity of the San Juan Islands and the Gulf Islands, the Strait of Juan de Fuca, and the Georgia Basin) with greatest frequency from May to October. Frequency of occurrence in inland marine waters for all pods declines starting in October and remains low through May; however, the J pod is more frequently detected than K and L pods during this period (Hanson and Emmons 2011). From November through December, Southern Resident killer whales are more frequently detected in Puget Sound than in the Georgia Basin and San Juan Islands, although the overall frequency of occurrence is much lower than in summer months. Occurrence of Southern Residents in inland marine waters has been relatively low from January to April in recent years (from 2003 to 2009) (Hanson and Emmons 2011). Ongoing efforts to document their distribution indicate that, instead, they are more often present in coastal waters of Washington, Oregon, and California, the coast of Vancouver Island, as well as the Straits of Juan de Fuca and Georgia (Ford 2012; Hanson et al. 2012; Balcomb 2012).

Cederholm et al. (2000) state that Southern Resident killer whales have a strong relationship with salmon and steelhead (Table 3.5-1). Diets of Southern Resident killer whales determined from scales, tissue, and fecal samples collected in the vicinity of the San Juan Islands and the Strait of Juan de Fuca show that the whales primarily consume large Chinook salmon from May to October, even when other salmon species are more abundant (Ford and Ellis 2006; Hanson et al. 2010) (Table 3.5-2). Southern Resident killer whales spend a large proportion of their time during these months in inland marine waters, including, in particular, the west side of San Juan Island, the Strait of Georgia, and the Strait of Juan de Fuca (Ford and Ellis 2006; Hauser et al. 2007; Hanson and Emmons 2011). During this period, their diet consists of more than 83 percent Chinook salmon and 14 to 15 percent other salmon species (steelhead, chum salmon, sockeye salmon, and coho salmon) (Hanson et al. 2010). Despite the greater abundance of pink salmon and sockeye salmon compared to Chinook salmon, these two species were rare in samples of Southern Resident killer whale prey remains (Hanson et al. 2010; Hanson 2011).

Table 3.5-2. Summary of important Southern Resident killer whale prey.

Month(s)	Percentage of Important Prey Species	Sample Location(s)	Source
May - October	Chinook salmon (71)[1]	SE Vancouver Island	Ford and Ellis (2006); Ford et al. (2010b)
May - September	Chinook salmon (83)[2]	San Juan Islands; Strait of Juan de Fuca	Hanson et al. (2010)
November - December	Chinook salmon (52)[2] Chum salmon (47)[2]	Puget Sound	Hanson (2011)

[1] Percent of salmon prey (scales and tissues) identified to species.
[2] Percent determined by quantitative DNA cloning (percent of prey DNA in sample; all species).

Ford and Ellis (2006) found that killer whales captured older (i.e., larger) than average Chinook salmon. Chinook salmon that rear in Puget Sound (resident Chinook salmon) are smaller than adult Chinook salmon that rear in the ocean and occur in relatively small numbers (Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon; Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon; and Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens). Thus, resident Chinook salmon would not be expected to form a substantial component of the Southern Resident killer whale diet.

Genetic studies indicate that Fraser River Chinook salmon stocks are an important component of the Southern Resident killer whale summer diet in the vicinity of the San Juan Islands and the western Strait of Juan de Fuca, British Columbia (Hempelmann et al. 2009; Hanson et al. 2010). Of the Chinook salmon prey remains sampled by Hanson et al. (2010) in these areas from May to September, 80 to 90 percent were inferred to have originated from the Fraser River and 6 to 14 percent were inferred to have originated from Puget Sound rivers. Thus, during the summer months, Southern Residents forage primarily on Chinook salmon stocks that are entering the Strait of Juan de Fuca or the Georgia Strait en route to spawning streams in the Fraser River system (Hanson et al. 2010).

Southern Resident killer whale feeding events were sampled from 2003 to 2011 (October to January) in Puget Sound from Tacoma to northern Admiralty Inlet (Hanson 2011; Hempelmann et al. 2012). During the October to January period, chum salmon compose a more substantial portion of the Southern Resident killer whale diet than during summer months (Table 3.5-2). There is little information about diet composition and selectivity in winter months (NMFS 2008a; Hanson 2011; Ford et al. 2012). Fewer feeding events were sampled during winter; samples obtained during February and March in the Strait of Georgia were Chinook salmon and one sample obtained in April in the Strait of Juan de Fuca was a steelhead (Ford 2012).

The extent to which Southern Resident killer whales depend on specific salmon runs or populations (including resident Chinook salmon) in the project area is not known, and is likely to vary in any given year depending on availability of the fish. At different times of the year, Southern Resident killer whales may consume Chinook salmon that originate in the Fraser River and Puget Sound (Hanson et al. 2010; Hanson 2011; Ford et al. 2012), but data are insufficient to identify the proportion of different Chinook salmon populations in the Southern Resident killer whale diet. In addition to data obtained from prey remains described above, observations of southern residents in various parts of their range suggest that they may be exploiting locally available prey. For example, sightings of Southern Resident killer whales off Westport, Washington and in the Columbia River mouth may coincide with the spring Chinook salmon run in the Columbia River (Krahn et al. 2004; Zamon et al. 2007).

The relationship between availability of salmon species and the nutritional condition, fecundity, and survival of resident killer whales was reviewed recently by an independent science panel convened by NOAA Fisheries, and Fisheries and Oceans Canada (Hilborn et al. 2012). The panel acknowledged correlations between overall Chinook salmon abundance and Southern Resident killer whale survival rates and fecundity (Ford et al. 2010a; Ward et al. 2012). However, the panel cautioned against assuming that there is a simple linear causative relationship between Chinook salmon abundance and the status of Southern Resident killer whales.

In conclusion, the association of Southern Resident killer whales with Chinook salmon in inland marine waters during summer months, even when other salmon species are more abundant, has been well documented, and recent studies establish the importance of chum salmon from October through January. There is no evidence that Southern Resident killer whales distinguish between hatchery-origin and natural-origin salmon (NMFS 2008a; Hanson et al. 2010). Adults returning from hatchery releases have partially compensated for declines in natural-origin salmon populations and may have benefitted Southern Resident killer whales (Myers 2011). Although Chinook salmon and chum salmon are selected with much greater frequency than other prey species of Southern Resident killer whales, other salmon and steelhead are also prey items during specific times of the year. Thus, all species of hatchery-origin salmon and steelhead may contribute to the diet of Southern Resident killer whales.

Finally, as noted in Subsection 3.5.2.1, Transfer of Toxic Contamimants and Pathogens, heavy contaminant loads in Puget Sound Chinook salmon (acquired during the time Chinook salmon are present in the relatively urbanized and contaminanted waters of Puget Sound) likely contribute to contaminant loads in Southern Resident killer whales, because the main prey source for the whales is Chinook salmon during some months of the year.

3.5.3.1.2 Marbled Murrelet

Marbled murrelets are listed as threatened under the ESA in California, Oregon, and Washington, and are protected under the Migratory Bird Treaty Act (Table 3.5-1). Primary causes of the species' decline include direct mortality from oil spills and as bycatch in gill-net fisheries, as well as loss of nest habitat (61 Fed. Reg. 26256, May 24, 1996). Marbled murrelet critical habitat was designated in Washington State (61 Fed. Reg. 26256, May 24, 1996). Its critical habitat is restricted to forested land that surrounds Puget Sound but does not include marine waters of Puget Sound. The marbled murrelet does not occur in freshwater streams. Critical habitat for the marbled murrelet is defined as "areas essential for successful marbled murrelet nesting." The USFWS has "focused on the following primary constituent elements: (1) individual trees with potential nesting platforms, and (2) forested areas within 0.8 kilometers (0.5 miles) of individual trees with potential nesting platforms, and with a canopy height of at least one-half the site-potential tree height" (61 Fed. Reg. 26256, May 24, 1996). The critical habitat designation for marbled murrelet was subsequently revised (76 Fed. Reg. 61599, October 5, 2011), reducing the area of critical habitat designated in southern Oregon and California, but making no changes to critical habitat in Washington.

Marbled murrelets occur in low numbers at many nearshore sites near the San Juan Islands, the Strait of Juan de Fuca, Whidbey and Camano Islands, the Skagit and Snohomish River deltas, northern portions of Hood Canal, and near or north of the Nisqually River delta in south Puget Sound (Nysewander et al. 2005). Major gaps in the at-sea distribution of marbled murrelets during the breeding season in Washington occur near metropolitan areas from Seattle to Olympia (McShane et al. 2004), probably because of the distance to suitable nesting habitat.

Most seabird species nest colonially, and many populations are limited by availability of food in the nesting season (Birkhead and Furness 1985; Croxall and Rothery 1991; Cairns 1992). Factors limiting marbled murrelet populations may be different from other seabirds because murrelets do not nest in colonies, although they do appear to respond to oceanographic conditions that tend to aggregate prey (Becker and Beissinger 2003). Their distribution during the breeding season appears to be constrained by the distance from sea to suitable nest sites in forest stands (Carter and Sealy 1990). In the non-breeding season, many murrelets disperse away from breeding areas (McShane et al. 2004; Piatt et al. 2007).

Marbled murrelet numbers increase in fall and winter in marine waters in the project area, suggesting that some murrelets migrate into Puget Sound after breeding elsewhere (Nysewander et al. 2005).

Marbled murrelets spend most of their lives in marine waters where they feed primarily on small fish and invertebrates in nearshore environments. The diet of marbled murrelets varies geographically; most available information is from Alaska, British Columbia, and central California (summarized by Burkett 1995; summarized by McShane et al. 2004), and no studies were published that document prey choice in the project area. Primary prey species range-wide include Pacific sand lance, Pacific herring, surf and night smelt, capelin, northern anchovy, gadids (especially walleye pollock), and crustaceans (mysids, euphausiids). No information on predation on salmon and steelhead in marine environments has been published, but Cederholm et al. (2000) note that marbled murrelets have a recurrent relationship with salmon and steelhead, and Carter and Sealy (1986) note predation on juvenile salmon in freshwater lakes, primarily in British Columbia and Alaska. That study and others reviewed by McShane et al. (2004) indicate that freshwater prey are not a significant component of the diet overall, and feeding on freshwater prey likely occurs in areas where large coastal lakes with substantial fish populations are in close proximity to nesting habitats. Although Cederholm et al. (2000) state that marbled murrelets have a recurrent relationship with salmon and steelhead in general, available information does not indicate that marbled murrelets have a relationship with salmon and steelhead in the project area, and likely do not benefit from Puget Sound hatchery-origin salmon and steelhead releases.

3.5.3.2 Non-listed Species—Birds

A variety of fish-eating birds forage on various life stages of salmon and steelhead in the project area (Table 3.5-3). Some species (such as the double-crested cormorant) are year-round residents in the project area, while others (such as the common goldeneye) occur primarily during migration and winter months. Most bird species are protected under the Migratory Bird Treaty Act. Fish-eating birds prey on juvenile and adult salmon and steelhead (as well as their carcasses) in both freshwater and marine habitats, including locations where the fish congregate, such as at hatchery release sites, tailraces of dams, and estuaries.

Trends in abundance for many fish-eating bird species are estimated through several long-term monitoring efforts, including the Puget Sound Assessment and Monitoring Program (PSAMP) (Nysewander et al. 2005) and the U.S. Geological Survey (USGS) Breeding Bird Survey for Washington (Sauer et al. 2011). These trends are summarized for species present in the project area in Table 3.5-3.

1 Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead.

Bird Species[1]	Bird Species Listing Status[2]	Bird Species Distribution and Habitat Associations within the Project Area[3]	Salmon and Steelhead Life Stage Used by Birds[4]	Bird Species Abundance		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]	Other Abundance Trend Information
Bald eagle	F: Protected under Bald and Golden Eagle Protection Act S: Threatened	Common year-round resident. Densest breeding population in San Juan Islands. Majority of wintering population occurs along major salmon rivers (e.g., Skagit, Nooksack) and along Puget Sound shorelines.	Juveniles, subadults, adults Spawning adults, carcasses	Increasing	No information	Increasing (Stinson et al. 2007)
Osprey	F: None S: Monitor	Fairly common summer resident at large lakes, rivers, bays, and estuaries throughout Puget Sound.	Juveniles, subadults, adults	Increasing	No information	Increasing since the 1970s (Poole et al. 2002).
Harlequin duck	F: None S: None	Fairly common winter resident of coastal waters with rocky substrates; uncommon summer resident on rivers in low- to mid-elevations of Olympic and Cascade mountains.	Drift eggs, alevin	No information	Increasing	Variable (WDFW 2012)
Common merganser	F: None S: None	Common, year-round, resident. Mostly on rivers (also uses large lakes) during breeding season; large lakes, rivers, and coastal waters during wintering period.	Drift eggs, alevin, juveniles	No apparent trend	Increasing	

Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead, continued.

Bird Species[1]	Bird Species Listing Status[2]	Bird Species Distribution and Habitat Associations within the Project Area[3]	Salmon and Steelhead Life Stage Used by Birds[4]	Bird Species Abundance		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]	Other Abundance Trend Information
Caspian tern	F: None S: Monitor	Uncommon in Puget Sound. Migrates along coast, stopping to forage, during spring and fall. Some spend summer in Puget Sound. Former nesting colonies on Dungeness Spit and on an unnamed island in Padilla Bay. Likely nesting attempts in Seattle Elliott Bay area.	Juveniles	No apparent trend	No information	Increasing in Washington (Shuford and Craig 2002)
Great blue heron	S: Monitor	Common, year-round resident of shorelines and shallow waters of lakes, rivers, bays, and wetlands throughout Puget Sound.	Juveniles	No apparent trend	No information	No apparent trend (Puget Sound Action Team 2007)
Common goldeneye	F: None S: None	Common winter resident in fresh and marine water; rare in summer, mainly at sewage ponds.	Drift eggs, alevin, juveniles	No apparent trend	Declining	Declining (WDFW 2012)
Barrow’s goldeneye	F: None S: None	Common, but local, winter resident in bays, also occurs in lakes. Fairly common summer resident at mid-elevation lakes in Cascade Mountains.	Drift eggs, alevin, juveniles	No apparent trend	Declining	Declining (WDFW 2012)
Red-breasted merganser	F: None S: None	Common winter resident in inland marine waters of Puget Sound.	Drift eggs, alevin, juveniles	No information	Increasing	

Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead, continued.

Bird Species[1]	Bird Species Listing Status[2]	Bird Species Distribution and Habitat Associations within the Project Area[3]	Salmon and Steelhead Life Stage Used by Birds[4]	Bird Species Abundance		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]	Other Abundance Trend Information
Resident gulls (year-round) Glaucous-winged gull	F: None S: None	Common year-round resident on coastal waters; some inland foraging (i.e., agricultural fields and lakes). Large nesting colony on Protection Island.	Drift eggs, alevin, juveniles, adult carcasses	No apparent trend	No information	Unclear trend; PSAT (2007) reported declining trend at traditional nesting sites
Ringed-billed gull	F: None S: None	In summer, abundant as non-breeders; common during spring and fall migration period; locally uncommon to variably common in winter. Usually common along Skagit River. Occurs in developed areas, fields, wetlands, coastal habitats, and estuaries.	Juveniles, adult carcasses	No apparent trend	No information	Increasing non-breeding in summer and winter (Wahl et al. 2005)
Migrant Gulls California gull	F: None S: None	Common in summer as non-breeders and in fall; uncommon in winter. Habitats include coastal and off-shore marine areas, agricultural fields.	Juveniles, adult carcasses	No apparent trend	No information	No apparent trend (Wahl et al. 2005)
Bonaparte's gull	F: None S: None	Common spring and fall migrant. Habitats include coastal marine and freshwater areas.	Drift eggs, juveniles, adult carcasses	No information	No information	Overall decline in wintering birds (Wahl et al. 2005)
Heerman's gull	F: None S: None	Uncommon summer and fall visitor in north Puget Sound, Strait of Georgia. Forages in tidal convergence areas.	Juveniles	No information	No information	No information

Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead, continued.

Bird Species[1]	Bird Species Listing Status[2]	Bird Species Distribution and Habitat Associations within the Project Area[3]	Salmon and Steelhead Life Stage Used by Birds[4]	Bird Species Abundance		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]	Other Abundance Trend Information
Herring gull	F: None S: None	Common migrant and winter visitor. Habitats include offshore and nearshore marine waters, lakes, and rivers.	Juveniles, adult carcasses	No information	No information	No apparent trend (Wahl et al. 2005)
Thayer's gull	F: None S: None	Common migrant and winter visitor. Habitats include offshore and nearshore marine waters.	Juveniles	No information	No information	
Double-crested cormorant	F: None S: None	Common year-round in coastal areas and inland marine waters; also in fresh water.	Juveniles	No apparent trend	Declining	Increasing since early 1980s (PSAT 2007)
Brandt's cormorant	F: None S: Candidate	Common as non-breeders in summer in marine waters of the San Juan Islands and northern Puget Sound. Fairly common to locally common winter resident in northern Puget Sound; uncommon in southern Puget Sound.	Juveniles	No information	No information	No apparent trend (Wahl et al. 2005)
Pelagic cormorant	F: None S: None	Common year-round resident in marine waters. More abundant in northern Puget Sound than in southern Puget Sound. Large colony at Protection Island.	Juveniles	No apparent trend	No information	Slight increase since early 1980s (PSAT 2007)

Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead, continued.

Bird Species[1]	Bird Species Listing Status[2]	Bird Species Distribution and Habitat Associations within the Project Area[3]	Salmon and Steelhead Life Stage Used by Birds[4]	Bird Species Abundance		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]	Other Abundance Trend Information
Common loon	F: None S: Sensitive	Common migrant and winter resident in coastal areas and lakes in Puget Sound. Rare in region during the nesting season; nesting areas are in large lakes and reservoirs.	Juveniles	No apparent trend	Declining	Stable (WDFW 2012)
Red-throated loon	F: None S: None	Common migrant and winter resident in protected marine waters; rare in lowland lakes.	Juveniles	No information	Declining	Declining (WDFW 2012)
Pacific loon	F: None S: None	Common winter resident in relatively deep, inland marine waters (e.g., Deception Pass, Rosario Straight).	Juveniles	No information	Declining	No apparent trend (WDFW 2012)
Western grebe, Clark's grebe	F: None S:Candidate	Winter resident in marine waters; local winter resident on large lowland lakes (Lake Washington).	Juveniles	Declining	Declining	Significant decline (WDFW 2012)
Pied-billed grebe	F: None S: None	Common year-round resident in wetlands and shallow lakes; rarely in marine water.	Juveniles	No apparent trend	Declining	
Pigeon guillemot	F: None S: None	Abundant and widespread in breeding season; migrants increase population during winter.	Juveniles	No information	Declining	Unclear trends; Bower (2003) and WDFW (2012) report declining trend.

Table 3.5-3 Bird species that have a strong or recurrent relationship with salmon and steelhead, continued.

Bird Species[1]	**Bird Species Listing Status[2]**	**Bird Species Distribution and Habitat Associations within the Project Area[3]**	**Salmon and Steelhead Life Stage Used by Birds[4]**	**Bird Species Abundance**		
				USGS Breeding Bird Survey, Washington 1980-2010[5]	**PSAMP Surveys in Puget Sound Marine Waters, 1994-2008[6]**	**Other Abundance Trend Information**
Common murre	F: None S: Candidate	Common resident along outer coast; locally common in summer in inland marine waters. Breeds on outer coast.	Juveniles	No information	No information	Fluctuating but possibly overall decline since 1980s (Wahl et al. 2005).
Rhinoceros auklet	F: None S: Candidate	Common summer resident in northern Puget Sound, but rare in southern Puget Sound. Large nesting population on Protection Island. Uncommon in winter.	Juveniles	No information	No information	30 percent decline since 1975 (PSAT 2007).
Belted kingfisher	F: None S: None	Fairly common year-round residents along freshwater and marine water shorelines.	Juveniles	No apparent trend	No information	
American/ northwestern crow	F: none S: none	Common year-round resident throughout project area.	Juveniles	No apparent trend	No information	
Common raven	F: none S: none	Common year-round resident throughout much of project area.	Juveniles, adult carcasses	Increasing	No information	

1 **Bold** species name indicates species with strong, consistent relationship with salmon and steelhead; non-bold species name indicates species with recurrent relationship, as determined by Cederholm et al. (2000).
2 Federal – F; State – S.
3 Sources: Opperman (2003); Seto et al. (2003); Bosakowski and Smith (2002); Speich and Wahl (1989); Smith et al. (1997); Baron and Acorn (1997); Wahl et al. (2005).
4 Source: Cederholm et al. (2000). Drift eggs, alevins, juveniles, spawning adults, and carcasses occur in freshwater habitats. Smolts, subadults, and adults occur in marine habitats.
5 Source: Sauer et al. (2011).
6 Source: Nysewander et al. (2005).

Salmon and steelhead are among many prey species that are eaten by birds according to their spatial and temporal availability. A few avian predators have a strong relationship with salmon and steelhead in the project area, defined by Cederholm et al. (2000) and described in Subsection 3.5.1, Introduction. In the project area, these species include the bald eagle, osprey, harlequin duck, common merganser, and Caspian tern (Table 3.5-3). A recurrent relationship (see Cederholm et al. 2000) (Subsection 3.5.1, Introduction) exists between many other avian predators (including marine birds, raptors, and wading birds) and salmon and steelhead.

Avian predators with a recurrent relationship with salmon and steelhead include osprey, great blue heron, loons, grebes, cormorants, gulls, waterfowl (most fish-eating ducks), most alcids (pigeon guillemot, rhinoceros auklet, common murre), and belted kingfisher. Some of these species (great blue heron, gull species, goldeneye species, cormorant species, common murre, rhinoceros auklet, and belted kingfisher) exploit local and temporal concentrations of juvenile salmon and steelhead. Some associations involve individuals or small numbers of birds (great blue heron, double-crested cormorant, and belted kingfisher) that forage near fish hatcheries in the project area when juvenile salmon are available. However, other prey species appear to dominate the diets of these avian predators in the breeding season and post-breeding, even during the periods when salmon and steelhead are available. Thus, the relationships of many avian predators in the project area with salmon and steelhead, although recurrent over time, are not strongly dependent.

Described below are the avian predators that have a strong relationship with salmon and steelhead followed by species that have a recurrent relationship with salmon and steelhead.

3.5.3.2.1 Bald Eagle

Bald eagles (protected under the Bald Eagle and Golden Eagle Protection Act) are common along marine and freshwater bodies at lower elevations in western Washington (Stinson et al. 2007) (Table 3.5-3). Resident bald eagles nest along marine shorelines, lakes, reservoirs, and rivers. In winter, bald eagle numbers increase three- or four-fold in western Washington as migrants from the north arrive to feed on salmon. The wintering distribution of bald eagles in Washington includes areas used by breeding residents, but includes more non-breeding bald eagles at salmon spawning streams and waterfowl wintering areas. The diet of bald eagles is diverse, in part because eagles can be active predators, scavengers, and may often steal prey from other predators. Stinson et al. (2007) reviewed food habit studies of bald eagles that nest along Puget Sound and its tributaries and stated that bald eagles preyed on fish, marine birds (including eggs and nestlings), waterfowl, and mammals, depending on availability.

Fish that were identified in these breeding season studies included flounder, ling cod, plainfin midshipman, dogfish shark, sculpin, rockfish species, walleye pollock, Pacific hake, and Pacific cod. Salmon and steelhead do not appear to form a significant part of nesting bald eagle diets in the project area and Cederholm et al. (2000) consider the strong relationship that bald eagles have with salmon and steelhead as confined to spawning salmon and their carcasses.

In contrast to breeding season diets in the project area, spawned salmon carcasses on riverbanks and bars are the most important food for wintering bald eagle populations (Stinson et al. 2007). The relatively mild winter climate and abundant fall salmon runs in western Washington attract eagles from northern Canada, Alaska, and Montana. The following review summarizes Stinson et al. (2007) and describes food habits of overwintering bald eagles in the project area.

Wintering eagles begin to arrive in western Washington in October and remain until March or early April. Salmon and steelhead are an important fall and winter food for bald eagles. Chum salmon are the most important because of their spawning time (winter) and concentration of carcasses. Chum salmon and pink salmon are the most abundant salmon species in the project area (Table 3.2-1). Chum salmon are distributed in streams throughout Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Subsection 3.2.10, Puget Sound/Strait of Georgia Chum Salmon ESU). Wintering bald eagles concentrate on and move between several Washington rivers in the project area to feed on chum salmon carcasses, including the Skagit, Snohomish, Stillaguamish, and Nooksack River systems, which traditionally had the largest runs, and also increasingly on the Green, Nisqually, and Puyallup Rivers.

Pink salmon do not seem to be a major food source for bald eagles, possibly because they are available in early fall before most overwintering bald eagles arrive. Chinook salmon, coho salmon, and steelhead are less abundant (Table 3.2-1) and their carcasses are more widely dispersed in tributaries and off-channel spawning sites; thus, they do not attract the concentrations of wintering eagles compared to chum salmon. However, coho salmon and steelhead may be important for some bald eagles in late winter and spring. Bald eagles do not appear to target salmon and steelhead as food sources when the eagles are nesting.

3.5.3.2.2 Osprey

In Washington State, osprey are listed as a state monitor species, which is not a listed species or a species of concern, but a species whose status and distribution are monitored by WDFW (Table 3.5-3). The species is managed by WDFW, as needed, to prevent the species from becoming listed as endangered, threatened, or sensitive.

Osprey are present in the project area during their breeding season where they nest near freshwater and marine habitats with suitable foraging areas. Osprey consume almost exclusively live surface-schooling or benthic fish that occur in shallows within a few feet of the surface (Poole et al. 2002). Prey are selected based on abundance or availability (Vana-Miller 1987), and thus osprey would be expected to target easily-obtained prey in the vicinity of their nests.

Osprey are unusual among raptors for being almost exclusively fish-eating birds (i.e., fish compose more than 99 percent of their prey items) (Poole 1989; Poole et al. 2002). Osprey diets in marine or freshwater environments in the project area have not been documented in the literature, but studies elsewhere in the ranges of salmon and steelhead found that osprey primarily prey on a variety of fish species but, in some locations, can feed primarily on salmon (Lind 1976; Hughes 1983; Steeger et al. 1992). The species is generally opportunistic and will eat whatever fish species are most abundant and accessible – either in shallow or deep waters. Studies in North America have documented more than 80 different prey species of ospreys. However, two or three common species may dominate the diet of ospreys in a given area (Poole 1989; Poole et al. 2002).

An estuarine study in southeast Alaska identified starry flounder (95 percent of prey) as the chief prey item, and osprey foraging in Humboldt Bay, northern California, primarily consumed surf perch (63 percent of prey) (Poole et al. 2002). Prey species in freshwater habitats in northwestern states included a wide variety of fish species such as bullhead, suckers, squawfish, and relatively small proportions of salmon and trout, although salmon were not identified to species (Poole et al. 2002). In British Columbia, Steeger et al. (1992) identified kokanee (landlocked sockeye salmon) as important in the diets of osprey. Cederholm et al. (2000) consider osprey as having a strong relationship with juvenile and adult salmon and steelhead.

3.5.3.2.3 Harlequin Duck

The harlequin duck is an uncommon migratory species that breeds in fast-flowing mountain streams where the majority of prey consist of aquatic insects, although alevins (newly hatched salmon and steelhead whose yolk sacs are still attached), and salmon and steelhead eggs are also eaten (Robertson and Goudie 1999; Lewis and Kraege 2004) (Table 3.5-3). Their winter range includes inland marine waters and rocky coastal areas where their prey is primarily benthic invertebrates (Vermeer 1983; Gaines and Fitzner 1987). In late summer and early fall, once salmon spawn, harlequin ducks commonly feed at creek mouths where their diet includes alevins and salmon eggs (Rosenberg and Rothe 2007). Cederholm et al.

(2000) consider harlequin ducks as having a strong relationship with salmon and steelhead based on their consumption of salmon alevin and eggs at specific times of the year.

3.5.3.2.4 Common Merganser

Common mergansers are common year-round residents in rivers, lakes, and nearshore marine waters in the project area (Wahl et al. 2005) (Table 3.5-3). Cederholm et al. (2000) state that common mergansers have a strong relationship with salmon and steelhead, specifically related to their consumption of salmon and steelhead eggs and juveniles. The authors cite 17 studies throughout North America demonstrating this relationship. In streams near marine waters on Vancouver Island (located outside the project area), the density of common merganser broods in fresh water was found to be highly correlated with juvenile salmon and steelhead production, including production from hatcheries (Wood 1986; 1987); however, similar studies have not been conducted in the project area. In coastal habitats in British Columbia (marine and freshwater aquatic habitats), salmon and steelhead accounted for approximately 11 percent of prey items of common mergansers (Mallory and Metz 1999).

The diet of common mergansers can vary by location. Wood (1987) noted that common mergansers prey on stream-rearing juvenile coho salmon, and out-migrating salmon and steelhead fry in freshwater streams. Conflicting information exists about the consumption of salmon and steelhead by common mergansers in tidally influenced or estuarine waters (Wood 1987; Mallory and Metz 1999). In summary, salmon and steelhead juveniles and eggs are part of the diet of common mergansers, and may be an important component when the birds are young.

3.5.3.2.5 Caspian Tern

The Caspian tern is an uncommon species occurring in the project area only during the spring and summer months (Table 3.5-3). Several common tern nesting colonies have been identified, including a colony that existed on the Everett waterfront in the early 1990s, and was displaced by construction of the United States Navy base. Another colony used the site of the ASARCO plant on the shoreline of Tacoma’s Commencement Bay until the plant was relocated in 2002 (Collis et al. 2002). Foraging Caspian terns have been documented in other Puget Sound locations in the summer, but they have not been monitored (PSAT 2007). Nesting colonies have been reported on the Dungeness Spit and Bellingham Bay in recent years but appear to be no longer present, and a possible nesting colony in Elliott Bay, Seattle was apparently not successful.

Caspian terns eat almost exclusively fish, which they catch with shallow plunge dives (Seattle Audubon Society 2009). The species is opportunistic in its response to prey abundance and availability. The diet of terns in the colony that nested in Commencement Bay (the colony is no longer present) included juvenile Chinook salmon, coho salmon, and other marine fish (Thompson et al. 2002). Tagged salmon in the Caspian tern diet samples collected at this site originated in hatcheries in the central and southern areas of Puget Sound.

Another study of Caspian terns that nested on a barge in Commencement Bay (the colony is no longer present) also showed that the terns ate juvenile salmon (Collis et al. 2002). Thus, salmon may be an important source of prey to the small number of nesting Caspian terns that occur in the project area.

3.5.3.2.6 Other Birds

This subsection describes bird species that have a recurrent relationship (as described in Subsection 3.5.1, Introduction [Wildlife]) with salmon and steelhead in the project area. These species prey on salmon and steelhead when and where locally available, but they are not dependent on salmon and steelhead as their primary source of food. Generally, these bird species are common and widely distributed throughout the project area, although some species are state monitor, candidate, or sensitive species (Table 3.5-3).

Great Blue Heron. Great blue herons are year-round residents in marine and freshwater habitats in the project area (Table 3.5-3). The greatest numbers of great blue herons in the project area nest in north Puget Sound, especially in Drayton Harbor, Port Susan, Lummi, Portage, Samish, Padilla and Skagit Bays (Puget Sound Action Team 2007).

The prey species of great blue herons vary seasonally across the wide range of habitats used by the species, including eelgrass beds and estuaries. In shallow marine habitats (primarily associated with eelgrass beds), herons target gunnel species, sculpin species, shiner perch, stickleback, pipefish, starry flounder, and pollock (Eissinger 2007). Freshwater habitats (especially wetlands) provide amphibians, crayfish, and small fishes, including trout, chub, and shiners. Great blue herons may opportunistically exploit juvenile hatchery-origin salmon and steelhead when prey are abundant and available (e.g., when the fish are concentrated in smolt acclimation ponds) (ODFW 1992; Siegel and Fast 2006).

The available literature on avian predation on juvenile salmon indicates that great blue herons are important predators (Collis et al. 2002; Siegel and Fast 2006). However, those studies were performed in the Columbia River basin, and may not be entirely applicable to the project area. This is because, in the Columbia River basin, avian predation on salmon and steelhead has been heavily influenced by human actions (i.e., the unintentional creation of nesting sites on dredge spoil islands). These factors may be responsible for the high predation rates and the strong great blue heron and salmon associations reported in Collis et al. (2002) and Siegel and Fast (2006). No comparable studies have been conducted in the project area. Anecdotal information indicates that great blue herons frequent fish hatcheries (ODFW 1992) and feed on out-migrating salmon and steelhead smolts at river mouths (Knudsen et al.1990). Because great blue herons in the project area are limited to foraging in shallow water and prey on a very wide variety of species, they have a recurrent relationship to salmon and steelhead in the project area.

Waterfowl. Waterfowl species in the project area consume salmon eggs and juveniles (particularly fry) (Table 3.5-3). Barrow's goldeneye and common goldeneye are migrant waterfowl species that occur during winter months in nearshore inland waters and certain lakes and rivers in the project area (Lewis and Kraege 2004). Both species consume salmon and steelhead eggs and parr, along with a wide variety of invertebrate prey (Eadie et al. 1995; Eadie et al. 2000), but do not appear to be dependent on these resources.

Red-breasted mergansers overwinter in the project area, spending most of their time in nearshore marine waters. In coastal British Columbia, this species forages on sculpins, herring and eggs of herring, coho salmon, and chum salmon (Titman 1999). Red-breasted mergansers exploit, but are not dependent upon, salmon and steelhead in the project area, where readily available.

Gulls. Common gull species in the project area include species that are year-round residents (ring-billed gull, glaucous-winged gull) or migrants and winter residents (herring gull, Thayer's gull, Bonaparte's gull, Heermann's gull, California gull) (Wahl et al. 2005) (Table 3.5-3). Gull species feed opportunistically on a wide variety of invertebrates, small fish, small mammals, carrion, and bird eggs, reflecting prey availability near nesting colonies and winter habitats. Several species shift from inland breeding areas to marine habitats in the non-breeding season, and thus more marine prey (including salmon and steelhead smolts) are taken when gulls are present in the project area.

Prey may include salmon and steelhead eggs and adult carcasses, where available. Some species, such as the ring-billed gull and the herring gull, may also prey on salmon and steelhead fry and small juveniles in freshwater systems. However, available information does not suggest that salmon and steelhead are important components of the diet of any gull species in the project area (Winkler 1996; Burger and Gochfield 2002; Hayward and Verbeek 2008; Pollet et al. 2012).

Cormorants. Double-crested cormorants and pelagic cormorants are widespread residents in marine habitats in the project area, and double-crested cormorants are also common in freshwater systems in western Washington (Wahl et al. 2005). Brandt's cormorant is most abundant in winter in northern Puget Sound (Table 3.5-3). Most data on prey species have been obtained in nesting colonies, and there are few studies of cormorant food habits in the project area (Wallace and Wallace 1998; Hatch and Weseloh 1999).

All cormorant species feed primarily on fish species, many of which are slow-moving or schooling species. In areas where all three cormorant species occur (such as in northern Puget Sound), pelagic cormorants tend to forage on rocky substrates, Brandt's cormorants forage above rocky substrates and over sand substrates, and double-crested cormorants forage over flat substrates such as sand and mud (Ainley et al. 1981). Diet studies of cormorant species in marine waters from California to British Columbia found that schooling rockfish, cottids, Pacific herring, surfperch species, and other forage fish were the important components of the cormorant prey base (Robertson 1974; Ainley et al. 1981). Available information does not suggest that salmon and steelhead are important components of the diet of any cormorant species that occurs in the project area (Hobson 1997; Wallace and Wallace 1998; Hatch and Weseloh 1999).

Loons and Grebes. Loon species (common loon, Pacific loon, and red-throated loon) and grebe species (western grebe, Clark's grebe, red-necked grebe, pied-billed grebe) are primarily winter visitors to the project area, although a few pairs of common loons breed in lakes (Table 3.5-3). Pied-billed grebes are year-round residents in lakes and shallow protected marine waters in the project area (Wahl et al. 2005).

Little is known about loon food habits in the project area, but Richardson et al. (2000) found Pacific staghorn sculpin, big skate, tidepool sculpin, flounder, and sole in common loon stomachs in marine waters of Skagit County. Available information does not suggest that loon species are dependent on salmon and steelhead in the project area.

Grebes consume a wide variety of prey including fish, mollusks, polychaete worms, crustaceans, aquatic and terrestrial insects, leeches, and amphibians (Muller and Storer 1999; Stout and Nuechterlein 1999; Stedman 2000). Available information does not suggest that grebe species are dependent on salmon and steelhead in the project area.

Alcids. The rhinoceros auklet, common murre, and pigeon guillemot are the most abundant alcid species in the project area (Table 3.5-3). Nysewander et al. (2005) identified their foraging areas and Smith et al.

(1997) identified their nesting colonies. Pigeon guillemots occupy a number of breeding colonies throughout Puget Sound and forage widely in nearshore habitats. Common murres nest outside of Puget Sound but forage in deeper water habitats in the northern portion of Puget Sound (Warheit and Thompson 2004). Rhinoceros auklets nest on a few islands (Smith, Protection, and Destruction Islands) (Smith et al. 1997), but forage in northern Puget Sound, as well as the Strait of Juan de Fuca in the summer. Common murres and pigeon guillemots remain in inland waters in smaller numbers in winter, and most rhinoceros auklets overwinter on the Pacific coast.

Alcids are diving birds that forage opportunistically on a variety of benthic fish, forage fish, and invertebrates. Pigeon guillemots forage on a diverse diet of epibenthic fish, including Pacific sandfish, capelin, cods, sculpins, gunnels, pricklebacks, and flatfish (Ewins 1993). Invertebrates (including crabs, shrimps, polychaetes, gastropods, and bivalve mollusks) are particularly important foods in winter months. Common murres and rhinoceros auklets consume benthic and midwater fish species, including Pacific herring, Pacific sandlance, stickleback, smelt species, and salmon and steelhead species (which account for 22 percent of common murre diets and 10 percent of rhinoceros auklet diets) in summer months in the project area (Lance and Thompson 2005) (Table 3.5-3).

Large numbers of common murres migrate in late summer from the Oregon coast into the Straits of Juan de Fuca and Georgia, where they feed on Pacific herring (Vermeer et al. 1987). In winter, small cephalopods and euphausiids are the predominant prey (Ewins 1993). Available information on the diets of these alcid species throughout their ranges and in the project area indicates that they exploit salmon and steelhead where available, but are not dependent upon these fish.

Belted Kingfisher. Belted kingfishers are widespread in the project area along sheltered marine shorelines and in freshwater locations. Most available dietary studies were conducted in eastern North America where the species consumes a variety of small fishes and crustaceans apparently in proportion to prey abundance and availability in shallow water (Prose 1985; Kelly et al. 2009). Kingfishers are known to frequent fish hatcheries (ODFW 1992), but data on consumption of hatchery-origin fish in the project area are not available. Kingfishers also forage on marine shorelines and in estuaries where out-migrating juvenile salmon and steelhead would be available as prey; however, available information does not suggest that kingfishers are dependent on salmon and steelhead in the project area (Table 3.5-3).

Crows and Ravens. Crows and ravens are widespread species in the project area, although ravens are less common in developed areas (Wahl et al. 2005). Both species feed opportunistically on a wide variety of marine and terrestrial organisms including salmon and steelhead fry and juveniles, and adult carcasses in freshwater systems (Cederholm et al. 2000) (Table 3.5-3). Crows were reported as important predators of trout at fish hatcheries in Pennsylvania (Parkhurst et al. 1992), but do not appear to be as important at hatcheries in the project area. Predation on salmon and steelhead by crows and ravens appears to be occasional and highly localized. Crows and ravens do not appear to be dependent on salmon and steelhead in the project area.

3.5.3.3 Non-listed Species—Marine Mammals

In addition to listed killer whale described in Subsection 3.5.3.1, ESA-listed Species, three non-listed marine mammal species, Steller sea lion, California sea lion, and harbor seal, forage on salmon and steelhead and are common in the project area (Table 3.5-4). Cederholm et al. (2000) state that Steller sea lions, California sea lions, and harbor seals have a recurrent relationship with salmon and steelhead. All marine mammal species in the project area are protected under the MMPA.

Other marine mammal species that do not consume salmon and steelhead as a primary food source and are rare in the project area include the gray whale, minke whale, northern elephant seal, and sea otter (Osborne et al. 1988; Osmek et al. 1998; Reeves et al. 2002). These marine mammals are not reviewed because these species would not be affected by any of the alternatives. Although Dall’s porpoise and harbor porpoise occur regularly in Puget Sound, the Strait of Juan de Fuca, and the Georgia Basin, their primary prey species are forage fish such as Pacific herring, squid, walleye, pollock, Pacific whiting, juvenile blackbelly eelpout, and eulachon smelt (Osmek et al. 1996; Osmek et al. 1998; Walker et al. 1998; Bowen and Siniff 1999; Reeves et al. 2002; Baird 2003). Cederholm et al. (2000) do not consider Dall’s porpoise or harbor porpoise to have strong or recurrent relationships with salmon and steelhead; therefore, these two species are also not discussed further in this EIS.

Marine mammal distribution, including Steller sea lion, California sea lion, and harbor seal, depends on availability of food resources, which in turn, depend on seasonal coastal upwellings, physical characteristics of foraging habitats (National Centers for Coastal Ocean Science 2008), other oceanographic conditions including El Niño and La Niña events, and long-term decadal oscillation events. These events affect Steller sea lion, California sea lion, and harbor seal survival, reproduction, and distribution through changes in the distribution and abundance of prey species.

Table 3.5-4. Status, distribution, habitat associations, and trends for marine mammals that prey on salmon and steelhead and have a recurrent relationship in the project area.

Mammal Species	Mammal Species Listing Status[1]	Mammal Species Distribution and Habitat Associations within the Project Area[2]	Salmon and Steelhead Life Stage Used by Mammal Species in Washington[3]	Trends in Mammal Species Abundance[4]
Steller sea lion, eastern distinct populationg segment (DPS)	F: Delisted S: Threatened	Haulouts on the outer coast and Strait of Juan de Fuca near project area. Haulouts are located throughout Puget Sound. Marine deep-water and nearshore habitats	Juvenile, adult	Eastern Pacific stock is stable or increasing
California sea lion	F: MMPA protected S: None	Nearshore and deeper water inland marine waters provide foraging habitat. Haulouts on manmade structures, rocks, and shoals.	Juvenile, adult	Stable
Harbor seal	F: MMPA protected S: Monitor	Nearshore and deeper water inland marine waters provide foraging habitat. Haulouts on manmade structures, rocks, and shoals	Juvenile, adult	Apparently stable

[1] Federal – F; State – S.
[2] Sources: Osborne et al. (1988); Calambokidis and Baird (1994); Osmek et al. (1998); Jeffries et al. (2000); S. Jeffries, pers. comm., WDFW, Marine Mammal Specialist, December 14, 2006; J. Laake, pers. comm., National Marine Mammal Laboratory, Marine Mammal Specialist, December 19, 2006; NMFS marine mammal stock assessment reports (Carretta et al. 2012); NMFS (2008a).
[3] Definitions from Cederholm et al. (2000). Marine habitat includes areas with smolts, subadults, or adults.
[4] Source: Allen and Angliss (2013) for Steller sea lion, Carretta et al. (2012) for California sea lion, and Jeffries (2013) for harbor seal.

In addition to natural-origin fish, hatchery-origin salmon and steelhead benefit Steller sea lions, California sea lions, and harbor seals as sources of prey. Marine mammal distribution is known to change in response to salmon and steelhead abundance and distribution. Similar to other species that forage on salmon and steelhead, foraging by Steller sea lions, California sea lions, and harbor seals is opportunistic, especially where fish congregate, such as in estuaries and at specific locations like the Ballard Locks in Seattle. Tribal fisheries managers have observed that Steller sea lions, harbor seals, and California sea lions respond to concentrations of migrating salmon and steelhead in the project area, although what the seals and sea lions actually eat is less well documented as described below in Subsection 3.5.3.3.1, Steller Sea Lion, Subsection 3.5.3.3.2, California Sea Lion, and Subsection 3.5.3.3.3, Harbor Seal.

3.5.3.3.1 Steller Sea Lion

The Steller sea lion consists of the western and eastern Pacific stocks: an eastern United States stock that consists of animals east of Cape Suckling, Alaska, and a western United States stock that consists of animals at and west of Cape Suckling. The western stock of Steller sea lions does not occur farther south than northeast Alaska, and is listed under the ESA as endangered. The eastern stock of Steller sea lions is no longer listed under the ESA as threatened (Table 3.5-4). Both stocks are protected under the MMPA. On November 4, 2013, NMFS issued a final rule to remove the eastern DPS of Steller sea lions from the List of Endangered and Threatened Wildlife (78 Fed. Reg. 66140, November 4, 2013). Based on extrapolations from pup counts, the stock is estimated to be within the range of 58,334 and 72,223 animals (Allen and Angliss 2013). Identified threats to Steller sea lions are not associated with hatcheries or hatchery production (NMFS 2014), but do include boat/ship strikes, contaminants/pollutants, habitat degradation, illegal hunting/shooting, offshore oil and gas exploration, and interactions (direct and indirect) with fisheries.

The eastern stock of Steller sea lions is resident year-round in Washington coastal waters. Abundance varies seasonally with peak counts of 1,000 animals present during the fall and winter months at haulouts (Jeffries et al. 2000). In terms of distribution, there are no known rookeries in Washington State, but the eastern stock of Steller sea lions is present along the outer coast of Washington at four major haulouts year round (NMFS 2008b). These animals are most likely immature or non-breeding adults from rookeries in other areas (NMFS 2008b), which include the southern coastline of Vancouver Island. The eastern stock of Steller sea lions has multiple haulouts in Puget Sound, including islands in the Puget Sound, Hood Canal, and at some Puget Sound docks, shoals, and deltas (NMFS 2014).

Abundance of the eastern stock of Steller sea lions at northern California, Oregon, Washington, and British Columbia rookeries and non-breeding haulouts show a gradual increase since 1976 (Pitcher et al. 2007; Olesiuk 2008; COSEWIC 2012).

The diet of eastern Steller sea lions is not well documented, but studies of prey remains in the lower Columbia River, the coast of Vancouver Island, and coastal sites in Washington describe opportunistic foraging behavior for a variety of prey species, including Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, salmon, steelhead, octopus, and lamprey (COSEWIC

2003; NMFS 2008b; Jeffries 2011). Steller sea lion scats collected along Vancouver Island and the Washington coast include all species of salmon and steelhead, with proportions varying by site and season. Most salmon remains in sea lion scat samples are adult-sized fish.

The proportion of salmon in the diet of eastern Steller sea lions on the west coast of Vancouver Island varies from about 7 to 16 percent, with the fall diet having the most salmon (Jeffries 2011; Pearson and Jeffries 2012). For these studies, coho salmon composed the largest proportion (about 28 percent) of DNA samples of salmon bones in sea lion scat samples, followed by pink salmon, Chinook salmon, and chum salmon. Chinook salmon composed about 18 percent of the salmon samples that could be identified genetically. These studies provide inferences regarding Steller sea lion feeding on salmon and steelhead in the project area.

There is no direct evidence in the literature suggesting that sea lions are strongly dependent on salmon or steelhead, but sea lions may opportunistically exploit particular species or populations of fish based on their availability. For example, Steller sea lions prey on white sturgeon, adult Chinook salmon, and Pacific lamprey in the tailrace of the Bonneville Dam on the Columbia River (Stansell et al. 2012) where migrating fish are concentrated and likely more easily preyed upon than in a natural setting. Using information from the Steller sea lion scat studies near Vancouver Island (Jeffries 2011; Pearson and Jeffries 2012), the authors concluded that the species is expected to include salmon as part of its diet depending on availability, detectability, and ease of capture. Thus, the proportion of salmon and steelhead (including specific species) in the diet of Steller sea lions within the project area is likely to vary by study location and season. Cederholm et al. (2000) states that the Steller sea lion has a recurrent relationship with salmon and steelhead (Table 3.5-4).

3.5.3.3.2 California Sea Lion

California sea lions range along the Pacific coast from central Mexico to British Columbia. Their primary breeding range is from the Channel Islands in southern California to central Mexico. The majority of females remain in waters of California and Baja California year-round and few are observed in the project area (Reeves et al. 2002; Maniscalco et al. 2004). Numbers in Washington coastal and inland harbor areas have been stable since 1990 (Jeffries et al. 2003), although recent surveys are not available. An estimated 3,000 to 5,000 California sea lions migrate to Washington and British Columbia waters during the non-breeding season from early September to late May (Jeffries et al. 2000). Peak numbers of up to 1,100 individuals occur in Puget Sound during this period, most of which are males (NMFS 1997).

Movements between Puget Sound and interior waters of British Columbia between November and April are common (Scordino 2010).

California sea lion haulouts include jetties; offshore rocks and islands; and log booms, docks, and navigation buoys (Table 3.5-4). Concentrations of sea lions regularly occur at Port Gardner near Everett, Elliott Bay in Seattle, Bangor Naval Base on Hood Canal (Navy 2010), and at Gertrude Island, Woodard Bay, and Nisqually River delta in south Puget Sound (Jeffries et al. 2000). Individuals haul out on buoys at a number of other locations in the project area. Relatively few California sea lions haul out at sites in the vicinity of the San Juan Islands.

California sea lions have received wide attention since the 1990s because of their predation on Chinook salmon in the vicinity of the Bonneville Dam tailrace on the Columbia River (NMFS 1997; Stansell et al. 2012). However, observations of California sea lions in the project area suggest that these opportunistic predators consume a much wider range of fish and squid species, consistent with the local and seasonal availability of different prey species, and with Cederholm et al. (2000) who state that California sea lions have a recurrent relationship with salmon and steelhead. WDFW surveyed predation by a small number of California sea lions in the lower Duwamish Waterway and found they took adult salmon and steelhead, as well as unidentified juvenile salmon and steelhead (reviewed by Scordino 2010). WDFW observations and those of gillnet fishers suggest that sea lions also forage on coho salmon and chum salmon in the lower Snohomish River (NMFS 1997; Scordino 2010).

California sea lions are attracted to winter-run steelhead at the mouth of the Cedar River in Lake Washington and at the Ballard Locks in Seattle, and out-migrating juvenile salmon and steelhead, and adult coho salmon and sockeye salmon at the Ballard Locks (NMFS 1997). They also frequent the mouth of the Nisqually River when adult Chinook salmon and chum salmon are returning (August to September and December to January, respectively) (C. Smith, pers. comm., Nisqually Tribe, Fisheries Management Biologist, January 5, 2009), and the mouth of the Duwamish Waterway when adult coho salmon and steelhead are returning (NMFS 1997). However, data from dietary studies at two California sea lion haulouts in Puget Sound (Port Gardner and Shilshole Bay) suggest non-salmon and steelhead species (i.e., Pacific whiting and Pacific herring) are the most frequent prey (Everitt et al. 1981; NMFS 1997). The presence of sea lions at Port Gardner is likely a response (in part) to large numbers of Pacific whiting spawners in waters off nearby Port Susan (NMFS 1997). Salmon and steelhead occur in about 6 percent of the California sea lion scat samples from the Port Gardner haulout and in 25 percent of the scat samples from the Shilshole Bay site. Thus, salmon and steelhead are a component of California sea lion diets in the project area depending on location and seasonal availability of various species, but non-salmon and steelhead may compose a larger portion of the sea lion diet overall. In summary, available information does not suggest that California sea lions are dependent on salmon and steelhead in the project area.

3.5.3.3.3 Harbor Seal

Harbor seals are the most abundant, widely distributed marine mammal in the project area. They are non-migratory, with local movements associated with food availability, reproduction, tides, currents, and weather (Zamon 2001). Harbor seals occur year-round at haulouts throughout Puget Sound, Georgia Basin, and the Strait of Juan de Fuca (Jeffries et al. 2000), and produce pups at a number of sites in the San Juan Islands, eastern bays of Puget Sound, southern Puget Sound, and Hood Canal.

Harbor seal populations in Washington recovered from low levels in the 1960s following removal of the harbor seal bounty program and passage of the Marine Mammal Protection Act. Harbor seals in Washington's inland waters have stabilized since the early 1990s at about 14,000 individuals (Carretta et al. 2012) (Table 3.5-4). Approximately 1,200 harbor seals occur at five primary haulouts in southern Puget Sound. Haulouts in the Everett area range from 100 to 300 individuals, and approximately 4,000 to 7,000 harbor seals occur on over 150 rocky and estuarine haulouts in the San Juan Islands (Scordino 2010).

Anecdotal information from tribal fisheries managers indicates that harbor seal presence is linked to salmon and steelhead. Increases in seal presence in the Skagit River coincide with commercial fisheries (R. Bernard, pers. comm., Upper Skagit Tribe, Fisheries Management Biologist, January 5, 2009), where seal predation is observed by tribal fishers as far upriver as RM 20. Predation of hatchery-origin and natural-origin Chinook salmon, and natural-origin coho salmon has been reported by these tribal fishers. Harbor seal predation on coho salmon is also observed by tribal fishers in Dungeness Bay (S. Chitwood, pers. comm., Jamestown S'Klallam Tribe, Fisheries Manager, January 5, 2009), and seals are typically present in the Snohomish River when adult steelhead, coho salmon, and chum salmon return (NMFS 1997). In the lower Nisqually River, harbor seals are present during Chinook salmon returns (August to September) and chum salmon returns (December to January) (C. Smith, pers. comm., Nisqually Tribe, Fisheries Management Biologist, January 5, 2009).

The diet of harbor seals in the project area varies with season and the local availability of a wide range of mostly pelagic and demersal fish species. Studies of prey remains in scat samples from haulouts indicate that harbor seal prey choice reflects the prey communities that are available in different foraging habitats, including rocky shores, soft-bottomed estuaries, sandy substrates, and open waters (Olesiuk 1993; Lance and Jeffries 2007, 2009; Luxa 2008). Lance et al. (2012) identified the major groups of harbor seal prey in northern Puget Sound as herring (year round), juvenile walleye pollock, sand lance, anchovy (winter/spring), and adult salmon (late July to September). Cederholm et al. (2000) state that California sea lions have a recurrent relationship with salmon and steelhead.

Predation on seasonally available salmon and steelhead has been documented in most of the studies of harbor seal diets in Washington inland marine waters, but there are differences in proportions of salmon and steelhead in scat samples in different areas. Adult salmon and steelhead are important in harbor seal diets in Hood Canal in the fall (late July to September) (as much as 26 percent frequency of occurrence in scat samples), and in the San Juan Islands during summer/fall (late July to September) (44 to 65 percent in scat samples). However, they are not an important component of harbor seal diets in south Puget Sound (Lance and Jeffries 2009). In contrast to adult salmon and steelhead, juvenile salmon are identified in smaller numbers of prey remains in south Puget Sound and the San Juan Islands, but are not an important component of the harbor seal diet in Hood Canal.

When runs of pink salmon are present (only in odd-numbered years), this species has the highest frequency of occurrence in scat samples; in other years, fall chum salmon and sockeye salmon are the species most frequently identified in scat samples (Lance and Jeffries 2007, 2009). London (2006) found that harbor seals in Hood Canal consume as much as 8 percent of the average escapement of chum salmon over a 5-year period.

Other studies indicate the importance of non-salmon and steelhead fish species as prey for harbor seals. Diet composition of seals using two Puget Sound estuaries (Padilla Bay and Drayton Harbor) during pre-pupping and pupping seasons (May to September) consist primarily of non-salmon and steelhead species that occupy a variety of nearshore habitats close to the pupping sites (Luxa 2008). Year-round harbor seal diet studies in the Strait of Georgia, north of the San Juan Islands, show that non-salmon and steelhead fish compose the vast majority of prey biomass, with salmon and steelhead representing 1 to 9 percent of prey biomass (Olesiuk 1993). Capture of adult salmon and steelhead by harbor seals is episodic and appears to be related to the timing of adult returns and tidal currents (Zamon 2001).

Thus, salmon and steelhead can form an important component of harbor seal diets, with variations that reflect seasonal and local availability of different species close to harbor seal haulouts and pupping sites in the project area, but other fish species may compose a larger proportion of their diet overall based on season and location.

3.5.3.4 Other Non-listed Aquatic and Terrestrial Wildlife

In addition to the listed species and other birds and marine mammals discussed in the subsections above, other wildlife species interact with hatchery-origin fish (Table 3.5-5). Some of these animals (e.g., river otter, mink, amphibians), are predators of hatchery-origin fish while others are prey (e.g., invertebrates). As described for listed species, avian predators, and marine mammals, hatcheries may benefit salmon and steelhead predators by providing a source of prey, particularly where hatchery-origin fish congregate outside of the hatchery facilities (e.g., release sites, weirs or dams, and estuaries) (Table 3.5-5); however, their preference for hatchery-origin salmon is unknown. At hatchery facilities, predation on hatchery-origin fish is expected to be generally low because of implementation of predation control measures (Subsection 3.5.2.2, Hatchery Predator Control Programs and Weirs).

Table 3.5-5. Status and habitat associations of other wildlife with strong or recurrent relationships with hatchery-origin salmon.

Species[1]	Wildlife Listing Status[1]	Wildlife Habitat[2]			Relationship of Wildlife Species to Salmon and Steelhead[3]			
		Freshwater	Estuarine/ Marine	Riparian	Predator	Competitor	Prey	Scavenger
River otter	F: None S: None	√	√		√			
Mink	F: None S: None	√	√		√			√
Amphibians[2]	N/A	√		√	√	√	√	
Freshwater and marine/estuarine invertebrates (e.g., insects, mollusks)[3]	N/A	√	√	√			√	√

[1] **Bold** species name indicates species with strong, consistent relationship with salmon and steelhead; non-bold species name indicates species with recurrent relationship, as determined by Cederholm et al. (2000).
[2] Relationships vary by species. See Cederholm et al. (2000).
[3] Cited by Cederholm et al. (2000) as providing a significant role in energy pathways of aquatic ecosystems.

3.5.3.4.1 River Otter and Mink

River otter are top predators of a wide variety of aquatic food chains, ranging from marine environments to mountain lakes. They are year-round residents of rivers and estuaries in the project area (Ingles 1965;

Chapman and Feldhamer 1982). Otter diets vary seasonally, but are heavily dependent on a wide variety of fish species, including salmon and steelhead (Chapman and Feldhamer 1982; Melquist 1997). River otters have a strong relationship with juvenile salmon, spawning salmon, and salmon carcasses (Chapman and Feldhamer 1982; Cederholm et al. 2000) (Table 3.5-4), and often frequent fish hatcheries to prey on hatchery-origin fish as described in Subsection 3.5.2.2, Hatchery Predator Control Programs and Weirs.

River otters' primary prey species in marine environments include schooling pelagic fishes that are seasonally abundant (Larsen 1984; Ben-David et al. 1997; Blundell et al. 2002) from spring through summer, after which foraging shifts to intertidal and demersal fishes. Spawning pink salmon and chum salmon and their carcasses are present in the diets of river otters in coastal southeastern Alaska (Larsen 1984). River otters in streams consume slower-moving fishes, including members of the families Catostomidae and Cyprindae, but also consume juvenile salmon, steelhead, and trout (Melquist 1997; Crait and Ben-David 2006).

Otter are more dependent on aquatic habitats and fish species other than salmon and steelhead as prey than are mink (Melquist 1997), although there is considerable dietary overlap between the two species in some areas (Ben-David et al. 1996). Mink are not as well adapted to foraging below the intertidal zone, and focus their efforts on prey within shallower tidal slopes, tide pools, and eelgrass beds exposed by the receding tide. Mink in freshwater and coastal environments also feed on terrestrial mammals and birds (Wise et al. 1981), and are considered more generalist predators with a recurrent relationship with salmon and steelhead by feeding on juvenile and spawning salmon and steelhead and their carcasses (Cederholm et al. 2000) (Table 3.5-4). Although population estimates for the river otter and mink are unknown for western Washington, both species are considered abundant game species and trapping is allowed during the winter and fall months in western Washington.

3.5.3.4.2 Amphibians and Reptiles

Listed amphibians (such as Van Dyke salamander and Oregon spotted frog) and reptiles (such as the western pond turtle) have not been cited as having a relationship with salmon and steelhead (Cederholm et al. 2000). However, Cederholm et al. (2000) identifies two non-listed salamander species (Pacific giant salamander and Copes' giant salamander) as having recurrent relationships with salmon and steelhead in fresh water.

The Pacific giant salamander is a common predator in its larval stage in Pacific Northwest headwaters and mid-sized streams in western Washington and Oregon, and consumes invertebrates, larval amphibians, and small fish, which may include salmon and steelhead fry (Cederholm et al. 2000). Within the project area, its occurrence is primarily west of the Cascade Mountains. The species does not occur within the Olympic Peninsula (Washington Natural Heritage Program 2013). Its abundance in Washington State is unknown, although its status is considered widespread, abundant, and secure (Hallock and McAllister 2009a).

Cope's giant salamander, a species that spends its entire life in small steep-gradient streams in the Olympic Peninsula and southwestern Washington, may also prey on salmon and steelhead. Cope’s giant salamanders were found in small streams with juvenile coho and steelhead, but their relationship with salmon and steelhead is unknown (Roni 2002). Its abundance in Washington State is unknown, although its status is generally considered widespread, abundant, and secure in its primary habitats (Hallock and McAllister 2009b).

The importance of salmon and steelhead to Pacific and Cope's giant salamanders is not well known (predator, prey, or competitor), nor is the extent of geographic overlap of hatchery-origin juvenile salmon and steelhead and giant salamanders in Northwest streams.

3.5.3.5 Freshwater, Estuarine, and Marine Invertebrates

Non-listed aquatic and terrestrial invertebrates, especially insects, are the most important prey of salmon juveniles (Table 3.5-5). Cederholm et al. (2000) do not indicate the strength of relationships between invertebrate species to salmon and steelhead, but do state that these invertebrates provide a significant role in energy pathways of aquatic ecosystems. Upon emergence from stream gravels, all species of salmon and steelhead fry actively feed on dipterans (fly species), stonefly and mayfly nymphs, and/or cladocerans (small crustaceans) (Healy 1991) (Subsection 3.2.1, Introduction [Fish]). Terrestrial invertebrates that feed on riparian vegetation along streams and estuaries, such as homopterans (leafhoppers), aphids, and other insects, can fall into streams and become prey for juvenile salmon and steelhead. In turn, aquatic insects (such as caddisflies, stoneflies, and midges) feed on salmon and steelhead carcasses (Cederholm et al. 2000). In addition to salmon and steelhead, other fish species (such as trout and sticklebacks) and amphibians compete for freshwater invertebrate prey. The abundance and distribution of freshwater, estuarine, and marine invertebrates is substantial and widespread throughout the project area.

Spawning by salmon and steelhead disturbs bottom substrates and can increase benthic macroinvertebrate communities by opening niche space (habitat) for blackflies, stonefly nymphs, and midge larvae, all of which are food sources for juvenile salmon and steelhead. Salmon and steelhead carcasses provide direct and indirect benefits to aquatic invertebrates as sources of food and nutrients to streams.

Marine and estuarine invertebrates in the project area are consumed by juvenile salmon and steelhead depending on each species' life history and habitat use. Estuarine habitat plays an important role in feeding and growth of juvenile salmon and steelhead. For example, subyearling Chinook salmon leave fresh water relatively soon after emergence, rear in Puget Sound estuaries before migrating to sea (Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon), and prey on chironomid larvae and other aquatic insects and marine invertebrates (e.g., mysids, gammarid amphipods, isopods, and copepods), along with other fish species (Bottom et al. 2005). In addition to salmon and steelhead, many other fish species (including starry flounder and forage fishes) compete for marine and estuarine invertebrate prey.

3.6 Water Quality and Quantity

This subsection describes potential risks to water quality and quantity associated with operation of hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens) in the analysis area (Subsection 4.6.1, Analysis Area [Water Quality and Quantity]). The affected environment is discussed in terms of 1) the water quality parameters that are affected by hatchery operations, 2) applicable water quality regulations for hatchery facilities, and 3) how hatchery operations affect surface and groundwater near hatchery facilities. Unless otherwise noted, the water quality and quantity issues addressed in the following subsections are considered representative of all hatchery facilities in Puget Sound and are not specific to a particular hatchery facility.

3.6.1 Water Quality

3.6.1.1 Water Quality Parameters

Hatchery effluent (water from streams that is used for hatchery operations and returned to streams) and some hatchery practices (distribution of salmon and steelhead carcasses into streams) have the potential to affect the health and productivity of receiving waters. Hatcheries may affect several water quality parameters when effluent is returned to the aquatic system. Water quality parameters that can be altered by effluent include temperature, ammonia, organic nitrogen, total phosphorus, biochemical oxygen demand (BOD), pH, and solids levels (Sparrow 1981; Ecology 1989; Kendra 1991; Cripps 1995; Bergheim and Åsgård 1996; Michael 2003). Chemicals within hatchery facility effluents that are used to support hatchery production include antibiotics (a therapeutic), fungicides, and disinfectants (Boxall et al.

2004; Pouliquen et al. 2009; Martinez-Bueno et al. 2009). Other chemicals and organisms that could potentially be released in effluent include polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT) and its metabolites (Missildine et al. 2005; HSRG 2009), pathogens (Mobrand et al. 2005; HSRG 2009), steroid hormones (Kolodziej et al. 2004), anesthetics, pesticides, herbicides, and feed additives.

Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities, describes the water quality parameters that may be affected by hatchery operations, how these parameters are transported into the aquatic system, and their potential effects on receiving waters. The water quality parameters are affected through hatchery effluent and from other hatchery-related activities, including decomposition of hatchery-origin salmon and steelhead carcasses that are deliberately placed in streams to enhance marine-derived nutrient levels, and decomposition of carcasses from hatchery-origin salmon and steelhead that spawn naturally. Discharges from hatchery facilities are regulated under the Clean Water Act, as discussed later in this subsection, while water quality impacts associated with the distribution of carcasses from hatchery-origin fish and carcasses from hatchery-origin fish spawning naturally are not regulated.

In general, stream productivity and some water quality parameters (nitrogen and phosphorus [Larkin and Slaney 1997; Compton et al. 2006]) may be improved by decomposition of carcasses from spawned-out salmon and steelhead at hatchery facility sites (i.e., from hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin adults that spawn naturally in streams, and from hatchery-origin carcasses that are deliberately placed in streams. The direct placement of spawned-out carcasses in watersheds is, in part, a response to research demonstrating that carcasses from adult salmon and steelhead that died after spawning historically contributed marine-derived nutrients to the benefit of the overall productivity of both the aquatic (Subsection 3.2.3.7, Benefits - Marine-derived Nutrients [Fish]) and terrestrial ecosystems (Subsection 3.5.2.3, Nutrients from Salmon and Steelhead Carcasses [Wildlife]). However, water quality can also be degraded by carcass distribution in streams or stream reaches that are impaired by excess nutrients or by carcass distribution at times when water quality conditions are poor (Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies), as well as through the possible introduction of toxins and pathogens from salmon carcasses (Compton et al. 2006). Carcass placement follows the *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWIFC and WDFW 2006) and *Stream Habitat Restoration Guidelines* (Cramer 2012) to help protect the health of organisms in waters where carcasses are placed or that may feed on salmon carcasses.

3.6.1.2 Applicable Hatchery Facility Regulations and Compliance

Hatchery facilities must comply with all applicable Federal, state, and tribal water quality standards for effluent discharges and Federal and state regulations on use of chemicals and fish food. This subsection discusses the Federal, state, and tribal regulations applicable to water quality and describes how hatchery facilities in the analysis area comply with these regulations.

3.6.1.2.1 Federal and State Regulations and Implementing Agencies

Federal and state governments work together to implement the Clean Water Act, with each agency responsible for implementing different components of the regulations. Ecology has primary responsibility for the health and protection of the State's water quality, but it depends primarily on the Federal EPA to develop and promulgate proposed water quality standards. The direct discharge of hatchery facility effluent is regulated by the EPA under the Clean Water Act through National Pollutant Discharge Elimination System (NPDES) permits. Sources of discharge from hatchery facilities (including hatcheries, rearing ponds, and acclimation ponds) are the rearing portions of the facilities and the off-line settling basin. Primary pollutants of concern are the waste food and feces, with pollutant loading characterized by amount of total suspended solids (TSS) and settleable solids. For net pens, primary pollutants of concern are the waste food, feces, and carcasses, with pollutant loading characterized by deposition of solids.

As described in Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities, hatchery facilities meeting minimum operating thresholds must obtain NPDES permit coverage for their effluent discharges. Both the EPA and Ecology have issued general NPDES permits that cover many of these hatchery facilities within the analysis area. As of January 2013, there are 37 hatchery facilities within the analysis area operating under NPDES permits, either EPA's general permit, Ecology's general permit, or an individual permit. These 37 facilities include 29 state facilities, 7 tribal facilities, and 1 Federal facility. Two of these facilities are covered by individual permits: the South Sound Net Pens (the only net pen facility that meets the minimum thresholds for an NPDES permit) and the Puyallup Hatchery (for implementation of approved total maximum daily loads (TMDLs) for BOD, ammonia, and residual chlorine).

All hatchery facilities within the analysis area are currently in compliance with their NPDES permits; however, periodic violations of effluent limits do occur. For the 37 hatchery facilities operating under NPDES permits in the analysis area, queries of Ecology's Water Quality Permitting and Reporting

Information System and EPA's Permit Compliance System database identified 12 effluent limit exceedances between January 2011 and November 2012 (the latest reporting month available in January 2013) from 8 facilities: 10 exceedances for total suspended solids (TSS) from 3 state and 4 tribal facilities, 1 exceedance for settleable solids from a tribal facility, and 1 exceedance for total residual chlorine from a Federal facility. None of these facilities discharge directly into water body segments that are impaired for turbidity or dissolved oxygen; however, two facilities (Issaquah Hatchery and Tulalip Creek Ponds) discharge upstream of water body segments with dissolved oxygen impairments (Issaquah Creek and Tulalip Bay, respectively). No permit violations were reported for the two hatchery facilities operating under individual NPDES permits (South Sound Net Pens and Puyallup Hatchery). In addition, hatchery facility permit holders are also required to report water quality sampling results at specific time periods and to submit results in a specific report format. There was 1 instance of monitoring not being conducted as required, and 20 instances of late submittal or non-submittal of the required report.

For hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens) that do not meet the minimum operating threshold for NPDES permit coverage and are not designated by the EPA or Ecology as a significant contributor of pollution, monitoring of effluent is not required, although these facilities are required to comply with state water quality and groundwater standards. Consequently, the potential for these hatchery facilities to contribute to receiving water impairment by exceeding water quality criteria is unknown but is considered minimal because effluent releases are below the NPDES threshold.

Additionally, any hatchery facility (e.g., hatchery, rearing pond, acclimation pond, or net pen) covered by an individual NPDES permit that has not been renewed in the previous 5 years may have discharge limits that do not address current water quality conditions or treatment technologies, possibly resulting in higher loads being discharged to receiving waters than would be allowed under a new individual permit. Only one hatchery net pen in the analysis area is not operating under a current NPDES permit (the South Sound Net Pens' NPDES permit expired in 2007, but it was extended until a renewed permit is issued).

Impacts from hatchery facilities to groundwater quality are also regulated under Ecology's Upland Fin-fish Hatching and Rearing NPDES General Permit. The provisions of this general permit do not allow violation of the State's groundwater standards (Chapter 173-200 WAC). Currently, no hatchery facilities in the analysis area operate under individual NPDES permits for groundwater discharge. All effluent limit violations reported between January 2011 and November 2012 were for hatchery facilities that discharge to surface water bodies.

The type and quantity of salmon and steelhead carcasses that could be placed in the environment are under the control of WDFW, which establishes guidelines for carcass distribution independent of hatchery program funding and management (Appendix B, Hatchery Effects and Evaluation Methods for Fish). WDFW has a program aimed at placing salmon carcasses in selected streams to increase marine-derived nutrients and is based on historical levels of salmon and steelhead escapement (WDFW 2004). Program guidelines include steps for minimizing the potential for violating water quality standards for nutrients as a result of carcass distribution. These include avoiding streams or stream reaches with identified water quality constraints for nutrients, obtaining approval from Ecology for placement in stream reaches that are impaired by excess nutrients, not depositing carcasses during poor water quality conditions, placing carcasses in terrestrial riparian zones, and monitoring (Cramer 2012). In addition and as described above, providing salmon and steelhead carcasses for placement follows the *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWIFC and WDFW 2006), which governs carcass placement to protect the health of organisms in waters where carcasses are placed or that may feed on salmon carcasses. Also, as discussed in Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, most of the contaminants in the bodies of returning salmon and steelhead are likely acquired during their time at sea; thus, the potential for pollutants from hatchery-origin fish carcasses to impact water quality would be similar to that from natural-origin fish (outside of the potential for resident Chinook salmon, which compose 4 percent of all Chinook salmon in Puget Sound, to carry an increased amount of contaminants).

3.6.1.2.2 Tribal Water Quality Standards

Twelve Puget Sound treaty tribes manage hatchery facilities located within the analysis area: the Lower Elwha Klallam Tribe, Lummi Nation, Muckleshoot Indian Tribe, Nisqually Indian Tribe, Port Gamble S'Klallam Tribe, Puyallup Tribe of Indians, Skokomish Tribal Nation, Squaxin Island Tribe, Stillaguamish Tribe of Indians, Suquamish Tribe, Tulalip Tribes, and Upper Skagit Indian Tribe. Of these, the Lummi, Puyallup, and Port Gamble S'Klallam Tribes are responsible for certifying NPDES-permitted projects located on tribal lands and have EPA-approved water quality standards. The Tulalip Tribe is also responsible for certifying NPDES-permitted projects located on its tribal lands, but does not currently have EPA-approved water quality standards.

The Tribal Fish Health Manual (NWIFC 2006), which includes *The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWIFC and WDFW 2006), provides guidance to tribal hatchery staff for producing healthy, quality fish and reducing the discharge of pollutants (solids, drugs, and chemicals) in tribal hatchery effluent. As noted above, four tribal hatchery facilities have reported effluent limit exceedances between January 2011 and November 2012. These include seven TSS exceedances and one settleable solids exceedance.

3.6.2 Water Quantity

By their very nature and function, hatchery facilities use large quantities of water. This requirement often influences hatchery facility site selection in terms of quality of the resource (particularly the temperature and dissolved oxygen) and availability and hydrology of the source. Subsection 3.6.1, Water Quality, and Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities, describe the types of water uses (consumptive and non-consumptive) required by hatchery facility operations. Hatchery facility use of water is both consumptive and non-consumptive, depending on the manner in which the water is withdrawn and returned to the environment, and whether water is stored over time in the hatchery facility (such as a pond) where evaporative losses could occur. Diversion of water from an adjacent stream to flow through the hatchery facility or pond system, and then return to the source at some location downstream of the diversion point, is considered a consumptive use. This consumptive use requires a water right, because some portion of the stream (the bypass reach) is dewatered (has less water between the point of diversion and discharge return to the river). In comparison, a non-consumptive use is when there is no diversion from the water source or diminishment of the source.

Water use by hatchery facilities consists of filling and maintaining ponds and raceways or flow-through systems, or by diversions. As mentioned above, ponds and settling basins require storage of water over time with the subsequent losses of water to evaporation or infiltration. Streams, lakes, and groundwater could also be affected through the construction, operation, and maintenance of diversion structures (weirs, intake pipes, and wells) that would remove or divert water into hatcheries or rearing ponds.

Diversion of water from streams for hatchery use, as well as in-water structures such as weirs, could alter stream flow between the points of withdrawal and discharge when they are not at the same location. Withdrawal of groundwater for hatchery facility use can also alter stream flow, especially during late summer months when stream flow is more dependent on groundwater draining into streambeds (Ecology 2010a). Flow alteration, either between intake and outflow locations, from diversion to discharge locations, or from withdrawal of groundwater, could affect both water quantity and quality, thereby potentially affecting aquatic species. The volume of water in a flow-altered stream segment could be reduced, resulting in the potential for larger changes in temperature (because of shallower water and slower flow) and reduced ability to dilute pollutants introduced from discharged effluent.

Three hatcheries (Dungeness Hatchery, Quilcene National Fish Hatchery, and White River Hatchery) in the analysis area are located along stream segments identified as being impaired for instream flow

(Ecology 2010b). The Dungeness and White River Hatcheries use both surface and groundwater for operations, while Quilcene National Fish Hatchery uses surface water. The Big Quilcene River, which provides most of the water for Quilcene National Fish Hatchery is also impaired for temperature. Eight other hatchery facilities in the analysis area are located along temperature-impaired stream segments (Ecology 2010b); however, it is not known whether temperature in these segments is affected by reduced stream flows because of surface or groundwater withdrawals from the hatchery facilities, or other water users within or upstream of the segments.

Washington State (through Ecology) is responsible for managing the State's water resources to meet current needs and ensure future water availability for people, fish, and the natural environment. To protect stream flows, the State can adopt instream flows, which are flows determined to be sufficient to sustain both the natural environment and community water supplies (Ecology 2014). These instream flows specify the amount of water needed in a particular place for a defined time, and they typically follow seasonal variations. Because instream flows do not affect existing water rights, adopting an instream flow does not ensure that the specified amount of water will actually be present in a stream. Consequently, all legal water uses within a watershed, including withdrawals for hatchery operations, can contribute to low stream flows without violations of water use law. However, Ecology may require a hatchery facility to pump its effluent back to the point of intake or diversion to maintain a minimum instream flow in the facility's bypass reach during periods of low flow.

Water resource inventory areas are delineated by Ecology for the purposes of instream flow management and compliance and are authorized under RCW 90.54. Within the analysis area, instream flows are established for all but one (Skokomish-Dosewallips) of the 18 water resource inventory areas (Ecology 2013a). Of these 18 water resource inventory areas, 8 are identified by Ecology as fish-critical because low stream flows in these areas are limiting factors for salmon and/or steelhead (Ecology 2013b). The eight fish-critical water resource inventory areas are Nooksack, Snohomish, Cedar-Sammamish, Duwamish-Green, Puyallup-White, Chambers-Clover, Quilcene-Snow, and Elwha-Dungeness. Ecology focuses its water law and instream flow compliance efforts in these and other fish-critical watersheds (Ecology 2013b).

In the past 2 years, Ecology has not recorded water use violations by hatchery facilities in the analysis area, nor have complaints or other issues been received by Ecology's regional compliance staff regarding water use. Additionally, there have been no instream flow violations by hatcheries in the past 2 years (D. Davidson, pers. comm., Ecology, Water Rights Impairment Lead Engineer, January 23, 2013).

3.7 Human Health

This subsection describes potential risks to human health from hatchery facility operations. Discussions in this subsection address common chemicals used in hatchery facilities and safe handling of those chemicals, potentially toxic contaminants in hatchery-origin fish, and potential disease vectors and contaminants transmitted from handling hatchery-origin fish. The human health issues addressed in the following subsections are considered representative of all hatchery facilities in Puget Sound and are not specific to a particular hatchery facility.

3.7.1 Hatchery Chemical Use and Handling

Hatchery operations routinely use a variety of chemicals to maintain a clean environment for the production of disease-free fish. These chemicals include disinfectants, therapeutics, anesthetics, pesticides and herbicides (Table 3.7-1), and feed additives. Appendix K, Chemicals Used in Hatchery Operations, provides a more detailed description of each of these types of chemicals.

Table 3.7-1. Properties of chemicals commonly used at hatchery facilities.

Chemical	Hazard Rank[1]	LD50 (mg/kg)[2]	Skin or Lung Irritant	Carcinogenic Rating [3]
DISINFECTANTS				
Chloramine-T	1	935_{rat}	Corrosive to skin and respiratory irritant	N/A -- N/A[4]
Formalin	2	100_{rat}	Skin and respiratory irritant	1 -- B1
Hydrogen Peroxide	1	$>2{,}000_{mouse}$	Mildly irritating to skin or lungs	3 -- N/A
Iodophor	0	$10{,}000_{rabbit}$	Skin irritant	N/A -- N/A
Quaternary Ammonia (hyamine)	2	350_{rat}	Skin and respiratory irritant	N/A -- N/A
Chlorine (sodium hypochlorite)	0	$5{,}800_{mouse}$	Skin and respiratory irritant	3 -- N/A
THERAPEUTICS				
Amoxicillin	N/A	N/A	Skin irritant	N/A -- N/A
Erythromycin	0	$9{,}272_{rat}$	Mild skin, eye, and respiratory irritant	N/A -- N/A
Florfenicol	1	800_{rat}	Mild skin, eye, and respiratory irritant	N/A -- N/A
Oxytetracycline (terramycin)	0	$7{,}200_{mouse}$	Mild skin, eye, and respiratory irritant	N/A -- N/A
Penicillin	N/A	N/A	Skin irritant	N/A -- N/A
Potassium Permanganate	1	750_{rat}	Skin, eye, and respiratory irritant	N/A -- N/A
ROMET®	1	665_{rat}	Skin, eye, and respiratory irritant	N/A -- N/A

Table 3.7-1. Properties of chemicals commonly used at hatchery facilities, continued.

Chemical	Hazard Rank[1]	LD50 (mg/kg)[2]	Skin or Lung Irritant	Carcinogenic Rating [3]
Sulfamethoxazole Trimethoprim	0	5,513$_{mouse}$	Skin irritant	N/A -- N/A
ANESTHETICS				
Benzocaine	N/A	N/A	NA	N/A -- N/A
Tricaine Methanesulfonate (MS-222)	N/A	N/A	Skin, eye, and respiratory irritant	N/A -- N/A
PESTICIDES and HERBICIDES				
2,4-Dichlorophenoxyacetic Acid	2	275$_{rat}$	Skin, eye, and respiratory irritant	2B -- N/A
2-Butoxyethyl 2,4-Dichlorophenoxy Acetate	1	831$_{rat}$	Skin, eye, and respiratory irritant	2B -- N/A
Chelated Copper	N/A	N/A	Skin, eye, and respiratory irritant	N/A -- N/A
Dichlobenil	1	2,126$_{mouse}$	Mild skin and respiratory irritant	N/A -- N/A
Diquat	2	130$_{rat}$	Skin, eye, and respiratory irritant	N/A -- N/A
Endothall	3	>38$_{rat}$	Skin, eye, and respiratory irritant	N/A -- N/A
Fluridone	0	>10,000$_{rat}$	Mild skin and respiratory irritant	N/A -- N/A
Glyphosate	1	1,568$_{mouse}$	Skin, eye, and respiratory irritant	N/A -- D
Rotenone	2	60$_{rat}$	Skin, eye, and respiratory irritant	N/A -- N/A
MISCELLANEOUS				
Alcohol Anhydrous (ethyl alcohol)	1	3,450$_{mouse}$	Skin, eye, and respiratory irritant	N/A -- N/A
Lime (calcium hypochlorite)	1	850$_{rat}$	Skin, eye, and respiratory irritant	3 -- N/A
Salt (sodium chloride)	1	3,000$_{rat}$	Mild eye irritant	N/A -- N/A
Sodium Thiosulfate	N/A	N/A	Skin, eye, and respiratory irritant	N/A -- N/A

Source: Information in this table was compiled from the Hazardous Substance DataBank (HSDB 2014) and supplemented by EPA (2014), Eka Chemicals (2011), PHARMAQ AS (2006), Spectrum Chemicals and Laboratory Products (2013), and Western Chemical, Inc. (2010).

[1] Hazard ranking based on oral toxicity (LD50) as follows: 0-Non-hazardous (LD50>5000), 1-Practically non-hazardous (LD50=500-5000), 2-Slightly hazardous (LD50=50-500), 3-Moderately hazardous (LD50=5-50), and 4-Highly hazardous (LD50=<5) (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection [GESAMP] 1997).

[2] LD50 means median lethal dose, a concentration that results in mortality of 50 percent of the animals tested after exposure to one oral dose. Typically reported for mammalian species.

[3] Potential for exposure to result in the development of cancer based on 1) International Agency for Research on Cancer (IARC) (1-Carcinogenic to humans, 2A-Probably carcinogenic to humans, 2B-Possibly carcinogenic to humans, 3-Unclassifiable (insufficient information), 4-Probably not carcinogenic to humans) or 2) EPA's Integrated Risk Information System (IRIS) (Group A - Human carcinogen, Group B - Probable human carcinogen, B1 - Indicates limited human evidence, B2 - Indicates sufficient evidence in animals and inadequate or no evidence in humans, Group C - Possible human carcinogen, Group D - Not classifiable as to human carcinogenicity, Group E - Evidence of non-carcinogenicity for humans).

[4] N/A means data not available to assess hazard ranking or carcinogenic potential.

3.7.1.1 Safe Handling of Hatchery Chemicals

The production of hatchery chemicals for the protection of public health and the environment is governed by the U.S. EPA (through the Federal Insecticide, Fungicide, and Rodenticide Act) and Food and Drug Administration (through the Federal Food, Drug, and Cosmetic Act).

Hatchery facilities typically follow Occupational Safety and Health Administration regulations and institute chemical control programs to protect their employees. Employers must train employees on the potential hazards (e.g., chemical or physical) that are present at hatchery sites. Typically, hazard communication programs are implemented to train employees to recognize hazards, to use protective measures (e.g., personal protective equipment), and to perform proper actions during an emergency. Medical surveillance may be necessary if overexposure to chemicals becomes apparent. Chemical safety and handling are also addressed by maintaining: 1) a general reduced chemical use policy, 2) current chemical information, 3) first aid training and materials, 4) symptom awareness training, and 5) proper procedures for chemical storage and disposal. Specific Federal and state programs and rules have been developed for worker safety or use of chemicals to protect hatchery facility workers from exposure to chemicals at potentially hazardous concentrations. Therefore, chemicals described above and in Table 3.7-1 are not considered hazardous to human health when safety precautions and state programs and rules are followed. Potential unsafe exposure to humans would be from accidental spills or environmental releases that are greater than that allowed under current Federal and state occupational safety regulations.

Chemicals used in hatcheries are typically disposed of according to label requirements or discharged as effluents to receiving waters according to established water quality guidelines developed through Federal and state programs and rules. Therapeutics (antibiotics) can be discharged to receiving waters through fish waste products, and water quality regulations currently do not exist for all veterinary products. However, therapeutics are typically applied infrequently and at low doses (GESAMP 1997). Concentrations that have been reported in receiving waters near fish farms and hatcheries in other parts of the United States and in Europe are usually well below those toxic to fish and invertebrates (Boxall et al. 2004). With limited use of therapeutics in the United States and application of therapeutics in compliance with manufacturers' directions, hatcheries pose minimal risk to human health and the environment (GESAMP 1997; MacMillan et al. 2006), although locally high concentrations could occur depending on a disease outbreak and the nature of the receiving environment.

3.7.2 Toxic Contaminants in Hatchery-origin Fish

Seafood consumption by humans is generally promoted because of the nutritional value of fish products. For example, fish contain elevated levels of omega-3 fatty acids, which are considered beneficial to the cardiovascular system (Mayo Clinic 2014). However, concerns have been raised that farm-raised and hatchery-origin fish may contain toxic contaminants (WHO 1999; Jacobs et al. 2002a; Jacobs et al. 2002b; Easton et al. 2002; Hites et al. 2004) that pose a health risk to consumers (Box 3-3). Sources of such contaminants in fish include chemicals or therapeutics, contamination of the nutritional supplements or feeds, and/or contamination of the environment where the fish are reared or released from sources unrelated to hatchery operations (Jacobs et al. 2002a; Jacobs et al. 2002b; Easton et al. 2002; Hites et al. 2004; Carlson and Hites 2005; Johnson et al. 2007; Maule et al. 2007; Kelly et al. 2008; Johnson et al. 2010). The contaminants of primary concern are those that are persistent in the environment and are known to accumulate in the tissues of fish (e.g., methylmercury, dioxins, DDTs, or PCBs) (Jacobs et al. 2002a; Jacobs et al. 2002b; Easton et al. 2002; Hites et al. 2004; Johnson et al. 2007; Maule et al. 2007; Kelly et al. 2008; Johnson et al. 2010). Appendix K, Chemicals Used in Hatchery Operations, summarizes studies that have evaluated contaminants in both hatchery-origin and natural-origin fish.

Box 3-3. What is the difference between hatchery-origin and farm-raised salmon and steelhead?

Commercial aquaculture produces farm-raised salmon and steelhead that spend their entire lives in captivity compared to hatchery-origin salmon and steelhead, which are reared in hatchery facilities as juveniles (generally for periods less than 1 year) and then released into the natural environment where they spend the remainder of their lives. When in captivity, both hatchery-origin and farm-raised salmon are fed artificial food products (e.g., pellets) of concentrated fish byproducts that may contain high levels of chemical toxins; however, hatchery-origin fish are exposed to these chemicals for a shorter time than are farm-raised fish.

Contaminants in hatchery-origin fish are not necessarily acquired from hatchery facilities and their operation, but may also be acquired from the natural environment. Migrating and rearing hatchery-origin (and natural-origin) salmon and steelhead encounter and accumulate contaminants in the rivers, estuaries, and oceans that they inhabit (Missildine et al. 2005; Johnson et al. 2007) (Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens [Wildlife]). Johnson et al. (2010) suggested that the greatest accumulation of contaminants in the bodies of hatchery-origin juvenile salmon that feed and rear in urban areas occurs after the fish are released from hatcheries and not during hatchery rearing. In contrast, for juvenile hatchery-origin fish that are released into relatively uncontaminated rural areas, hatchery feed can be a primary source of contaminants. Contaminants accumulated during hatchery rearing would probably contribute very little to concentrations of contaminants in returning adult salmon and steelhead, because concentrations acquired only during the relatively short juvenile rearing period would be diluted as the fish grow larger to adulthood.

Studies suggest that, for returning adult salmon, most of the contaminants present in their bodies are acquired during their time at sea (Kelly et al. 2007; Cullon et al. 2009; O'Neill and West 2009). An exception would be natural-origin and hatchery-origin resident Chinook salmon (about 4 percent of Chinook salmon hatchery releases) that remain in Puget Sound. These resident Chinook salmon carry a heavier load of contaminants than ocean-going salmon and steelhead that spend less time in Puget Sound marine waters and more time at sea (Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens [Wildlife]). No information is available that demonstrates individual hatchery-origin fish have a higher contaminant load than individual natural-origin fish of a similar marine life history; thus, it is assumed that hatchery-origin salmon and steelhead do not present a greater threat of contamination than natural-origin salmon and steelhead.

Overall, the potential for human exposure to contaminants in fish is directly associated with the frequency of consuming fish (EPA 1999). Current information indicates that some groups of people (often termed consumers) eat greater quantities of fish than the general population (EPA 1999; ODEQ 2008; Ecology 2013). Thus, consumers would likely have greater exposure to contaminants than the general population. As noted above, the contribution of contaminants from individual hatchery-origin fish would be expected to be similar to the contribution from individual natural-origin fish.

3.7.3 Relevant Disease Vectors and Transmission

A number of pathogens (parasites, viruses, and bacteria) are potentially harmful to human health and can be transmitted to people from fish or fish carcasses (Leira and Baalsrud 1997; Durborow 1999; Lehane and Rawlin 2000). Many of these pathogens are transmitted primarily through consumption (i.e., improperly cooked or under-cooked fish). However, exposure to these pathogens may also occur through skin contact with infected fish or accidental needle-stick injuries during vaccination of infected fish (Leira and Baalsrud 1997; Durborow 1999; Lehane and Rawlin 2000).

Some common bacteria and virus species transmittable to humans through contact with infected fish (Durborow 1999) are:

- Mycobacterium marinum
- Streptococcus iniae
- Vibrio species
- Aeromonas species
- Erysipelothirx rhusiopathiae
- Cryptosporidium

The transmission of fish-borne pathogens to humans is rare and can be controlled with proper safety measures (i.e., wearing protective clothing when handling fish and thoroughly cooking fish). In addition, FDA regulations (21 CFR 123) require processors of fish and fishery products to develop and implement Hazard Analysis Critical Control Point systems for their operations to limit the potential for exposure and spread of pathogens and contaminants. In hatchery operations, compliance with safety programs, applicable rules and regulations, and the use of personal protective equipment limits the spread of pathogens, minimizing the potential risk to human health. Potential unsafe exposure to humans involved in hatchery operations would be from accidental skin contact and needle-stick injuries involving infected fish.

Chapter 4

Environmental Consequences

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4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

This chapter reviews the environmental consequences of the four alternatives evaluated in this EIS that are described in Chapter 2, Alternatives. The affected environment for the six resources that are evaluated under the alternatives (fish, socioeconomics, environmental justice, wildlife, water quality and quantity, and human health) are described in Chapter 3, Affected Environment. This chapter describes methods used for the analysis of environmental effects, and describes direct and indirect effects associated with each alternative. This chapter also describes the general approach to identification and analysis of measures to mitigate environmental effects described for the alternatives evaluated in this EIS, including adaptive management. A table summarizing environmental effects for each resource and alternative is presented at the end of this chapter. Cumulative effects are described in Chapter 5, Cumulative Effects. Each resource subsection in Chapter 3, Affected Environment, has a corresponding effects subsection in this chapter. The sequence of subsections in this chapter is:

- Introduction (Subsection 4.1)
- Fish (Subsection 4.2)
- Socioeconomics (Subsection 4.3)
- Environmental Justice (Subsection 4.4)
- Wildlife (Subsection 4.5)
- Water Quality and Quantity (Subsection 4.6)
- Human Health (Subsection 4.7)
- Summary of Resource Effects (Subsection 4.8)

4.1.1 Mitigation Measures and Adaptive Management

Council on Environmental Quality regulations (40 CFR 1508.20), which are the implementing regulations for the National Environmental Policy Act (NEPA), define mitigation to include:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

In compliance with CEQ regulations, this EIS identifies mitigation to decrease potential negative impacts associated with the action alternatives. Mitigation that may affect resource risks or benefits is identified and analyzed in subsections of this chapter for each resource. Mitigation under the action alternatives is primarily addressed by limiting the degree or magnitude of the hatchery programs and their implementation, and/or reducing or eliminating the impact over time by preservation and maintenance operations during the life of the programs (i.e., via adaptive management measures). While the mitigation focus would result in direct mitigation on fish resources, a mitigation measure to address risks to one resource, such as fish, may affect other resources; mitigation measures that reduce risks may also reduce benefits to other resources. For example, a measure intended to reduce risks to fish by decreasing hatchery production (minimizing negative impacts to fish resources by reducing competitive and genetic interactions with natural-origin fish) may also reduce water quality and/or human health risks from chemicals used at hatcheries. However, this measure would likely lead to fewer returning hatchery-origin adults and would, therefore, decrease socioeconomic and environmental justice benefits gained from the hatchery program.

Best management practices (BMPs) are currently applied to hatchery operations. These BMPs are similar to, but not limited to, the guidelines outlined by the Hatchery Scientific Review Group (e.g., HSRG 2004). Mitigation measures proposed in this EIS include existing BMPs that are not currently in use at all hatchery operations to minimize fish resource impacts and improve maintenance and operational effectiveness. Examples of proposed mitigation measures associated with BMPs include alteration of juvenile release strategies, management of the proportion of hatchery-origin fish spawning naturally, and improvements to hatchery infrastructure, such as water intakes.

Adaptive management is the overarching and long-term approach that would be applied under the action alternatives as described in Subsection 2.2.4, Adaptive Management. Under adaptive management, specific mitigation measures would be implemented over time for individual hatchery programs to reduce risks to salmon and steelhead (e.g., develop program performance measures to reduce competition and predation risks, monitor hatchery-origin fish after release, and reduce proportions of hatchery-origin fish spawning naturally). Measures to reduce risks to fish, while also potentially reducing risks to other resources, may also affect benefits gained from the hatchery program.

The premise of adaptively managing hatchery programs is that the programs would evolve over time to reduce or eliminate impacts in response to new technical information and in the context of policy, management, and budgetary considerations. Adaptively managing the hatchery programs would, therefore, reduce or eliminate impacts over time by preservation and maintenance operations during the life of the action alternatives.

The primary objectives of incorporating adaptive management and associated mitigation would be to reduce deleterious impacts on natural-spawning fish, to more efficiently and effectively meet hatchery production objectives through changes in maintenance and operations, and to better meet specific harvest objectives. Examples of adaptive management mitigation measures include updating existing BMPs or applying new BMPs to reduce negative resource impacts and protect salmon and steelhead, and reducing the size of hatchery programs, potentially including termination, which may avoid negative impacts altogether.

Adaptive management mitigation measures would be implemented over time following detailed review of 1) proposed actions represented in hatchery and genetic management plans (HGMPs), and 2) harvest effects. As noted in Subsection 1.1, Introduction, and Subsection 2.2.1, Context for the Alternatives, additional review under NEPA and the ESA may be needed over time as new information, actions, or changes in baseline conditions warrant substantial changes in RMPs and/or HGMPs. For example, because many or all of the activities described in the HGMPs would require compliance with the ESA, substantial new information or project descriptions would likely require re-initiation of consultation for listed species under the ESA as provided in 50 CFR 402.16.

4.2 Fish

4.2.1 Introduction

The fish analyses address effects of salmon and steelhead hatchery programs on existing fish conditions described in Subsection 3.2, Fish, when combined with effects anticipated under each alternative. The analysis focuses on natural-origin fish populations that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food. This subsection describes effects on salmon, steelhead, and other fish species associated with the alternatives for the four risk categories and three benefit categories described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, as listed below:

- Risks
  - Competition
  - Predation
  - Genetics
  - Hatchery facilities and operation
- Benefits
  - Total return
  - Viability
  - Marine-derived nutrients

As discussed in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, harvest and its associated risks on salmon and steelhead are evaluated in detail in the *Puget Sound Chinook Harvest Resource Management Plan Final Environmental Impact Statement* (NMFS 2004a) and *Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation National Marine Fisheries Service (NMFS) Evaluation of the 2010-2014 Puget Sound Chinook Harvest Resource Management Plan under Limit 6 of the 4(d) Rule* (NMFS 2011b). The NMFS 2004 final EIS is herein incorporated by reference (Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish). However, the beneficial effects of harvest on people under each of the alternatives are reviewed in this EIS in Subsection 4.3, Socioeconomics.

The analysis of effects on fish resources under each alternative is organized in the following order: 1) listed salmon, steelhead, and trout; 2) non-listed salmon; and 3) other fish species with a relationship to salmon and steelhead (i.e., predators and prey of salmon and steelhead). The species and groups are:

- Listed salmon, steelhead, and trout
  - Chinook salmon
  - Hood Canal summer-run chum salmon
  - Steelhead
  - Bull trout
- Non-listed salmon
  - Coho salmon
  - Fall-run chum salmon
  - Odd- and even-year pink salmon
  - Sockeye salmon
- Other fish species
  - Rainbow trout
  - Coastal cutthroat trout
  - Sturgeon and lamprey
  - Forage fish
  - Groundfish
  - Resident freshwater fish

The specific focus of this EIS analysis is how the alternatives affect existing risks and benefits to listed salmon and steelhead, with emphasis on natural-origin Chinook salmon. Table 4.2-1 provides an overview of risks and benefits that are analyzed for each species group. Analyses of effects emphasize salmon, steelhead, and trout in Puget Sound that are listed as threatened under the ESA (Chinook salmon, summer-run chum salmon, steelhead, and bull trout). For salmon and steelhead, additional analyses include potential effects of the alternatives on natural-origin salmon and steelhead life history, distribution, and abundance, as well as potential changes in characteristics of hatchery-origin salmon.

Table 4.2-1. Overview of risks and benefits of hatchery programs evaluated by affected species group.

Effect	Listed Salmon, Steelhead, and Trout	Non-listed Salmon	Other Species with a Relationship to Salmon and Steelhead				
			Rainbow and Cutthroat Trout	Sturgeon and Lamprey	Forage Fish	Groundfish	Resident Freshwater Fish
Risk							
Competition	X	X	X	X	X	X	X
Predation	X	X	X	X	X	X	X
Genetics	X	X	X				X
Hatchery Facilities and Operation	X	X					
Benefit							
Total Return	X	X					
Viability	X	X	X				
Marine-derived Nutrients	X	X					

In addition to hatchery-related effects, decreases in the quality and extent of salmon and steelhead habitat, harvest, the presence of dams and diversions, and changes in climate and oceanic conditions have all contributed to impacting salmon and steelhead in the analysis area (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead). Analysis of fish resources in Subsection 4.2, Fish, is focused on the effects under the alternatives associated with hatchery production, which is one of the general factors affecting salmon and steelhead in the analysis area (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead). Thus, outside of hatchery production, the effects to salmon and steelhead from other general factors (e.g., habitat, climate change) are described in Chapter 5, Cumulative Effects.

4.2.2 Analysis Area

The analysis area for fish resources is the same as the project area as described in Subsection 1.4, Project and Analysis Areas. Information on listed salmon and steelhead in this EIS is described at the scale of ESUs or DPSs, and includes population and stock-scale information where applicable. Information may also be presented for river basins and watersheds for some fish species to help describe hatchery programs within specific areas of Puget Sound. For federally listed species, maps of the ESU and DPS boundaries can be found at http://www.westcoast.fisheries.noaa.gov/maps_data/species_population_boundaries.html.

4.2.3 Overall Methods for Analyzing Effects

This subsection provides a general overview of the methods and evaluation criteria used to analyze effects of hatchery programs, described in Subsection 3.2.4.2, Hatchery Programs Reviewed, on fish. Additional detail on methods is provided in subsequent subsections for each species. Using existing scientific literature and data available within NMFS and from other Federal and state agencies, NMFS identified opportunities where fisheries models and quantitative analyses could be applied based on sufficient information. It is important to understand as much about the natural environment and condition of fish as possible to develop a reasonably accurate indication of effects under each alternative. Therefore, where there was insufficient data available for modeling and quantitative analysis, analyses relied on qualitative inferences from best available science. For example, more quantitative data are available to analyze impacts on Chinook salmon than on other salmon, steelhead, and other fish species. Applying both quantitative data and qualitative inferences from available and reliable information constitutes the best method for NMFS to evaluate impacts to fish where there are limitations on quantitative data.

An overview showing how methods used to assess risks and benefits on fish vary between species is provided in Table 4.2-2. More detailed information on specific methods used to predict risk and benefits levels are provided in the respective species subsections in Subsection 4.2, Fish, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and in the appendices that support subsections for species.

Analyses of effects are addressed at multiple scales, depending on the extent of information available for the particular effect. For example, most effects for Chinook salmon and Hood Canal summer-run chum salmon are analyzed by hatchery program and at the population scale (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population; and Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population) and then summarized at the Puget Sound Chinook Salmon ESU scale and Hood Canal Summer-run Chum Salmon ESU scale, respectively. Similarly, effects on natural-origin steelhead are evaluated for hatchery programs and steelhead river basins (Appendix H, Steelhead Effects Analysis by Basin) and then summarized at the DPS scale. Listed bull trout are evaluated primarily at the core area scale (a designation used by the USFWS for analysis and recovery of listed bull trout), and to a lesser extent at the DPS scale. Other fish species are evaluated at the scales of their respective ESUs, if ESUs are delineated and they cover a smaller range than the analysis area scale (Subsection 4.2.2, Analysis Area), otherwise they are evaluated at the analysis area scale.

Table 4.2-2. Predominant methods used to estimate effects of the alternatives on natural-origin fish species by risk and benefit category.

	Risk				Benefit		
Fish Species	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return[1]**	**Viability[2]**	**Marine-derived Nutrients**
Chinook salmon	PCD[3] (fresh water) Inferences[4] (marine areas)	PCD (fresh water) Inferences (marine areas)	AHA[5]	HPV Tool[6] and operator surveys	Percentage contribution toward restoration spawner abundance	Inferences	Inferences
Summer-run chum salmon	Inferences	Inferences	NA[7]	NA	NA	NA	NA
Steelhead	HPV coarse filter tool[8]	HPV coarse filter tool	HPV coarse filter tool	HPV coarse filter tool	Percentage contribution toward adult return goal	Inferences	Inferences
Bull trout	NA	NA	NA	Inferences (fish barrier emphasis)	NA	Inferences	NA
Coho salmon	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences
Fall-run chum salmon	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences
Pink salmon	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences
Sockeye salmon	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences	Inferences
Rainbow trout	Inferences	Inferences	Inferences	NA	NA	Inferences	NA
Coastal cutthroat trout	Inferences	Inferences	Inferences	NA	NA	Inferences	NA
Sturgeon and Lamprey	Inferences	Inferences	NA	NA	NA	NA	NA
Forage fish	Inferences	Inferences	NA	NA	NA	NA	NA
Groundfish	Inferences	Inferences	NA	NA	NA	NA	NA
Resident freshwater fish	Inferences	Inferences	Inferences (kokanee only)	NA	NA	NA	NA

[1] Benefit is from combined hatchery-origin and natural-origin abundances.
[2] Benefit is generally from integrated hatchery programs only.
[3] PCD risk model (Appendix D, PCD RISK 1 Assessment); fresh water only.
[4] Inferences are logical judgments or conclusions based on the best available and reliable information.
[5] All H Analyzer model (Appendix E, Overview of the All H Analyzer).
[6] Hatchery Program Viewer tool (Appendix F, Hatchery Program Viewer [HPV] Analysis).
[7] Not applicable.
[8] Hatchery Program Viewer coarse filter tool (in part, Appendix F, Hatchery Program Viewer [HPV] Analysis; Appendix H, Steelhead Effects Analysis by Basin).

As described in Subsection 3.2.1, Introduction, the terms used to describe effects under the alternatives for the three groups of fish species analyzed in this EIS vary, depending on the extent of information available and analysis methods. For listed salmon, steelhead, and trout, effects under the alternatives are described in terms of defined rating categories (i.e., negligible, low, moderate, and high), as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. For non-listed salmon and other fish species, effects under the alternatives are described in qualitative, relative terms (e.g., minimal, likely, substantial, unsubstantial). If a risk or benefit is considered inconsequential in magnitude (i.e., minimal), it is not carried forth into the analysis in Subsection 4.2, Fish; the reasoning for this is described in Subsection 3.2, Fish.

In general, effects of alternatives are examined over the near term (e.g., from the present time through the subsequent 15 years), and most analyses are based on averages of data using recent information to describe the affected environment. The 15-year time frame encompasses about three generations of salmon or steelhead (one generation takes about 5 years), which is the number of generations over which changes in response to management actions might reasonably be expected (Subsection 5.2, Geographic and Temporal Boundaries of Cumulative Effects Analysis).

4.2.4 Puget Sound Chinook Salmon ESU

Described in this subsection are the effects of salmon and steelhead hatchery programs on the Puget Sound Chinook Salmon ESU. Risk and benefit categories are generally described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Methods used to analyze effects by risk and benefit category are described in more detail here, including how the effects are quantitatively and/or qualitatively determined. Following the methods subsection is the analysis of effects, initially by risk and benefit category, for the ESU. These effects do not make assumptions about the outcomes of adaptive management processes that would include mitigation measures over time. Chinook salmon effects by hatchery program are provided in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, using the methods described below.

As described in Subsection 3.2.5, Puget Sound Chinook Salmon ESU, factors that limit recovery of the ESU are habitat degradation (specifically estuarine and marine habitat, floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, and stream substrate), water quality, hatchery-related adverse effects, and predation/competition/disease from non-native species (NMFS 2011c). The recovery plan for Chinook salmon addresses these factors and is being implemented to restore, conserve, and protect the ESU and its habitat (72 Fed. Reg. 2493, January 19, 2007). Recovery plan implementation will continue into the future under all alternatives (Subsection 5.5.3, Habitat Restoration [Cumulative Effects]). With two exceptions (i.e., hatchery-related adverse effects and water quality), hatchery production under the alternatives would not affect the above factors or associated recovery efforts aimed at decreasing impacts of those factors. Actions under the alternatives would affect the hatchery-related adverse effects and water quality limiting factors, as described in Subsection 4.2.4.15, Summary of Risks and Benefits by Alternative [Chinook Salmon], and Subsection 4.2.4.16, Mitigation Measures and Adaptive Management [Chinook Salmon].

4.2.4.1 Methods for Analysis

The effects analyzed below are the risks and benefits that could be either quantitatively or qualitatively reviewed. Most effects are addressed at the hatchery program and population scales in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, and then summarized at the ESU scale in this EIS. However, some effects are evaluated only at the ESU scale (e.g., competition and predation in marine areas and contribution of marine-derived nutrients). The following subsections contain the reasoning used to evaluate risks and benefits in each category, followed by summary tables showing risks and benefits by category. The analysis of effects on Chinook salmon from salmon and steelhead hatchery production uses quantitative tools (modeling) and inferences from qualitative information (Table 4.2-3 and Subsection 4.2.3, Overall Methods for Analyzing Effects) based on the best available science, and as described in more detail in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Unless otherwise noted, effects of the alternatives on Puget Sound Chinook salmon are evaluated for the 22 listed natural-origin populations identified by the Puget Sound TRT (Ruckelshaus et al. 2006) (Table 3.2-8 and Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population), that are the focus of the Puget Sound Chinook salmon recovery plan (72 Fed. Reg. 2493, January 19, 2007).

In many cases, more than one Chinook salmon population exists in a watershed or more than one hatchery program affects a population in a watershed. In those cases, the composite risk is rated the same as the highest risk rating of the programs associated with the watershed or population (Subsection 4.2.3, Overall Methods for Analyzing Effects; Appendix B, Hatchery Effects and Evaluation Methods for Fish; Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). This approach is reasonable because it compensates for existing analytical constraints and uses information that is available. Rating the composite risks to individual natural-origin populations according to highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

Table 4.2-3. Summary of evaluation methods used to determine effects on natural-origin Puget Sound Chinook salmon.

Effect	Evaluation Method
Risks	
Competition and predation in fresh water	PCD Risk Model (for effects from Chinook salmon and coho salmon programs) Inferences based on the likelihood for competition and predation interactions to occur (for effects from steelhead programs and in lakes)
Competition in marine areas	Inferences based on the likelihood for competition interactions to occur from hatchery-origin subyearling Chinook salmon, considering subyearling Chinook salmon production levels in contrast to baseline conditions (ESU scale only)
Predation in marine areas	Inferences based on the likelihood for predation interactions to occur from hatchery-origin yearling Chinook salmon, considering yearling Chinook salmon production levels in contrast to baseline conditions (ESU scale only)
Genetics	Domestication risks are assessed using the AHA Model, using the pHOS metric for isolated programs, and the PNI metric for integrated programs Loss of among-population diversity/outbreeding depression risks are based on pHOS where non-local hatchery-origin fish stray data are available Loss of within-population diversity risks are qualitatively assessed based on inferences on the likelihood for losses to occur (ESU scale only)
Hatchery facilities and operation	HPV Tool (for listed Chinook salmon programs) and surveys of hatchery operators
Benefits	
Total return	Estimated total return based on recent year average smolt-to-adult survival rates to fisheries and escapement, applied to smolt release numbers, compared to restoration spawner abundance estimates as reference points
Viability	Inferences based on the likelihood of benefits to VSP parameters
Marine-derived nutrients	Inferences based on the likely extent of marine-derived nutrient contribution (ESU scale only)

4.2.4.2 Determining Overall Risks and Benefits

Each risk and most benefits for Puget Sound Chinook salmon hatchery programs are evaluated using the methods and criteria as described above and detailed in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and applied to the 22 natural-origin Chinook salmon populations in Appendix C, Puget

Sound Chinook Salmon Effects Analysis by Population. Using these criteria, risks and benefits for each of the Chinook salmon populations are then assigned numeric scores (Table 4.2-4) for summing at the ESU scale. Unweighted sums of scores for each of the 22 populations are divided by the respective number of hatchery programs. These unweighted averages at the population scale are then averaged to obtain overall means for the corresponding risk or benefit level for each population comprising the ESU. This simple approach weights each listed natural-origin population equally and allows consistent application across the ESU based on currently available information. Similarly, for each alternative at the ESU scale, overall risks and overall benefits are summarized by averaging scores across risks and benefits, respectively. This approach weights each benefit and risk category equally and allows consistent application across the ESU. For the purposes of this analysis, mean values with fractions less than 0.5 are rounded down, and mean values with fractions greater than or equal to 0.5 are rounded up. Because the extent of information available at the population scale is limited, marine-derived nutrient benefits are not evaluated at the population scale, but only at the ESU scale.

Table 4.2-4. Numeric scoring of risk and benefit levels.

Risk or Benefit Level	Score
Negligible	0
Low risk or benefit	1
Moderate risk or benefit	2
High risk or benefit	3

4.2.4.3 Summaries of Risks and Benefits

Where possible, each of the subsections evaluating the risks and benefits of the alternatives concludes with a summary of risks and benefits and their net effect by alternative at the ESU scale. Risk and benefit levels may vary among programs for a particular type of risk or benefit. Levels included in summary tables are averages reflecting arithmetic means. Averages at the population scale (in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population) and at the ESU scale (using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish) are calculated by translating negligible, low, moderate, and high risk or benefit results into numeric values of 0, 1, 2, and 3, respectively (Table 4.2-4). These numeric values are then summed for each appropriate hatchery program or population risk or benefit factor, and then divided by the total number of programs or populations. These values are rounded to the nearest whole number and then translated back into summary descriptions of negligible, low, moderate, and high for each risk and benefit evaluated.

Risks and benefits to natural-origin Chinook salmon are evaluated for 133 hatchery programs across Puget Sound (Subsection 1.5.1, Hatchery Facilities in Puget Sound), with effects primarily occurring from 48 Chinook salmon programs, 23 steelhead programs, and 43 coho salmon programs (Table 3.2-5).

4.2.4.4 Hatchery Release Levels

Under Alternative 1, the number of hatchery-origin Chinook salmon released annually into the analysis area would be about 45.3 million fish (Table 2.4-1), the same as under existing conditions. Table 4.2-5 provides release levels by age of release, Chinook salmon population, and alternative. Subyearlings would comprise 94 percent of the total number of hatchery-origin Chinook salmon released under Alternative 1, whereas yearlings would comprise 6 percent of the total released. The release level under Alternative 2 would be the same as under Alternative 1.

Under Alternative 3, Chinook salmon hatchery production designed to produce fish for harvest would decrease by 50 percent, compared to Alternative 1, in watersheds where recovery categories 1 and 2 Chinook salmon populations occur (recovery categories are shown in Table 2.2-1 in Subsection 2.2.2, Hatchery Management Goal and Strategies), but would not be reduced in watersheds with recovery category 3 Chinook salmon populations (Table 2.4-2, Table 2.4-3). Under Alternative 3, the number of hatchery-origin Chinook salmon released into the analysis area would be about 37.2 million fish (Table 2.4-1 and Appendix A, Puget Sound Hatchery Programs and Facilities). Subyearlings would comprise 94 percent of the total number of hatchery-origin Chinook salmon released, whereas yearlings would comprise 6 percent of the total released (Table 4.2-5). There would be no changes to production levels for hatchery programs designed to aid recovery.

Under Alternative 4, Chinook salmon production would increase to provide increased harvest opportunities (Table 2.4-2, Table 2.6-1). Increases would only occur to the extent that additional hatchery capacity is available (e.g., appropriate availability of water quantity, water quality, water temperature, space, and timing). Under Alternative 4, the number of hatchery-origin Chinook salmon released into the analysis area would be about 51.3 million fish (Table 2.4-1 and Appendix A, Puget Sound Hatchery Programs and Facilities). Table 4.2-5 provides release levels by age of release, Chinook salmon population, and alternative. Subyearlings would comprise 89 percent of the total number of hatchery-origin Chinook salmon released under Alternative 4, whereas yearlings would comprise 11 percent of the total released (Table 4.2-5). More details on hatchery releases and effects on individual Chinook salmon natural-origin populations are provided in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population. Effects at the ESU scale are summarized in this subsection.

Table 4.2-5. Releases of hatchery-origin Chinook salmon subyearlings and yearlings evaluated by natural-origin Chinook salmon population and alternative[1].

Life Stage of Hatchery Releases[1]	Alternative 1 (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
	Number	Number	Percent Change from Alt 1	Number	Percent Decrease from Alt 1	Number	Percent Increase from Alt 1
ESU Totals Evaluated at the Population Scale[2]							
Subyearlings	30,452,000	30,452,000	0	22,652,000	26	31,572,000	4
Yearlings	1,595,000	1,595,000	0	1,260,000	21	1,845,000	16
Total	**32,047,000**	**32,047,000**	**0**	**23,912,000**	**25**	**33,417,000**	**4**
ESU Totals Evaluated Puget Sound-wide[3]							
Subyearlings	12,350,000	12,350,000	0	12,350,000	0	14,350,000	16
Yearlings	920	920	0	920	0	3,540	285
Total	**13,270,000**	**13,270,000**	**0**	**13,270,000**	**0**	**17,890,000**	**35**
All Releases[4]							
Subyearlings	42,802,000	42,802,000	0	35,002,000	18	45,922,000	7
Yearlings	2,515,000	2,515,000	0	2,180,000	13	5,385,000	114
Total	**45,317,000**	**45,317,000**	**0**	**37,182,000**	**18**	**51,307,000**	**13**

[1] Included are numbers of listed Chinook salmon released associated with each population and where applicable, numbers of non-listed Chinook salmon.
[2] Releases that are associated with effects evaluations for more than one natural-origin Chinook salmon population (e.g., North Fork Nooksack and South Fork Nooksack, North Fork Stillaguamish and South Fork Stillaguamish, Skykomish and Snoqualmie, Sammamish and Cedar, and Puyallup and White populations) are only counted once in these totals.
[3] Releases that are evaluated ESU-wide (e.g., marine releases), and not at the scale of individual Chinook salmon populations (Appendix A, Puget Sound Hatchery Programs and Facilities).
[4] Sums of ESU totals evaluated at the population scale, plus those evaluated Puget Sound-wide.

4.2.4.5 Life History of Natural-origin Chinook Salmon

As described in Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon, Chinook salmon populations have unique life history traits that reflect the variability of aquatic habitat conditions unique to each river system. Differences within and among Chinook salmon populations represent the genetic and behavioral diversity that allows the fish to adapt to short-term and long-term habitat changes over time. The life history diversity attributes of natural-origin Chinook salmon would be the same under any alternative because variations in hatchery production would not impact these attributes. Life history diversity attributes include:

- Timing and location of incubation, hatching, and fry emergence
- Juvenile residence times in fresh water, estuaries, and marine water
- Out-migration timing
- Return timing of adults to fresh water for spawning
- Occurrence of stream-type and ocean-type life histories
- Timing of sexual maturation and age of fish upon return
- Preferred food
- Habitat locations preferred for cover, feeding, spawning, and resting
- Social behavior

4.2.4.6 Distribution and Abundance of Natural-origin Chinook Salmon

As described in Subsection 3.2.5.2, Distribution and Abundance of Natural-origin Chinook Salmon, 22 Chinook salmon populations are distributed throughout the analysis area at varying abundance levels. The distribution of Chinook salmon and their abundance helps the ESU to be able to adapt to short-term and long-term environmental changes over time. Under all alternatives, natural-origin Chinook salmon populations (juveniles in watersheds and entering Puget Sound, and returning adults) would continue to occur at the same locations as described under existing conditions (Figure 3.2-2, Table 3.2-9). However, abundance of listed Chinook salmon populations may vary in response to changes in production from listed (integrated) hatchery programs (Table 3.2-5) associated with the action alternatives as described in Subsection 4.2.4.13, Benefits - Viability.

In addition, Chinook salmon recovery plan actions and changes in other factors that influence salmon and steelhead abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead), would be expected to affect the abundance of natural-origin Chinook salmon over the long term. However, while reduced risks likely have benefits to natural-origin Chinook salmon, changes in abundance associated with risks specifically attributable to hatchery production under the alternatives would not be measurable. These risks and benefits cannot be quantified because of the inherent variability in abundance of the salmon that compose the ESU (Figure 3.2-3). Further, such variability cannot be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.4.7 Characteristics of Hatchery-origin Chinook Salmon

Hatchery-origin Chinook salmon are currently released in the analysis area as subyearlings predominantly in May and June at a size of about 3.1 inches, and as yearlings predominantly in April at a size of about 6.1 inches (Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The juvenile hatchery-origin fish are released into fresh water and in estuarine waters, through which most out-migrate to the ocean for rearing prior to return as adults. Under all alternatives, the following characteristics of the hatchery environment and hatchery-origin Chinook salmon releases would be the same:

- Hatchery conditions that could influence foraging behavior, social behavior, habitat preferences, morphological and physiological characteristics, reproductive potential, and overall survival
- Times of releases and sizes of fish at release
- Residence times of hatchery-origin fish in fresh water, estuarine water, or marine water (including hatchery-origin fish that remain in Puget Sound, commonly called blackmouth salmon)
- Potential for straying and success at spawning
- Broodstock collection

Because these characteristics would not change under any alternative, the alternatives would not affect hatchery conditions such as type and number of broodstock used, spawning methods, incubation methods, juvenile rearing methods, and life stage and condition of hatchery-origin fish.

4.2.4.8 Risks - Competition

Fresh Water. Competition occurs when hatchery-origin fish overlap in space and time with similarly sized natural-origin juvenile Chinook salmon (particularly potential interactions between hatchery-origin subyearling Chinook salmon, steelhead, and coho salmon with natural-origin Chinook salmon), and is considered overall as a moderate effect under existing conditions (Subsection 3.2.5.4.1, Risks - Competition - Fresh Water).

Under Alternative 1, the overall effect to natural-origin Chinook salmon from competition in fresh water is also rated as a moderate risk (average score would be 1.7) (Table 4.2-6), which would be the same as under existing conditions (Subsection 3.2.5.4.1, Risks - Competition - Fresh Water). The risk of competition effects would be the same (average score would be 1.7, moderate) for Alternative 2 (Table 4.2-6), because hatchery production levels would be the same as under Alternative 1 (Table 4.2-5). Changes in hatchery production levels under Alternative 3 and Alternative 4 would decrease and increase freshwater competition risk scores to 1.6 and 1.8, respectively (which would be rated moderate risks).

Marine. Information on the dynamics of competition associated with Chinook salmon in Puget Sound marine waters is described in Subsection 3.2.5.4.2, Risks - Competition - Marine. Under all alternatives, competition would occur when hatchery-origin subyearling Chinook salmon overlap in space and time with natural-origin juvenile Chinook salmon and may compete for food. Overlap is likely greatest in estuarine areas adjacent to river mouths where hatchery-origin Chinook salmon may concentrate before migrating to the ocean (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population).

Releases of hatchery-origin subyearling Chinook salmon are widely distributed in Puget Sound, thus reducing concentrations of fish and the potential for these fish to compete with natural-origin Chinook salmon populations. In addition, the largest releases of hatchery-origin subyearling Chinook salmon under the alternatives would occur in south Puget Sound (Appendix A, Puget Sound Hatchery Programs and Facilities, and Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population) where there are few natural-origin Chinook salmon populations (Table 3.2-8); thus, the risk of competition in those areas would be low.

Under Alternative 1, the overall effect to natural-origin Chinook salmon from competition with hatchery-origin subyearling Chinook salmon production (including hatchery-origin Chinook salmon that remain in Puget Sound [blackmouth]) would be low (Table 4.2-6), which would be the same as under existing conditions. Compared to Alternative 1, the hatchery production levels for Alternative 2 would be the same and, thus, marine effects would be the same. Compared to Alternative 1, decreases in hatchery production under Alternative 3 (Table 4.2-5) would reduce the risks of competition with natural-origin Chinook salmon in marine areas, whereas the increase in production under Alternative 4 would increase the risk of competition. However, the changes in production under Alternative 3 and Alternative 4 would not be substantial enough to change the competition risk in marine areas from a low risk (Table 4.2-6).

Table 4.2-6. Summary average population scores and ratings by risk and benefit categories for the Puget Sound Chinook Salmon ESU by alternative.

Effect	**Alternative 1 (No Action) Average Score or Rating**	**Alternative 2 (Proposed Action) Average Score or Rating**	**Alternative 3 (Reduced Production) Average Score or Rating**	**Alternative 4 (Increased Production) Average Score or Rating**
Risks				
Competition in:				
Fresh Water	1.7[1] Moderate	Same as Alternative 1	1.6 Moderate	1.8 Moderate
Marine Areas	Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Predation in:				
Fresh Water	2.7 High	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Marine Areas	Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Genetics	2.0 Moderate	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	1.0 Low	Same as Alternative 1	0.9 Low	Same as Alternative 1
Overall Risk	1.6 Moderate	Same as Alternative 1	1.5 Moderate	Same as Alternative 1
Benefits				
Total Return	1.6 Moderate	Same as Alternative 1	Same as Alternative 1	1.7 Moderate
Viability	1.1 Low	Same as Alternative 1	1.0 Low	Same as Alternative 1
Marine-derived Nutrients	Negligible	Same as Alternative 1	Same as Alternative 1	Low
Overall Benefit	0.9 Low	Same as Alternative 1	Same as Alternative 1	1.3 Low

[1] Average scores by risk and benefit category for Chinook salmon populations shown. Lack of scores indicates results at the ESU scale only.

4.2.4.9 Risks - Predation

Fresh Water. As described in Subsection 3.2.5.4.3, Risks - Predation - Fresh Water, predation on natural-origin Chinook salmon is considered a high risk, and occurs from hatchery releases where the released fish are larger than the out-migrating natural-origin Chinook salmon juveniles, which includes hatchery releases of coho salmon, steelhead, and yearling Chinook salmon. Under Alternative 1, the overall effect to natural-origin Chinook salmon from predation in fresh water would be a high risk (average score is 2.7) (Table 4.2-6), which would be the same as under existing conditions (Subsection 3.2.5.4.3, Risks - Predation - Fresh Water). The risk of predation effects would be the same (average score would be 2.7, high) for Alternative 2, Alternative 3, and Alternative 4 (Table 4.2-6). The increase in hatchery production that would occur under Alternative 4 would not increase the high risk rating, because that rating is the highest category of risk used in this analysis. The decreases in hatchery production under Alternative 3 would be insufficient to decrease the risk from high.

Marine. Predation could occur based on the limited extent to which hatchery-origin yearling Chinook salmon overlap in space and time with the generally smaller-sized natural-origin juvenile Chinook salmon (Subsection 3.2.5.4.4, Risks - Predation - Marine). Overlap would be greatest in nearshore areas adjacent to river mouths where the fish concentrate on their migration from fresh to marine waters. Although hatchery-origin Chinook salmon yearlings are large enough to prey on smaller natural-origin Chinook salmon, documentation of such predation is lacking (Subsection 3.2.5.4.4, Risks - Predation - Marine); thus, the risk under existing conditions is low.

Under Alternative 1, the overall effect to the Chinook salmon ESU from predation by hatchery-origin Chinook salmon production would be low (Table 4.2-6), which would be the same as under existing conditions (Subsection 3.2.5.4.4, Risks - Predation - Marine). The hatchery production levels under Alternative 2 would be the same as under Alternative 1, and marine effects would be the same. Compared to Alternative 1, decreased hatchery production under Alternative 3 (Table 4.2-5) would reduce the risk of predation on natural-origin Chinook salmon in marine areas (although still rated a low risk) (Table 4.2-6), whereas the increase in production under Alternative 4 would increase the risk of predation (although still rated as a low risk) (Table 4.2-6).

4.2.4.10 Risks - Genetics

Under existing conditions, genetic risks to the Chinook salmon ESU are moderate because of hatchery-induced selection (sometimes called domestication) risks at specific hatchery programs and risks of gene flow (introgression) posed by hatchery-origin fish straying and spawning in natural aquatic habitat (Subsection 3.2.5.4.5, Risks - Genetics).

Under Alternative 1, the overall genetic risk to natural-origin Chinook salmon would be rated a moderate risk (average score would be 2.0) (Table 4.2-6), which would be the same as under existing conditions. The hatchery production levels under Alternative 2 would be the same as under Alternative 1 and genetic risks would be the same (average score would be 2.0) (Table 4.2-6). Under Alternative 3 and Alternative 4, changes in hatchery production levels (Table 4.2-5) would not result in different genetic risk scores and ratings (average score and rating would be 2.0 and moderate, respectively) (Table 4.2-6). Under Alternative 4, hatchery production would increase but would be insufficient to increase the genetic risk rating compared to Alternative 1.

4.2.4.11 Risks - Hatchery Facilities and Operation

Hatchery facilities and operation risks include broodstock collection practices, including timing, duration, and methods of collection; hatchery water withdrawal and effluent discharge levels; and fish disease pathogen incidence and transfer (Subsection 3.2.5.4.6, Risks - Hatchery Facilities and Operation). The risk is rated low under existing conditions because compliance with BMPs by most Chinook salmon hatchery programs is generally satisfactory. However, some Chinook salmon hatchery programs lack compliance with some BMPs, including adult holding (water temperature profiles) and release and management plans with performance indicators.

Under Alternative 1, the overall effect to natural-origin Chinook salmon from hatchery facilities and operation would be rated a low risk (average score would be 1.0) (Table 4.2-6), which would be the same as under existing conditions. The risk of hatchery facilities and operation effects would be the same (average score would be 1.0, low) under Alternative 2, because hatchery production levels would be the same as under Alternative 1. The reduction in hatchery production under Alternative 3 (Table 4.2-5) would decrease the average risk score to 0.9, which would remain a low risk (Table 4.2-6). As described in Subsection 4.6.3, Water Quality, these reductions in hatchery production may decrease the contribution of hatchery facility effluent to the total pollutant load of receiving waters and the potential for water quality degradation, which is a limiting factor for Chinook salmon (as described in Subsection 3.2.5, Puget Sound Chinook Salmon ESU). As a result, the decrease in hatchery production may indirectly improve water quality for Chinook salmon. The increase in hatchery production under Alternative 4 (Table 4.2-5) would result in the same average risk score as under Alternative 1 (Table 4.2-6), and would be rated a low risk.

As described in Subsection 4.6.3, Water Quality, under Alternative 4 there may be an increase in impairments to water quality compared to Alternative 1, because increased hatchery production may increase the amount of chemicals and organisms released from hatchery facility operations discharged to receiving waters. This may increase the contribution of hatchery facilities to the total pollutant load of receiving waters and the potential for water quality impairment relative to Alternative 1. As a result, the increase in hatchery production may indirectly reduce water quality for Chinook salmon.

4.2.4.12 Benefits - Total Return

Under existing conditions, the total return benefit from hatchery-origin Chinook salmon to fisheries and escapement is moderate based on recent year returns of hatchery-origin and natural-origin fish, compared to restoration spawner abundance targets associated with individual natural-origin Chinook salmon populations (Subsection 3.2.5.4.7, Benefits - Total Return). This benefit rating is moderate because, for most Chinook salmon populations, the projected total adult returns from natural-origin Chinook salmon and from releases of hatchery-origin Chinook salmon would be between 20 and 50 percent of the restoration spawner abundance estimates (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population).

Under Alternative 1, the overall total return benefit would be moderate (average score would be 1.6) (Table 4.2-6), which would be the same as under existing conditions. Under Alternative 2, the total return benefit would also be moderate (average score would be 1.6) (Table 4.2-6) because hatchery production levels would be the same as under Alternative 1 (Table 4.2-5). The reduction in hatchery production under Alternative 3 (Table 4.2-5) would not change the total return benefit (moderate) compared to Alternative 1 (Table 4.2-6); however, increased production under Alternative 4 would increase the total return benefit score to 1.7, but the benefit would remain moderate (Table 4.2-6).

4.2.4.13 Benefits - Viability

As described in Subsection 3.2.5.4.8, Benefits - Viability, benefits can accrue to the viability of the Puget Sound Chinook Salmon ESU when genetic resources important to the ESU reside in fish produced by hatchery programs. Under NMFS' policy for considering hatchery-origin fish in extinction risk evaluations (70 Fed. Reg. 37204, June 28, 2005), these fish can benefit populations to the extent that they positively contribute to the abundance, productivity, diversity, and spatial structure of natural populations, which are the four VSP parameters identified by McElhany et al. (2000). For the Chinook salmon hatchery programs evaluated for viability benefits under existing conditions (those that produce listed fish), no programs benefit all four viability parameters for any Chinook salmon population; two or three of the abundance, diversity, and spatial structure parameters accrue to 11 of the 16 natural-origin Chinook salmon populations; 1 parameter benefits 2 populations; and no benefits accrue to 3 populations (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). The effect of Chinook salmon hatchery programs results in an overall low benefit rating, because benefits to VSP parameters from listed hatchery programs are limited.

Under Alternative 1, the overall viability benefit would be low (average score would be 1.1) (Table 4.2-6), which would be the same as under existing conditions (Subsection 3.2.5.4.8, Benefits - Viability). Under Alternative 2, viability benefits would be the same (average score would be 1.1, low) (Table 4.2-6) because hatchery production levels would be the same as under Alternative 1 (Table 4.2-5). The reduction in hatchery production under Alternative 3 (Table 4.2-5) would decrease the average benefit score to 1.0 (Table 4.2-6), primarily because benefits from the abundance VSP parameter would be reduced. The increase in hatchery production under Alternative 4 (Table 4.2-5) would be insufficient to change the benefit rating compared to Alternative 1 (Table 4.2-6), primarily because there would be relatively few increases in integrated hatchery programs.

4.2.4.14 Benefits - Marine-derived Nutrients

Natural-origin Chinook salmon and their ecosystems benefit from marine-derived nutrients that are delivered into fresh water by returning adult hatchery-origin and natural-origin salmon and steelhead that spawn and die (Subsection 3.2.5.4.9, Benefits - Marine-derived Nutrients). Returning hatchery-origin Chinook salmon adults help contribute to marine-derived nutrients in freshwater ecosystems, which are considered a negligible benefit to natural-origin Chinook salmon at the ESU scale. This is because hatchery-origin and natural-origin Chinook salmon contribute a relatively small proportion (less than 10 percent) to the total number of salmon and steelhead carcasses in Puget Sound watersheds, and of the total number of carcasses that are distributed from hatcheries to watersheds, 18 percent are hatchery-origin Chinook salmon.

Under Alternative 1, the percentage of hatchery-origin Chinook salmon carcasses distributed into Puget Sound watersheds (18 percent) (Appendix B, Hatchery Effects and Evaluation Methods for Fish) would be the same as under existing conditions, and the overall beneficial effect on marine-derived nutrients from those carcasses would be negligible (Table 4.2-6). Under Alternative 2, hatchery production levels and resulting carcasses would be the same as under Alternative 1 (Table 4.2-5), and benefits from marine-derived nutrients would also be negligible. Under Alternative 3, hatchery-origin Chinook salmon production (Table 4.2-5) and carcasses would decrease 18 percent compared to Alternative 1, and the benefits would remain negligible (which is the lowest benefit level). Under Alternative 4, hatchery-origin Chinook salmon production and carcasses would increase 13 percent, raising the effect of marine-derived nutrients to a low benefit compared to negligible under Alternative 1 (Table 4.2-6).

4.2.4.15 Summary of Risks and Benefits by Alternative

Risks and benefits for the Puget Sound Chinook Salmon ESU under each alternative are summarized in Table 4.2-6. Risk and benefit levels summarized in the table reflect averages associated with the 22 natural-origin populations that are described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, with the exception of competition and predation risks in marine areas, and marine-derived nutrient benefits, which are described only at the ESU scale. This subsection summarizes overall risks and overall benefits for the ESU by alternative.

Alternative 1 (No Action). Under Alternative 1, considering current risks for all risk categories, the overall risk to the Puget Sound Chinook Salmon ESU would be moderate (average score would be 1.6) (Table 4.2-6). The most important influencing factors would be high predation risks from coho salmon and steelhead hatchery programs and moderate competition and genetic risks from Chinook salmon hatchery programs (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Alternative 1 would not affect the limiting factor associated with hatchery-related adverse effects to Chinook salmon (Subsection 3.2.5, Puget Sound Chinook Salmon ESU) compared to existing conditions.

Under Alternative 1, considering current benefits for all benefit categories, the overall benefit would be low (average score would be 0.9) (Table 4.2-6). The most important influencing factor would be the moderate benefit to the total return of natural-origin Chinook salmon.

Alternative 2 (Proposed Action). Under Alternative 2, considering all categories, the overall risk and the overall benefit to natural-origin Chinook salmon would be the same as under Alternative 1 (average scores would be 1.6 and 0.9, respectively) (Table 4.2-6) because the number of fish released would be the same (Table 4.2-5). Alternative 2 would not affect the limiting factor associated with hatchery-related adverse effects to Chinook salmon (Subsection 3.2.5, Puget Sound Chinook Salmon ESU) compared to Alternative 1, although mitigation measures under adaptive management have the potential to reduce risks over time.

Alternative 3 (Reduced Production). Under Alternative 3, considering all risk categories, the overall risk would decrease (average score would be 1.5, moderate) (Table 4.2-6) compared to Alternative 1 (average score 1.6) (Table 4.2-6), primarily because of reduced hatchery production, which would decrease predation risks from coho salmon and steelhead hatchery programs (that would occur primarily in fresh water), and competition and genetic risks from Chinook salmon hatchery programs (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). The decrease in overall risk under

Alternative 3 (although still moderate) may reduce the impact of the limiting factor associated with hatchery-related adverse effects to Chinook salmon (Subsection 3.2.5, Puget Sound Chinook Salmon ESU) compared to Alternative 1. Mitigation measures under adaptive management have the potential to further reduce these risks over time.

Under Alternative 3, considering all benefit categories, the overall benefit would be the same (low) as under Alternative 1 (average score would be 0.9) (Table 4.2-6). The most important influencing factor would be the moderate benefit to the total return of natural-origin Chinook salmon. The 18 percent decrease in hatchery production under Alternative 3 compared to Alternative 1 (Table 4.2-5) would not be substantial enough to decrease the overall benefit score or rating.

Alternative 4 (Increased Production). Under Alternative 4, considering all risk categories, the overall risk would be moderate, the same as Alternative 1 (average score would be 1.6) (Table 4.2-6). The most important influencing factors would be high predation risks from coho salmon and steelhead hatchery programs, and moderate competition and genetic risks from Chinook salmon hatchery programs (Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population). Increases in hatchery production levels under Alternative 4 (Table 4.2-5) would not be substantial enough to increase the overall risk score or rating. Alternative 4 would not reduce the impact of the limiting factor associated with hatchery-related adverse effects to Chinook salmon (Subsection 3.2.5, Puget Sound Chinook Salmon ESU) compared to Alternative 1, although mitigation measures under adaptive management have the potential to reduce risks over time.

Under Alternative 4, considering all benefit categories, the overall benefit would be low (average score would be 0.9), the same as Alternative 1, Alternative 2, and Alternative 3 (Table 4.2-6). The most important influencing factor would be the increase in the number of Chinook salmon releases (Table 4.2-5), which would provide moderate total return benefits. In addition, the 13 percent increase in hatchery production under Alternative 4 compared to Alternative 1 (Table 4.2-5) would increase the marine-derived nutrient benefit from negligible to low compared to Alternative 1.

4.2.4.16 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, but is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks to other resources. For example, a measure intended to reduce risks to fish by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed mitigation measures for Chinook salmon are summarized in Table 4.2-7.

As shown in Table 4.2-7, not all potential mitigation measures would apply to all action alternatives, depending on the objective of the alternative. For example, some risk reduction measures may not be needed under Alternative 3 (Reduced Production). Any mitigation measures that would reduce hatchery production under Alternative 3 would operate within the operational limitations of that alternative.

Under adaptive management, in addition to applicable updated or new BMPs that may become available, the primary proposed mitigation measures implemented to reduce or eliminate negative impacts to fish resources would be those associated with managing the number and proportion of hatchery-origin fish in natural spawning areas (also known as pHOS), reducing hatchery program size (number of hatchery-origin fish released), and/or discontinuing hatchery programs. In general, those measures would reduce negative impacts to fish resources by reducing juvenile competitive and predatory interactions, genetic risks to natural-origin fish, and hatchery facilities and operation risks. Although such reductions in the negative effects of limiting factors associated with hatchery programs would likely occur, negative effects of other limiting factors (e.g., habitat degradation) would not be eliminated even with adaptive management implementation under the action alternatives.

Table 4.2-7. Examples of potential mitigation measures for Chinook salmon hatchery programs applicable under adaptive management.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Monitor post-release competition and/or predation (applicable to all hatchery programs), and use results to change hatchery programs to reduce risk identified through monitoring. **Value**[1] – Determines extent of effect and identifies and implements specific hatchery program measures to reduce competition, predation, and genetic risks. **Constraints**[2] – If implementation requires reducing hatchery production, then total return benefits from hatchery-origin fish may be reduced, and viability benefits may be reduced. Otherwise, other changes not likely to result in constraints.		√	√ (possible based on monitoring results)	√
Reduce numbers of hatchery-origin fish released – applicable to specific hatchery programs. **Value** – Reduces competition, predation, and genetic risks. **Constraints** – Reduces total return benefits from hatchery-origin fish available for harvest, and may reduce viability benefits.		√		√
Discontinue program – for specific hatchery programs. **Value** – Eliminates all risks from a hatchery program. **Constraints** – Eliminates total return benefits from hatchery-origin fish available for harvest.		√	√	
Develop integrated conservation program (using locally adapted broodstock). **Value** – Reduces competition and genetic risks and may contribute to viability of natural-origin populations. **Constraints** – Depending on harvest management objective, may not contribute to total return benefits from hatchery-origin fish available for harvest. Reduces the number of locally adapted or natural-origin fish available to spawn naturally.		√	√	√

Table 4.2-7. Examples of potential mitigation measures for Chinook salmon hatchery programs applicable under adaptive management, continued.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Implement more effective trapping of returning adults at existing facilities. **Value** – Reduces genetic and competition risks by removing hatchery-origin adults and preventing them from spawning naturally. **Constraints** – None		√	√	√
Develop more efficient fisheries. **Value** – Reduces genetic and competition risks by harvesting a greater number of hatchery-origin adults. Increases number of fish available for harvest. **Constraints** – Harvest increases may increase incidental harvest impacts to natural-origin fish.		√	√	√
Develop and implement plan for monitoring and reducing pHOS. **Value** – Results would help reduce genetic and competition risks. **Constraints** – Depending on implementation methods (e.g., more efficient fisheries, weirs), natural-origin fish and/or access to hatchery-origin fish for broodstock may be incidentally affected.		√	√	√
Apply broodstock collection and mating practices that ensure that the hatchery-origin fish do not diverge more than moderately from the donor natural-origin population. **Value** – Reduces genetic risks. **Constraints** – None		√	√	√
Alter juvenile release strategy (timing and/or location). **Value** – Reduces competition and predation risks in freshwater and marine areas. **Constraints** – None		√	√	√
Change to a subyearling release strategy. **Value** – Mimics the primary juvenile Chinook salmon life history strategy and reduces the potential for divergence from the natural-origin Chinook population. **Constraints** – Compared to yearling releases, program costs would increase because smolt-to-adult survival rates for hatchery releases would be reduced.		√	√	√

Table 4.2-7. Examples of potential mitigation measures for Chinook salmon hatchery programs applicable under adaptive management, continued.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Manage hatchery operations to reduce or avoid straying of hatchery-origin fish into areas used by natural-origin fish (e.g., monitor stray rates, acclimate juvenile hatchery-origin fish away from natural production areas, release fish on-station). **Value** – Reduces competition, predation, and redd superimposition, and genetic risks of interbreeding by increasing the separation between hatchery-origin and natural-origin fish; improves survival and homing of returning fish to desired harvest or natural production areas. **Constraints** – None		√	√	√
Change the hatchery water temperature profile. **Value** – Temperature profile is more representative of the temperature profile in the natural environment and reduces hatchery facility and operations risks **Constraints** – None		√	√	√
Upgrade intake screens to current standards. **Value** – Reduces hatchery facilities and operation risks of injury and mortality of natural-origin fish. **Constraints** – None		√	√	√
Improve hatchery infrastructure such as hatchery weirs. **Value** – Increases efficiency and reduces flood or fish passage-related hatchery facilities and operation risks. **Constraints** – None		√	√	√

[1] Value describes how the measure may reduce risks.
[2] Constraints describe how the measure may reduce benefits.

4.2.5 Hood Canal Summer-run Chum Salmon ESU

Described in this subsection are the effects of salmon and steelhead hatchery programs on the Hood Canal Summer-run Chum Salmon ESU. Risk and benefit categories are generally described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Subsection 4.2.3, Overall Methods for Analyzing Effects. Methods used to analyze effects by risk category are described in more detail in Subsection 4.2.5.1, Methods for Analysis, and Subsection 4.2.5.2, Determining Overall Risks, including how the effects are quantitatively and/or qualitatively determined. Effects by risk category for the ESU are described after the methods subsection, followed by a summary of risks by alternative. Because summer-run chum salmon hatchery programs are not evaluated in this EIS, as described below, genetic and hatchery facility and operations risks, and total return, viability, and marine-derived benefits of hatchery programs are not discussed. These effects do not make assumptions about the outcomes of adaptive management processes that would include potential mitigation measures. However, anticipated effects resulting from implementation of mitigation measures and adaptive management are discussed in Subsection 4.1.1, Mitigation Measures and Adaptive Management, and Subsection 4.2.5.10, Mitigation Measures and Adaptive Management.

Effects by hatchery program are provided in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population, using the methods described below. Non-listed fall-run chum salmon overlap the geographic boundaries of the Hood Canal Summer-run Chum Salmon ESU and form a separate Puget Sound/Strait of Georgia Chum Salmon ESU. Effects of hatchery programs on that non-listed ESU are discussed in Subsection 4.2.9, Puget Sound/Strait of Georgia Chum Salmon ESU.

The alternatives evaluated in this EIS do not include summer-run chum salmon hatchery production. This is because NEPA and ESA evaluations for Hood Canal summer-run chum salmon hatchery programs have already been completed, and these hatchery programs are not included in the co-manager RMPs and HGMPs submitted for NMFS’ review as the Proposed Action herein. The two hatchery programs that would continue to produce hatchery-origin Hood Canal summer-run chum salmon (Lilliwaup Hatchery and Tahuya programs) previously received authorization under the ESA (NMFS 2002a) and were reviewed under NEPA (NMFS 2002b, 2004b). They are not included as a part of the RMP for this Proposed Action that pertains to salmon and steelhead (PSTT and WDFW 2004), and thus are not evaluated in this EIS. Therefore, the alternatives evaluated in this EIS do not include summer-run chum salmon hatchery production.

As described in Subsection 3.2.6, Hood Canal Summer-run Chum Salmon ESU, factors that limit recovery of the ESU are habitat degradation (specifically estuarine and marine habitat, floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream substrate, and stream flow) and predation/competition/disease from non-native species (NMFS 2011c). The recovery plan for summer-run chum salmon addresses these limiting factors and, through its implementation, is helping to restore, conserve, and protect the ESU and its habitat (72 Fed. Reg. 29121, May 24, 2007). Recovery plan implementation will continue into the future under all alternatives (Chapter 5, Cumulative Effects). Hatchery production under the alternatives would not alter the impact that limiting factors would continue to have on the Hood Canal Summer-run Chum Salmon ESU.

4.2.5.1 Methods for Analysis

Competition and predation risks are determined based on natural-origin summer-run chum salmon life history traits (Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon), and distribution and abundance (Subsection 3.2.6.2, Distribution and Abundance of Natural-origin Summer-run Chum Salmon) relative to hatchery program releases of other species (Appendix A, Puget Sound Hatchery Programs and Facilities) within habitat occupied by summer-run chum salmon (Figure 3.2-5). Risks and benefits to summer-run chum salmon associated with hatchery programs for other species in the area are based on the analysis of effects and findings in NMFS (2002a, 2002b, 2004b).

As described above, summer-run chum salmon hatchery programs are not evaluated in this EIS because they previously received authorization under the ESA (NMFS 2002a), and thus are not part of the Proposed Action (co-manager hatchery RMPs). The analysis for this species focuses on evaluations of competition and predation risks from other hatchery programs to natural-origin Hood Canal summer-run chum salmon (Table 4.2-8). Thus, as described in Subsection 3.2.6.4, Hatchery Program Risks, genetic and hatchery facilities and operation risks, as well as total return, viability, and marine-derived nutrient benefits to listed summer-run chum salmon are not evaluated, because hatchery programs for listed summer-run chum salmon are not evaluated in the EIS.

Table 4.2-8. Summary of evaluation methods used to determine effects on natural-origin Hood Canal summer-run chum salmon.

Effect	Evaluation Method
Risk	
Competition	As described in NMFS (2002a), inferences for juvenile and adult (redd superimposition) competition based on the likelihood for competitive interactions to occur from hatchery production, considering spatial and temporal overlap between species, and diet overlap in areas used by summer-run chum salmon.
Predation	As described in NMFS (2002a), inferences for direct and indirect predation based on the likelihood for competitive interactions to occur from hatchery production, considering spatial and temporal overlap between species, and potential for direct and indirect predation effects considering relative fish sizes.

The geographic area analyzed is that occupied by the listed Hood Canal Summer-run Chum Salmon ESU (Subsection 3.2.6, Hood Canal Summer-run Chum Salmon ESU), and is within the analysis area for fish (Subsection 4.2.2, Analysis Area). For the purposes of this EIS, unless otherwise noted, effects of the alternatives on the Hood Canal Summer-run Chum Salmon ESU are evaluated for the two listed populations identified by the Puget Sound Technical Recovery Team (TRT) (Sands et al. 2009) (Subsection 3.2.6 2, Distribution and Abundance of Natural-origin Summer-run Chum Salmon; Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population), that are the focus of the Hood Canal summer-run chum salmon recovery plan (72 Fed. Reg. 29121, May 24, 2007).

4.2.5.2 Determining Overall Risks

Risks are evaluated using the methods and criteria as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and applied to the programs associated with each of the two summer-run chum salmon populations as described in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population. Using these criteria, risks for each population are then assigned a numeric score (Table 4.2-4) for summing at the ESU scale. Unweighted sums of scores for each of the two populations are divided by the respective number of hatchery programs to obtain an average score for each population. The unweighted averages at the population scale are then averaged to obtain an overall mean for the corresponding risk level for the ESU. This simple approach weights each population equally and allows consistent application across the ESU based on currently available information. For the purposes of this analysis, mean values with fractions less than 0.5 are rounded down, and mean values with fractions greater than or equal to 0.5 are rounded up.

As described in Subsection 3.2.6.4, Hatchery Program Risks (Summer-run Chum Salmon), hatchery programs located within the geographic area bounded by the Hood Canal Summer-run Chum Salmon ESU (Figure 3.2-5) pose the greatest competition and predation risks to summer-run chum salmon juveniles and adults. There are minimal effects of hatchery programs outside of the Hood Canal Summer-run Chum Salmon ESU on natural-origin summer-run chum salmon, and those programs are not evaluated in the EIS.

4.2.5.3 Summaries of Risks

Where possible, each of the subsections evaluating the risks of the alternatives concludes with a summary of risks and their net effect by alternative at the ESU scale. As described in Subsection 3.2.6.4, Hatchery Program Risks, no benefits are evaluated for Hood Canal summer-run chum salmon. Risk levels may vary among programs for a particular type of risk. Levels included in summary tables are averages reflecting arithmetic means. Averages at the population scale (in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population) and at the ESU scale (using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish) are calculated by translating negligible, low, moderate, and high risk results into numeric values of 0, 1, 2, and 3, respectively. These numeric values are then summed for each appropriate hatchery program or population risk factor, and then divided by the total number of programs or populations. These values are rounded to the nearest whole number and then translated back into summary descriptions of negligible, low, moderate, and high for each risk evaluated.

4.2.5.4 Hatchery Release Levels

Risks and benefits to natural-origin summer-run chum salmon are evaluated for 19 hatchery programs, including 6 fall-run chum salmon programs, 4 fall-run Chinook salmon programs, 2 steelhead programs, 1 pink salmon program, and 6 coho salmon programs (Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population). Releases of hatchery-origin summer-run chum salmon are not evaluated in this EIS because, as described above, those hatchery programs have been previously evaluated (NMFS 2002a, 2002b, 2004b).

The number of hatchery-origin salmon and steelhead released annually within the area bounded by the Hood Canal Summer-run Chum Salmon ESU under Alternative 1 is about 34.6 million fish (Table 4.2-9), which is the same as existing conditions (Subsection 3.2.6.3, Hatchery Programs within the Summer-run Chum Salmon ESU). The release levels under Alternative 2 would be the same as under Alternative 1 (Table 4.2-9).

Table 4.2-9. Releases of hatchery-origin salmon and steelhead in the Hood Canal Summer-run Chum Salmon ESU area by life stage and alternative.

Life Stage and Species of Hatchery Releases	Alternative 1 (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
	Number	Number	Percent Change from Alt. 1	Number	Percent Decrease from Alt. 1	Number	Percent Increase from Alt. 1
Fry							
Fall-run chum salmon	25,000,000	25,000,000	0	25,000,000	0	33,000,000	32
Coho salmon	36,000	36,000	0	36,000	0	36,000	0
Pink salmon	500,000	500,000	0	500,000	0	1,000,000	100
Total fry	**25,536,000**	**25,536,000**	**0**	**25,536,000**	**0**	**34,036,000**	**33**
Subyearlings							
Chinook salmon	6,810,000	6,810,000	0	4,910,000	28	6,810,000	0
Coho salmon	9,000	9,000	0	9,000	0	9,000	0
Total sub-yearlings	**6,819,000**	**6,819,000**	**0**	**4,919,000**	**28**	**6,819,000**	**0**
Yearlings							
Chinook salmon	340,000	340,000	0	280,000	18	340,000	0
Coho salmon	1,809,000	1,809,000	0	1,559,000	14	2,259,000	25
Steelhead	59,540	59,540	0	54,540	8	59,540	0
Total yearlings	**2,208,540**	**2,208,540**	**0**	**1,893,540**	**14**	**2,658,540**	**20**
Adults							
Steelhead	883	883	0	883	0	883	0
Total adults	**883**	**883**	**0**	**883**	**0**	**883**	**0**
Grand Total	**34,564,423**	**34,564,423**	**0**	**32,349,423**	**6**	**43,514,423**	**26**

Under Alternative 3, hatchery production designed to produce fish for harvest would decrease by 50 percent compared to Alternative 1 in watersheds where recovery category 1 and 2 Chinook salmon populations occur, but would not be reduced in watersheds with recovery category 3 Chinook salmon populations (recovery categories are shown in Table 2.2-1) (Table 2.4-3). Under Alternative 3, the number of hatchery-origin salmon and steelhead released into the Hood Canal Summer-run Chum Salmon ESU area would be about 32.3 million fish (Table 4.2-9). There would be no changes to production levels for hatchery programs designed to aid recovery.

Under Alternative 4, hatchery production would increase to provide increased fishing opportunities (Subsection 2.4.5, Alternative 4 [Increased Production]). The additional production would depend on the match of available hatchery capacity with the broodstock collection, spawning, incubation, and rearing needs of the fish species produced. Under Alternative 4, the number of hatchery-origin salmon and steelhead released into the Hood Canal Summer-run Chum Salmon ESU area would be about 43.5 million fish (Table 4.2-9).

More detail on hatchery releases and effects associated with each of the two summer-run chum salmon populations is provided in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population. Effects at the ESU scale are summarized in this subsection.

4.2.5.5 Life History of Natural-origin Hood Canal Summer-run Chum Salmon

As described in Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon, summer-run salmon populations have unique life histories. The life history diversity attributes of natural-origin summer-run chum salmon would be the same under any alternative because variations in hatchery production would not impact these attributes. Life history diversity attributes include:

- Timing and location of incubation and fry emergence
- Out-migration timing
- Juvenile residence times in fresh water, estuaries, and marine water
- Return timing of adults to fresh water for spawning
- Timing of sexual maturation
- Habitat locations for spawning, juvenile rearing, and feeding
- Preferred food

4.2.5.6 Distribution and Abundance of Natural-origin Summer-run Chum Salmon

As described in Subsection 3.2.6.2, Distribution and Abundance of Natural-origin Summer-run Chum Salmon, two summer-run chum salmon populations are distributed in the analysis area (Table 3.2-11) at varying abundance levels (Table 3.2-12). The distribution of natural-origin summer-run chum salmon in watersheds used for spawning and juvenile rearing, and in marine areas would be the same under any alternative because variations in hatchery production would not impact its distribution. Under all alternatives, natural-origin summer-run chum salmon populations (juveniles in watersheds and entering Puget Sound, and returning adults) would continue to be distributed at the same locations as described under existing conditions (Figure 3.2-5, Table 3.2-12).

Along with ongoing summer-run chum salmon recovery actions and changes in other factors that influence salmon and steelhead abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead), hatchery production of other salmon and steelhead species under the alternatives may affect the abundance of natural-origin summer-run chum salmon over the long term. However, while reduced risks have likely benefits to natural-origin summer-run chum salmon, changes in abundance associated with risks specifically attributable to hatchery production under the alternatives would not be measurable. These risks and benefits cannot be quantified because of the inherent variability in abundance of the salmon that compose the ESU (Table 3.2-12). Further, such variability cannot be isolated from the range of other factors known to influence overall abundance of the ESU (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.5.7 Risks - Competition

Under Alternative 1, the overall effect to natural-origin summer-run chum salmon from competition in freshwater (juvenile and adult) and marine (juvenile) environments would be low (average score would be 1.0) (Table 4.2-10), the same as existing conditions (Subsection 3.2.6.4.1, Risks - Competition). For juveniles, the low competition risk is primarily because of the limited extent to which hatchery-origin salmon and steelhead would overlap in space and time with natural-origin summer-run chum salmon because of hatchery release timing. For adults, the risk of redd superimposition from hatchery-origin Chinook salmon and coho salmon would be negligible, primarily because hatchery-origin Chinook salmon return to hatchery facilities rather than natural summer-run chum spawning areas, and because hatchery-origin fish returning to streams with large flows (e.g., Skokomish, Hamma Hamma, and Dungeness Rivers) disperse over a broad area of streams in the vicinity of the Hood Canal Summer-run

Chum Salmon ESU (Subsection 3.2.6.4.1, Risks - Competition). The overall risks of juvenile competition effects and adult competition effects would be the same under Alternative 2 as under Alternative 1 (average scores would be 1.0 [low] and 0.3 [negligible], respectively) (Table 4.2-10), because hatchery production levels would be the same as under Alternative 1 (Table 4.2-9). Effects from changes in hatchery production levels under Alternative 3 and Alternative 4 (Table 4.2-9) for this ESU would not be substantial enough to result in different competition risk ratings for juveniles and adults at the ESU scale (average scores would remain 1.0 [low], and 0.3 [negligible], respectively) (Table 4.2-10).

Table 4.2-10. Summary of risks and benefits for the Hood Canal Summer-run Chum Salmon ESU by alternative.

Effect	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Risks				
Competition:				
Juveniles	1.0 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Adults	0.3 Negligible	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Predation	0.7 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Overall Risk	0.8 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

4.2.5.8 Risks - Predation

Under Alternative 1, the overall risk to natural-origin summer-run chum salmon from predation (direct and indirect) in freshwater and marine environments would be low (average score would be 0.7) (Table 4.2-10), the same as existing conditions (Subsection 3.2.6.4.2, Risks - Predation), primarily because of the limited extent to which hatchery-origin salmon and steelhead would overlap in space and time with natural-origin summer-run chum salmon. The overall risk of predation effects in freshwater and marine areas would be the same (average score would be 0.7 [low]) under Alternative 2 (Table 4.2-10) because hatchery production levels would be the same as under Alternative 1 (Table 4.2-9). Effects from changes in hatchery production levels under Alternative 3 and Alternative 4 (Table 4.2-9) for this ESU would not be substantial enough to result in different predation risk ratings at the ESU scale (average scores would remain 0.7 [low]).

4.2.5.9 Summary of Risks by Alternative

Risks to the Hood Canal Summer-run Chum Salmon ESU from hatchery production are summarized in Table 4.2-10. As described in Subsection 4.2.5.2, Determining Overall Risks, risk levels in the table reflect averages from individual hatchery programs for each of the two populations as described in Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population. This subsection summarizes overall risks for the ESU by alternative.

Alternative 1 (No Action). Under Alternative 1, considering current risks for all risk categories, the overall risk to the ESU would be low (average score would be 0.8) (Table 4.2-10). The most important influencing factors would be low competition and low predation risks from fall-run chum salmon, Chinook salmon, coho salmon, pink salmon, and steelhead hatchery programs in freshwater and marine areas (Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population).

Alternative 2 (Proposed Action). Under Alternative 2, considering all risk categories, the overall risk to natural-origin summer-run chum salmon would be the same as under Alternative 1 (average score would be 0.8 [low]) (Table 4.2-10), because the number of fish released would be the same.

Alternative 3 (Reduced Production). Under Alternative 3, considering all risk categories, the overall risk would be the same as under Alternative 1 (average score would be 0.8 [low]) (Table 4.2-10). The most important influencing factors would be low competition and low predation risks from fall-run chum salmon, Chinook salmon, coho salmon, pink salmon, and steelhead hatchery programs in freshwater and marine areas. The 6 percent decrease in hatchery production under Alternative 3 would not be substantial enough to decrease the overall risk rating.

Alternative 4 (Increased Production). Under Alternative 4, considering all risk categories, the overall risk rating would be low (average score would be 0.8), the same as under Alternative 1, Alternative 2, and Alternative 3 (Table 4.2-10). The most important influencing factors would be low competition and low predation risks from fall-run chum salmon, Chinook salmon, coho salmon, pink salmon, and steelhead hatchery programs in freshwater and marine areas.

4.2.5.10 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect risks to other resources. For example, a measure intended to reduce risks to natural-origin summer-run chum salmon by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. A proposed potential mitigation measure for summer-run chum salmon is summarized in Table 4.2-11.

Table 4.2-11. Example of a potential mitigation measure for hatchery programs applicable to listed summer-run chum salmon under adaptive management.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Reduce numbers of hatchery-origin fish released - applicable to a specific hatchery program (Snow Creek coho salmon supplementation) **Value**[1] – Reduces predation risks **Constraints**[2] – May reduce numbers of hatchery-origin adults available for harvest		√		√

[1] Value describes how the measure may reduce risks.
[2] Constraints describe how the measure may reduce benefits.

Under adaptive management, in addition to applicable updated or new BMPs that may become available, the primary proposed mitigation measure implemented to reduce or eliminate negative impacts to summer-run chum salmon would be reducing hatchery program size (number of hatchery-origin fish released). In general, the measure would reduce negative local impacts to summer-run chum salmon by reducing predatory interactions from juveniles of a hatchery-origin species that are substantially larger than co-occurring natural-origin summer-run chum salmon juveniles.

4.2.6 Puget Sound Steelhead DPS

Described in this subsection are the effects of salmon and steelhead hatchery programs on the Puget Sound Steelhead DPS. Risk and benefit categories are generally described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and in Subsection 4.2.3, Overall Methods for Analyzing Effects. Methods used to analyze effects by risk and benefit categories are described in more detail here, including how the effects are quantitatively and/or qualitatively determined. Effects by risk and benefit category for the DPS are described after the methods subsection, followed by a summary of risks by alternative. These effects do not make assumptions about the outcomes of adaptive management processes that would include mitigation measures over time. However, anticipated trends resulting from implementation of mitigation measures and adaptive management are discussed in Subsection 4.1.1, Mitigation Measures and Adaptive Management, and Subsection 4.2.6.15, Mitigation Measures and Adaptive Management. Effects by hatchery program are provided in Appendix H, Steelhead Effects Analysis by Basin, using the methods described below.

As described in Subsection 3.2.7, Puget Sound Steelhead DPS, limiting factors for steelhead have not been formally identified (NMFS 2011c); however, principal factors cited for the decline of Puget Sound steelhead are the present or threatened destruction, modification, or curtailment of its habitat or range, including barriers to fish passage and adverse effects on water quality and quantity resulting from dams; the loss of wetland and riparian habitats; and agricultural and urban development activities (72 Fed. Reg. 26722, May 11, 2007). NMFS is currently preparing a recovery plan for the Puget Sound Steelhead DPS, as well as identifying limiting factors specific to steelhead. Once completed, the plan would be implemented to address the limiting factors associated with steelhead. These efforts will continue into the future under all alternatives. Hatchery production under the alternatives would not alter the impact that the factors identified for steelhead decline and described in the steelhead listing determination (72 Fed. Reg. 26722, May 11, 2007) would continue to have on Puget Sound steelhead.

4.2.6.1 Methods for Analysis

The effects analyzed below are the risks and benefits that could be qualitatively reviewed. Most effects are addressed at the hatchery program and basin scales in Appendix H, Steelhead Effects Analysis by Basin, and then summarized at the DPS scale in the EIS. However, one effect (contribution of marine-derived nutrients) is evaluated only at the DPS scale. The following subsections contain the reasoning used to evaluate risks and benefits in each category, followed by summary tables showing risks and benefits by category. The analysis of effects on steelhead from salmon and steelhead hatchery production uses qualitative tools, approaches, and inferences (Table 4.2-12) based on the best available science and described in more detail in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table 4.2-12. Summary of evaluation methods used to determine effects on natural-origin Puget Sound steelhead.

Effect	Evaluation Method
Risks	
Competition	HPV Coarse Filter Tool (for effects from hatchery-origin steelhead), and inferences based on the likelihood for competitive interactions to occur (for effects from hatchery-origin Chinook salmon and coho salmon)
Genetics	HPV Coarse Filter Tool
Hatchery Facilities and Operation	HPV Coarse Filter Tool
Benefits	
Abundance	Adult abundance derived from recent-year smolt-to-adult return survival rates compared to adult abundance reference point derived from return rate goal (PSTT and WDFW 2004)
Viability	Extent of contribution from integrated steelhead conservation hatchery programs, based on the likelihood for viability benefits to occur
Marine-derived Nutrients	Extent of marine-derived nutrient contribution (DPS scale only)

Each of the alternatives are evaluated with regard to the 10 river basins identified in Table 3.2-14 for Puget Sound steelhead, and as described in Appendix H, Steelhead Effects Analysis by Basin. The risks and benefits are developed based on steelhead life history traits (Subsection 3.2.7.1, Life History of Natural-origin Steelhead), and distribution and abundance (Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead) relative to hatchery program releases (Subsection 3.2.7.3, Description of Hatchery-origin Steelhead) within habitat present in each of the 10 river basins that support naturally spawning steelhead that compose the Puget Sound Steelhead DPS (Table 3.2-14). Outside of the marine-derived nutrients benefit, effects are addressed at the hatchery program scale and then summarized at the river basin and DPS scales. Marine-derived nutrients are evaluated only at the DPS scale. The following subsections contain the reasoning used to evaluate risks and benefits in each category, followed by summary tables showing the resulting risks and benefits by category.

As described in Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead, there is a scarcity of data available regarding the status of natural-origin steelhead in Puget Sound compared to other species such as listed Chinook salmon. As a result, the analysis of effects on steelhead from salmon and steelhead hatchery production uses qualitative tools, approaches, and inferences based on the best information that is available (Table 4.2-12).

For the purposes of this EIS, effects of the alternatives on Puget Sound steelhead are evaluated for the entire DPS and organized geographically in the context of the 10 Puget Sound river basins identified by Scott and Gill (2008). This organizational approach considers and encompasses stocks identified in the river basins delineated in WDFW's Salmonid Stock Inventory (WDFW 2002), as well as the populations identified by the Puget Sound Steelhead TRT (Myers et al. 2014) (Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead) (Table 3.2-14).

Because of analytical constraints and the scarcity of available information, where more than one hatchery program affects a population or stock in a river basin, the aggregate effect is rated the same as the highest rating of the programs for the river basin for both risks and benefits (Appendix H, Steelhead Effects Analysis by Basin). This approach is reasonable because it compensates for existing analytical constraints and uses information that is available. Rating the composite risks according to the highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

4.2.6.2 Determining Overall Risks and Benefits

Each risk and most benefits (with the exception of benefits from marine-derived nutrients) for Puget Sound steelhead hatchery programs are evaluated at the river basin and DPS scales using the methods and criteria as described above and detailed in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and applied to the 10 river basins in Appendix H, Steelhead Effects Analysis by Basin. Risks and benefits for each hatchery program are then assigned a numeric score (Table 4.2-4) for summing at the river basin and DPS scales. Unweighted sums of scores within each of the 10 river basins are divided by the respective number of hatchery programs to obtain an average for each river basin. The unweighted averages at the river basin scale are then averaged to obtain an overall mean score for the corresponding risk or benefit level for the DPS. This simple approach weights each river basin equally and allows consistent application across the DPS based on currently available information. For the purposes of this analysis, mean values with fractions less than 0.5 are rounded down, and mean values with fractions greater than or equal to 0.5 are rounded up. Marine-derived nutrient benefits are evaluated at the DPS scale only.

4.2.6.3 Summaries of Risks and Benefits

Where possible, each of the subsections evaluating the risks and benefits of the alternatives concludes with a summary of risks and benefits and their net effect by alternative at the DPS scale. Risk and benefit levels may vary among programs for a particular type of risk or benefit. Levels included in summary tables are averages reflecting arithmetic means. Averages at the river basin scale (Appendix H, Steelhead Effects Analysis by Basin) and at the DPS scale (using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish) are calculated by translating negligible, low, moderate, and high risk or benefit results into numeric values of 0, 1, 2, and 3, respectively. These numeric values are then summed for each appropriate hatchery program or river basin risk or benefit factor, and then divided by the total number of programs or river basins. These values are rounded to the nearest whole number and then translated back into summary descriptions of negligible, low, moderate, and high for each risk and benefit evaluated.

4.2.6.4 Hatchery Release Levels

Risks and benefits to natural-origin steelhead are evaluated considering 133 hatchery programs across Puget Sound (Subsection 1.5.1, Hatchery Facilities in Puget Sound), including 23 steelhead programs, 48 Chinook salmon programs, and 43 coho salmon programs (Appendix H, Steelhead Effects Analysis by Basin). Under Alternative 1, the number of hatchery-origin steelhead released annually into the analysis area is about 2.5 million fish (Table 4.2-13), which is the same as existing conditions. The release level under Alternative 2 would be the same as under Alternative 1.

Table 4.2-13. Releases of steelhead from isolated and integrated hatchery programs into Puget Sound river basins by alternative.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
River Basin	**Number**	**Number**	**Percent Change from Alt. 1**	**Number**	**Percent Decrease from Alt. 1**	**Number**	**Percent Increase from Alt. 1**
Nooksack River (all isolated)	190,000	190,000	0	115,000	39	195,000	3
Skagit River (all isolated)	534,000	534,000	0	267,000	50	564,000	6
Stillaguamish River (all isolated)	220,000	220,000	0	110,000	50	220,000	0
Snohomish River (all isolated)	705,000	705,000	0	352,500	50	705,000	0
Lake Washington	0	0	0	0	0	0	0
Duwamish/ Green River							
Isolated	300,000	300,000	0	150,000	50	358,000	19
Integrated	50,000	50,000	0	50,000	0	50,000	0
Total	**350,000**	**350,000**	**0**	**200,000**	**43**	**408,000**	**17**
Puyallup River							
Isolated	200,000	200,000	0	100,000	50	200,000	0
Integrated	35,000	35,000	0	35,000	0	35,000	0
Total	**235,000**	**235,000**	**0**	**135,000**	**43**	**235,000**	**0**
South Sound	0	0	0	0	0	0	0
Hood Canal (all integrated)	49,450	49,450	0	49,450	0	49,450	0
Strait of Juan de Fuca							
Isolated	10,000	10,000	0	5,000	50	10,000	0
Integrated	175,000	175,000	0	175,000	0	175,000	0
Total	**185,000**	**185,000**	**0**	**180,000**	**3**	**185,000**	**0**
TOTALS for DPS							
Isolated	**2,159,000**	**2,159,000**	**0**	**1,099,500**	**49**	**2,252,000**	**4**
Integrated	**309,450**	**309,450**	**0**	**309,450**	**0**	**309,450**	**0**
Grand Total	**2,468,450**	**2,468,450**	**0**	**1,408,950**	**43**	**2,561,450**	**4**

Under Alternative 3, steelhead hatchery production designed to produce fish for harvest would decrease by 50 percent compared to Alternative 1 in watersheds where recovery category 1 and 2 Chinook salmon populations occur, but would not be reduced in watersheds with recovery category 3 Chinook salmon populations (categories are shown in Table 2.2-1 and described in Box 2-2) (Table 2.4-3). Under Alternative 3, the number of hatchery-origin steelhead released into the analysis area would be about 1.4 million fish (Table 4.2-13). There would be no changes to production levels for integrated conservation hatchery programs designed to aid recovery (Table 4.2-13). Some steelhead river basins may contain hatchery production associated with recovery category 1, recovery category 2, and recovery category 3 Chinook salmon populations, isolated programs intended to enhance harvest, and integrated conservation programs intended to aid recovery. For this reason, the release numbers and percent changes shown in Table 4.2-13 for the Nooksack River basin reflect steelhead hatchery production from different types of programs.

Under Alternative 4, steelhead production would increase to provide increased fishing opportunities (Subsection 2.4.5, Alternative 4 [Increased Production]). Increases in hatchery releases would only occur to the extent that additional hatchery capacity meets the needs of the fish (e.g., appropriate availability of water quantity, water quality, water temperature, space, and timing). Under Alternative 4, the number of hatchery-origin steelhead released into the analysis area would be about 2.6 million fish (Table 4.2-13). There would be no changes in steelhead integrated conservation programs designed to aid recovery.

More detail on effects within steelhead river basins is provided in Appendix H, Steelhead Effects Analysis by Basin. Effects for the DPS are summarized in this subsection.

4.2.6.5 Life History of Natural-origin Steelhead

As described in Subsection 3.2.7.1, Life History of Natural-origin Steelhead, steelhead have unique life history traits that reflect the variability of aquatic habitat conditions unique to each river basin. Life history differences within and among steelhead that occur in the 10 river basins represent the genetic and behavioral diversity within the DPS that allows the species to adapt to short-term and long-term habitat changes over time. The life history diversity attributes of natural-origin steelhead would be the same under any alternative because variations in hatchery production would not impact these attributes. Life history diversity attributes include:

- Timing and location of incubation, hatching, and fry emergence
- Juvenile residence times in fresh water, estuaries, and marine water

- Out-migration timing
- Return timing of adults to fresh water for spawning
- Occurrence of stream-type and ocean-type life histories
- Timing and age of fish upon return
- Habitat locations preferred for cover, feeding, and spawning

4.2.6.6 Distribution and Abundance of Natural-origin Steelhead

As described in Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead, WDFW identified 53 Puget Sound steelhead stocks, Scott and Gill (2008) identified 10 river basins where steelhead occur, and the Puget Sound Steelhead TRT identified 32 demographically independent steelhead populations in three major population groups (Myers et al. 2014) (Table 3.2-14). The distribution of natural-origin steelhead in river basins used for spawning and juvenile rearing, and their occurrence in marine areas, would be the same under any alternative because variations in hatchery production would not impact their distribution. However, abundance of listed steelhead may vary in response to changes in production from listed (integrated) hatchery programs (Table 3.2-5) associated with the action alternatives as described in Subsection 4.2.6.12, Benefits - Viability.

Along with ongoing recovery actions for Puget Sound salmon and changes in other factors that influence salmon and steelhead populations (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead), hatchery production under the alternatives may affect abundance of natural-origin steelhead over the long term. However, while reduced risks have likely benefits to natural-origin steelhead, changes in abundance associated with risks specifically attributable to hatchery production under the alternatives would not be measurable. These risks cannot be quantified because of the inherent variability in abundance of the steelhead that compose the DPS (Ford 2011). Further, such variability cannot be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.6.7 Characteristics of Hatchery-origin Steelhead

Hatchery-origin steelhead are currently released in the analysis area as yearlings, predominantly in May at an average size of 8.1 inches fork length (206 mm) (Table 3.2-4). The hatchery-origin fish are often released high in the watershed and out-migrate rapidly, spending little time in fresh water

(Subsection 3.2.7.3, Description of Hatchery-origin Steelhead). Under all alternatives, the following characteristics of the hatchery environment and hatchery-origin steelhead releases would be the same:

- Size and age of fish at release
- Times and locations of releases
- Residence times and out-migration of hatchery-origin fish in fresh water (including residualism), estuarine water, or marine water

Because these characteristics would not change under any alternative, the alternatives would not affect hatchery conditions such as type and number of broodstock used, spawning methods, incubation methods, juvenile rearing methods, and life stage and condition of hatchery-origin fish, as described in Subsection 3.2.3.4, Risks - Hatchery Facilities and Operation, and Appendix B, Hatchery Effects and Evaluation Methods for Fish).

4.2.6.8 Risks - Competition

Under Alternative 1, the overall effect to natural-origin steelhead smolts from competition would be a moderate risk from yearling releases of steelhead (average score would be 1.6) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.1, Risks - Competition). Under Alternative 1, the overall effect to natural-origin steelhead smolts from competition would be a moderate risk from yearling releases of Chinook salmon and coho salmon (average scores would be 1.6 and 2.3, respectively) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.1, Risks - Competition). Competition risks to natural-origin steelhead smolts from yearling releases of hatchery-origin steelhead, Chinook salmon, and coho salmon would be moderate because of similarities in fish size, the times and areas of occurrence, and magnitudes of releases. Overall risks of competition effects under Alternative 2 would be the same as under Alternative 1 (Table 4.2-14).

Under Alternative 3, the overall risk of competition effects to steelhead smolts from releases of hatchery-origin Chinook salmon and coho salmon yearlings would be moderate (average scores would be 1.6 and 2.2, respectively) (Table 4.2-14). Competition risks from steelhead hatcheries would decrease to low (average score would be 0.9) (Table 4.2-14) because releases would be 43 percent less (reduced to about 1.4 million fish) than under Alternative 1 (Table 4.2-13). Effects from decreases in coho salmon production (22 percent) (Table 2.4-1) under Alternative 3 would decrease the average risk score from coho salmon hatcheries to 2.2 from 2.3 under Alternative 1 (Table 4.2-14), but that change would not be enough to change the risk rating compared to Alternative 1. Effects from decreases in Chinook salmon production (18 percent) (Table 2.4-1) would not change the average competition risk score or rating from Chinook salmon hatcheries (average score would continue to be 1.6) (Table 4.2-14). Effects from increases in production under Alternative 4 (increases of 13 percent for Chinook salmon, 4 percent for steelhead, and 27 percent for coho salmon [Table 2.4-1]) would not be substantial enough to change competition risk scores (1.6, 1.6, and 2.3, respectively) (Table 4.2-14) and moderate ratings for these three species, compared to Alternative 1, because their spatial and temporal overlap with natural-origin steelhead would continue.

Table 4.2-14. Summary of risks and benefits for the Puget Sound Steelhead DPS by alternative.

Effect	**Alternative 1 No Action (Average Score)**	**Alternative 2 Proposed Action (Average Score)**	**Alternative 3 Reduced Production (Average Score)**	**Alternative 4 Increased Production (Average Score)**
Risks				
Competition from:				
Steelhead Hatcheries	1.6[1] Moderate	Same as Alternative 1	0.9 Low	Same as Alternative 1
Chinook Salmon Hatcheries	1.6 Moderate	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Coho Salmon Hatcheries	2.3 Moderate	Same as Alternative 1	2.2 Moderate	Same as Alternative 1
Genetics	1.2 Low	Same as Alternative 1	0.8 Low	1.3 Low
Hatchery Facilities and Operation	1.2 Low	Same as Alternative 1	0.8 Low	1.3 Low
Overall Risk	1.6 Moderate	Same as Alternative 1	1.3 Low	Same as Alternative 1
Benefits				
Total Return	1.2 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Viability	0.8 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Marine-derived Nutrients	Negligible	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Overall Benefit	0.7 Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

[1] Where available, average scores by risk and benefit category are shown. Lack of scores indicates results are for the DPS scale only.

4.2.6.9 Risks - Genetics

Under Alternative 1, the overall risk to natural-origin steelhead from genetic effects would be low (average score would be 1.2) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.3, Risks - Genetics). The overall risk rating under all alternatives from genetic effects would be low (average scores would range from 0.8 to 1.3) (Table 4.2-14). The risk would be primarily because of potential gene flow from hatchery-origin steelhead to natural-origin steelhead from the 19 isolated hatchery program releases in most of the river basins (Appendix H, Steelhead Effects Analysis by Basin). As described in Subsection 3.2.7.4.3, Risks - Genetics, the isolated programs use non-listed, out-of-DPS, Chambers Creek winter-run and Skamania Hatchery summer-run steelhead stocks and would negatively affect both the among-population diversity and the fitness of natural-origin steelhead populations (Scott and Gill 2008; Ford 2011). McMillan et al. (2010) came to these same conclusions regarding risks posed by the hatchery release of Chambers Creek winter-run steelhead to the remnant natural-origin winter-run steelhead population in the Elwha River. Effects from decreases in steelhead release levels under Alternative 3 of 43 percent (Table 4.2-13) would reduce the average genetic risk score to 0.8 (Table 4.2-14) compared to Alternative 1, and effects from increases in steelhead release levels under Alternative 4 of 4 percent would increase the average risk score to 1.3 (Table 4.2-14). However, effects from these changes would not be enough to change the genetic risk ratings for either alternative from low, compared to Alternative 1 (Table 4.2-14), because the risks of hatchery-induced selection and genetic introgression to among-population diversity and fitness of natural-origin steelhead (Appendix, B, Hatchery Effects and Evaluation Methods for Fish) would not change substantially.

4.2.6.10 Risks - Hatchery Facilities and Operation

Under Alternative 1, the overall risk to natural-origin steelhead from hatchery facilities and operation effects would be low (average score would be 1.2) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.4, Risks - Hatchery Facilities and Operation). The overall risk rating under all alternatives from hatchery facilities and operation effects would be low (average scores would range from 0.8 to 1.3) (Table 4.2-14). Hatchery facilities and operation factors include broodstock collection practices such as timing, duration, and methods of collection; hatchery water withdrawal and effluent discharge levels; and fish disease pathogen incidence and transfer. The risk is low (but not negligible) because steelhead hatchery programs in about half of the river basins would lack performance standards and indicators in their management plans. As described in Subsection 4.6.3, Water Quality, reductions in hatchery production under Alternative 3 may decrease the contribution of hatchery facility effluent to the total pollutant load of receiving waters and the potential for water quality degradation, compared to

Alternative 1. As a result, the decrease in hatchery production may indirectly improve water quality for steelhead. Conversely, increases in hatchery production under Alternative 4 may increase the contribution of hatchery facility effluent to the total pollutant load of receiving waters and the potential for water quality degradation, compared to Alternative 1. Although effects from changes in steelhead release levels under Alternative 3 and Alternative 4 would decrease and increase risks scores, respectively, these changes would not be enough to change the overall low hatchery facilities and operation risk ratings compared to Alternative 1 (Table 4.2-14), primarily because there would be no changes in performance standards and indicators in management plans.

4.2.6.11 Benefits - Total Return

Under Alternative 1, the overall total return benefit to natural-origin steelhead would be low (average score would be 1.2) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.5, Benefits - Total Return). The overall total return benefit rating under all alternatives would be low (average scores would be 1.2) (Table 4.2-14). Total return benefits would result primarily from the 19 isolated steelhead hatchery programs intended to produce fish for harvest, and to a lesser extent from the four integrated conservation hatchery programs intended to aid recovery of natural-origin steelhead. The ratings would be low because, for most of the 10 river basins in the DPS, the projected total adult returns from natural-origin steelhead and from releases of hatchery-origin steelhead would be less than 50 percent of the restoration spawner abundance estimates for the populations (Appendix H, Steelhead Effects Analysis by Basin).

4.2.6.12 Benefits - Viability

Under Alternative 1, the overall viability benefit to natural-origin steelhead would be low (average score would be 0.8) (Table 4.2-14), the same as existing conditions (Subsection 3.2.7.4.6, Benefits - Viability). The overall viability benefit rating under all alternatives would be low (average scores would be 0.8) (Table 4.2-14). Of the 23 steelhead hatchery programs, four are integrated programs designed to benefit viability (abundance, productivity, diversity, spatial structure) in 4 of the 10 river basins (Appendix H, Steelhead Effects Analysis by Basin). The 19 isolated hatchery programs for steelhead would provide no benefit to population viability parameters (Subsection 3.2.7.4.6, Benefits - Viability).

4.2.6.13 Benefits - Marine-derived Nutrients

A small portion (average 3 percent) of the carcasses distributed into Puget Sound watersheds from WDFW hatcheries each year are hatchery-origin steelhead (Appendix B, Hatchery Effects and Evaluation

Methods for Fish). Under Alternative 1, the overall effect on marine-derived nutrients would be a negligible benefit (Table 4.2-14), which is the same as existing conditions (Subsection 3.2.7.4.7, Benefits - Marine-derived Nutrients). Under Alternative 2, the benefit would be negligible because hatchery production levels would be the same as under Alternative 1 (Table 4.2-13). Under Alternative 3, hatchery-origin steelhead production would decrease 43 percent compared to Alternative 1 (Table 4.2-13), and the benefit would be negligible (Table 4.2-14). Although this reduction is substantial and the benefit would be less, the benefit would remain negligible (the benefit would not decrease to none) because hatchery-origin steelhead would continue to be released and marine-derived nutrient benefits would continue. Under Alternative 4, hatchery-origin steelhead production would increase 4 percent (Table 4.2-13), which would not be sufficient to increase the benefit from negligible, the same as under Alternative 1 (Table 4.2-14), because few additional carcasses would be distributed.

4.2.6.14 Summary of Risks and Benefits by Alternative

Risks and benefits for the Puget Sound Steelhead DPS under each alternative are summarized in Table 4.2-14. With the exception of the marine-derived nutrients benefit, risk and benefit levels summarized in the table reflect averages associated with the 10 natural-origin stocks within the 10 river basins that are described in Appendix H, Steelhead Effects Analysis by Basin. Marine-derived nutrient benefits are described only at the DPS scale. This subsection summarizes overall risks and overall benefits at the DPS scale, by alternative.

Alternative 1 (No Action). Under Alternative 1, considering current risks for all risk categories, the overall risk to the Puget Sound Steelhead DPS would be moderate (average score would be 1.6) (Table 4.2-14). The most important influencing factors are the moderate competition risks to natural-origin steelhead from steelhead, Chinook salmon, and coho salmon hatchery programs, whose average scores would range from 1.6 to 2.3 (Table 4.2-14).

Under Alternative 1, considering current benefits for all benefit categories, the overall benefit would be low (average score would be 0.7) (Table 4.2-14). The most important influencing factors are the low benefits to the total return of natural-origin steelhead from the generally low total returns of adult hatchery-origin steelhead resulting from isolated hatchery programs, and the low benefit to viability because of the limited number of integrated conservation hatchery programs.

Alternative 2 (Proposed Action). Under Alternative 2, considering all categories, the overall risk and overall benefit to natural-origin steelhead would be the same as under Alternative 1 (average scores would be 1.6 and 0.7, respectively) (Table 4.2-14) because the number of fish released would be the same (Table 4.2-13).

Alternative 3 (Reduced Production). Under Alternative 3, considering all risk categories, the overall risk would be low (average score would be 1.3) (Table 4.2-14), which is less than the moderate risk rating under Alternative 1 (average score would be 1.6) (Table 4.2-14). The most important influencing factors are the competition risks (moderate) associated with releases from Chinook salmon and coho salmon hatcheries whose scores would be 1.6 and 2.2, respectively (Table 4.2-14). Compared to Alternative 1, the risk of competition from steelhead hatchery programs, and genetics and hatchery facilities and operation risks, would decrease to low (average scores would be 0.9, 0.8, and 0.8, respectively) (Table 4.2-14) because the number of hatchery-origin steelhead would decrease by 43 percent (or by about 1.1 million fish, to 1.4 million fish) (Table 4.2-13).

Under Alternative 3, considering all benefit categories, the overall benefit would be low (average score would be 0.7) (Table 4.2-14), which is the same as Alternative 1 (Table 4.2-14). The most important influencing factors would be the low benefit to the total return of natural-origin steelhead from the relatively low total returns of adult hatchery-origin steelhead resulting from isolated hatchery programs, and the low benefit to viability because of the limited number of integrated hatchery programs. The 43 percent decrease in hatchery-origin steelhead production under Alternative 3 compared to Alternative 1 (Table 4.2-13) would tend to reduce the low total return benefit from isolated steelhead hatchery programs, but not enough to decrease the total return benefit score from 1.2 or the benefit rating to a negligible level (Table 4.2-14).

Alternative 4 (Increased Production). Under Alternative 4, considering all risk categories, the overall risk would be moderate (average score would be 1.6), the same as under Alternative 1 (Table 4.2-14). The most important influencing factors would be the moderate competition risks from releases from steelhead, Chinook salmon, and coho salmon hatcheries (average scores would be 1.6, 1.6, and 2.3, respectively) (Table 4.2-14). Risk scores for genetic and hatchery facilities and operation risks would increase slightly (average scores for each would be 1.3) (Table 4.2-14), but their risk ratings would each remain low (Table 4.2-14). Overall risks under Alternative 4 would be the same as under Alternative 1 because the increase in numbers of steelhead released would only be 4 percent, or 93,000 fish (Table 4.2-13).

Under Alternative 4, considering all benefit categories, the overall benefit would be low (average score would be 0.7), which would be the same as under Alternative 1 (Table 4.2-14). The most important influencing factors would be the low benefit to the total return of natural-origin steelhead from the relatively low total returns of adult hatchery-origin steelhead resulting from isolated hatchery programs, and the low benefit to viability because of the limited number of integrated hatchery programs. The 4 percent increase in steelhead hatchery production under Alternative 4 compared to Alternative 1 (Table 4.2-13) would positively affect benefits, but this small percentage increase would not be enough to increase the overall low benefit score or rating for the DPS (Table 4.2-14).

4.2.6.15 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect other resources. For example, a measure intended to reduce risks to natural-origin steelhead by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures for steelhead are summarized in Table 4.2-15.

As shown in Table 4.2-15, not all potential mitigation measures would apply to all action alternatives, depending on the objective of the alternative. For example, some risk reduction measures may not be needed under Alternative 3 (Reduced Production). Any mitigation measures that would reduce hatchery production under Alternative 3 would operate within the operational limitations of that alternative.

Table 4.2-15. Examples of potential mitigation measures for steelhead hatchery programs applicable under adaptive management.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Develop performance measures and monitoring plan – applicable to all hatchery programs **Value**[1] – Identifies and implements specific hatchery program measures to reduce competition, predation, genetic risks, and hatchery facilities and operation risks **Constraints**[2] – None		√	√	√
Reduce program size - suggested for specific hatchery programs **Value** – Reduces competition, predation, and genetic risks **Constraints** – Reduces benefits of abundance of hatchery-origin fish available for harvest		√		√
Discontinue program – suggested for specific hatchery programs **Value** – Eliminates all risks from a hatchery program **Constraints** – Eliminates benefits of abundance of hatchery-origin fish available for harvest		√	√	
Develop integrated conservation program **Value** – Uses locally adapted broodstock, reduces genetic risks, and contributes to viability of natural-origin populations **Constraints** – Depending on harvest management objective, may not contribute to abundance of hatchery-origin fish available for harvest		√	√	√
Implement more effective trapping of returning adults **Value** – Reduces genetic and competition risks by removing potential hatchery-origin spawners **Constraints** – None		√	√	√

Table 4.2-15. Examples of potential mitigation measures for steelhead hatchery programs applicable under adaptive management, continued.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Develop more efficient fisheries **Value** – Reduces genetic and competition risks by harvesting a greater number of hatchery-origin adults. Increases number of fish available for harvest **Constraints** – Harvest increases may increase incidental harvest impacts to natural-origin fish		√	√	√
Develop integrated conservation program (using locally adapted broodstock) **Value** – Reduces genetic and competition risks and may contribute to viability of natural-origin populations **Constraints** – Depending on harvest management objective, may not contribute to total return benefits from hatchery-origin fish available for harvest. Reduces the number of locally adapted natural-origin fish available to spawn naturally		√	√	√
Develop and implement plan for monitoring and reducing pHOS **Value** – Results would help reduce genetic and competition risks **Constraints** – None		√	√	√
Apply broodstock collection and mating practices that ensure that the hatchery-origin population does not diverge more than moderately from the donor natural population **Value** – Reduces genetic risks **Constraints** – None		√	√	√
Alter juvenile release strategy **Value** – Reduces competition and predation risks in freshwater and marine areas **Constraints** – None		√	√	√

Table 4.2-15. Examples of potential mitigation measures for steelhead hatchery programs applicable under adaptive management, continued.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Develop and use acclimation ponds **Value** - Reduces competition and genetic risks by increasing the likelihood that hatchery fish will out-migrate promptly from streams after release, and improves survival and homing of returning fish to desired harvest or natural production areas **Constraints** - None		√	√	√
Upgrade all intakes, when feasible, to current standards **Value** - Reduces hatchery facility and operations risks **Constraints** - None		√	√	√
Improve hatchery infrastructure such as hatchery weirs and water intakes **Value** - Increases efficiency and reduces flood or fish passage-related hatchery facilities and operation risks **Constraints** - None		√	√	√

[1] Value describes how the measure may reduce risks.
[2] Constraints describe how the measure may reduce benefits.

Under adaptive management, in addition to applicable updated or new BMPs that may become available, the primary proposed mitigation measures implemented to reduce or eliminate negative impacts to steelhead would be those associated with managing the number and proportion of hatchery-origin fish in natural spawning areas (also known as pHOS), reducing hatchery program size (number of hatchery-origin fish released), and/or discontinuing hatchery programs. In general, those measures would reduce negative impacts to fish resources by reducing juvenile competitive and predatory interactions, genetic risks to natural-origin fish, and hatchery facilities and operation risks.

4.2.7 Washington Coastal-Puget Sound Bull Trout DPS

Described in this subsection are the effects of salmon and steelhead hatchery programs on the portion of the threatened Washington Coastal-Puget Sound Bull Trout DPS within the analysis area (i.e., Puget Sound westward, including the Elwha River) (Subsection 4.2.2, Analysis Area [Fish]). The entire bull trout DPS also includes areas (coastal) that are outside the analysis area. Risk and benefit categories evaluated are as described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Subsection 4.2.3, Overall Methods for Analyzing Effects. Methods used to analyze effects by risk and benefit categories are described in more detail in Subsection 4.2.7.1, Methods for Analysis, and Subsection 4.2.7.2, Determining Overall Risks and Benefits. Effects are described following the methods subsection, initially by risk and benefit category. There is no hatchery production of bull trout in the analysis area.

As described in Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS, factors that limit recovery of the DPS in the analysis area are associated with habitat degradation (including water temperature [bull trout prefer colder streams typical of headwaters], and lack of cover [bull trout require complex cover forms, including large woody debris, undercut banks, bounders, and pools]), lack of channel form and stability, lack of spawning and rearing substrate, lack of migratory corridors, and continued human disturbance. Of these factors, the lack of migratory corridors (i.e., barriers to bull trout migration) is related to hatchery programs in the analysis area because temporary or permanent barriers may be used in hatchery operations. The draft recovery plan for listed bull trout addresses these limiting factors and, through its implementation, is helping to restore, conserve, and protect the DPS and its habitat (USFWS 2004a, 2004b). Recovery plan implementation will continue into the future under all alternatives (Chapter 5, Cumulative Effects). Releases of hatchery-origin fish under the alternatives would not alter the impact that limiting factors would continue to have on the portion of the Washington Coastal-Puget Sound Bull Trout DPS that is in the analysis area.

4.2.7.1 Methods for Analysis

Risks and benefits to bull trout are evaluated for the 48 hatchery programs in the analysis area that operate in the 9 bull trout core areas (Subsection 3.2.8.2, Distribution and Abundance of Bull Trout), including 23 steelhead programs, 16 coho salmon programs, and 9 Chinook salmon programs.

The effects analyzed below consist of risks and benefits that are qualitatively reviewed. The risks and benefits analyzed were determined based on bull trout life history traits (Subsection 3.2.8.1, Life History of Bull Trout) and bull trout distribution and abundance (Subsection 3.2.8.2, Distribution and Abundance of Bull Trout) relative to hatchery program releases (Subsection 3.2.4.2, Hatchery Programs Reviewed) within habitat occupied by bull trout in the analysis area, and based on the relationships between bull trout and salmon and steelhead (Section 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout]). One risk (i.e., hatchery facilities and operation risk associated with migration barriers) is evaluated at the hatchery program and bull trout core area level, and one benefit (i.e., viability) is evaluated at the DPS scale. The analysis of effects on bull trout from salmon and steelhead hatchery production uses qualitative inferences based on the best available science and described in more detail in Appendix B, Hatchery Effects and Evaluation Methods for Fish. The following subsections contain reasoning and summary tables for the risk and benefit.

Risks to bull trout in the analysis area are evaluated based on the likelihood of impacts from hatchery-related barriers to migration of bull trout. Risks consider the location of the hatchery structures associated with the 48 salmon and steelhead hatchery programs in the 9 bull trout core areas, bull trout use of the areas where structures are located, and the identified risk status of the core area in general. The benefits to bull trout are evaluated considering the extent to which hatchery programs may contribute to bull trout viability, and based on the likelihood of bull trout predation on salmon and steelhead in marine areas.

Hatchery-related risk and benefit levels are assigned in the context of other factors identified as limiting the survival and viability of bull trout in relevant Federal (USFWS 2004a, 2004b, 2008a) and state (WDFW 2004) status review documents. Thus, the assigned risk levels would be commensurate with the extent to which the hatchery-related risk contributes to overall risks faced by the species. Considering the limiting factors identified for bull trout (Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS), one limiting factor is related to hatchery programs (i.e., migratory corridors). Dams and barriers associated with fish passage facilities in bull trout migratory corridors have been identified as a factor in isolating bull trout populations if the barriers do not provide adequate two-way passage for subadults and adults (USFWS 2004a, 2004b).

4.2.7.2 Determining Overall Risks and Benefits

The one risk (hatchery facilities and operation) and one benefit (viability) for bull trout are evaluated using the methods and criteria detailed in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and applied to the bull trout core areas and the analysis area. The hatchery facilities and operation risk is associated with migration barriers, and based on information compiled from evaluations of 13 individual hatchery program facilities. Applicable migration barriers are assigned a numeric score (Table 4.2-16) for summing at the analysis area scale. Individual scores are summed and divided by the total number of hatchery-related bull trout migration barriers evaluated, resulting in a mean score representing the risk at the analysis area scale. For the purposes of this analysis, mean values with fractions less than 0.5 are rounded down, and the assigned risk level reflects the lower number. Fractions greater than or equal to 0.5 are rounded up, and the assigned risk level reflects the higher number. Viability benefits are evaluated only at the analysis area scale and a single benefit rating is identified.

Table 4.2-16. Numeric scoring of risk levels.

Risk Level	Score
Negligible	0
Low	1
Moderate	2
High	3

4.2.7.3 Life History of Bull Trout

As described in Subsection 3.2.8.1, Life History of Bull Trout, there are four life history patterns and traits represented by bull trout (i.e., resident, fluvial, adfluvial, and anadromous). The life history patterns pertain primarily to differences in migration within and between freshwater and marine areas. Under all alternatives, these life history patterns and traits for bull trout would be the same:

- Habitat locations for spawning, rearing, migration, and feeding
- Timing of spawning
- Juvenile residence times and locations used for rearing
- Migration timing within and between freshwater areas and marine areas
- Size and age
- Preferred food and feeding

These attributes would be the same under all alternatives because hatchery production associated with the alternatives would not impact the aquatic habitat of bull trout.

4.2.7.4 Distribution and Abundance of Bull Trout

As described in Subsection 3.2.8.2, Distribution and Abundance of Bull Trout, bull trout are distributed in core areas and watersheds in the analysis area. Under all alternatives, bull trout would continue to occur at the same locations as described under existing conditions (Subsection 3.2.8.2, Distribution and Abundance of Bull Trout). Changes in abundance of bull trout associated with risks and benefits specifically attributable to hatchery-origin salmon and steelhead production under the action alternatives may occur based on the relationship of bull trout to salmon and steelhead as described in Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout). However, changes in the abundance of bull trout would not be expected to vary substantially in response to changes in hatchery production under the action alternatives, because salmon and steelhead likely form a relatively minor component of the overall bull trout prey base (Subsection 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout], and Subsection 4.2.7.6, Benefits - Viability).

4.2.7.5 Risks - Hatchery Facilities and Operation

The overall risk of hatchery facilities and operation risks to bull trout associated with the 13 identified hatchery-related migration barriers in the analysis area (described in Subsection 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout]), are summarized in this subsection. Details on each of these hatchery structures that affect 9 bull trout core areas are contained in Appendix B, Hatchery Effects and Evaluation Methods for Fish. With one exception (Dungeness Hatchery), hatchery facilities and operation risks to bull trout at individual structures is negligible or low under all alternatives (Appendix B, Hatchery Effects and Evaluation Methods for Fish) because the structures are not in bull trout core areas, bull trout do not use the areas where structures are located, and/or because of the risk status of the core area in general. At the Dungeness Hatchery, the risk is moderate because the water intake is a permanent structure that does not allow passive fish passage. In addition, the Dungeness River core area has high risk status (USFWS 2008a). However, it is unlikely that the effects of hatchery structures substantially impact or impede the recovery of bull trout at the analysis area scale because the effect is localized to one core area (the Dungeness River).

Considering all potential hatchery barriers and under all alternatives, the overall risk of effects from migration barriers to bull trout would be low (Table 4.2-17), which is the same as existing conditions, because most hatchery-related migration barriers would operate seasonally for a few months of the year and would be manually operated to move any bull trout present either upstream or downstream of the barrier. Over the majority of the year, the structures would continue to provide upstream and downstream passage. The risk would not change among alternatives because operation and use of the facilities would be the same under all alternatives. Changes in hatchery production among the alternatives would not affect operation of existing migration barriers.

Table 4.2-17. Summary of risks and benefits for the Washington Coastal-Puget Sound Bull Trout DPS in the analysis area by alternative.

Effect	**Alternative 1 (No Action)**	**Alternative 2 (Proposed Action)**	**Alternative 3 (Reduced Production)**	**Alternative 4 (Increased Production)**
Risk				
Hatchery Facilities and Operation (migration barriers)	Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Benefit				
Viability	Low	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

4.2.7.6 Benefits - Viability

As described in Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout), benefits can accrue to the viability of bull trout from increases in their food supply (including hatchery-origin salmon and steelhead as prey for bull trout). Overall, the contribution of hatchery-origin fish to the bull trout food base is most likely in marine areas, because that is where hatchery-origin fish co-mingle with bull trout on their way to the ocean. However, the effect of salmon and steelhead hatchery programs on bull trout is low, because salmon and steelhead likely form a relatively minor component of the overall bull trout prey base in marine areas.

Under Alternative 1, the overall viability benefit to bull trout from hatchery programs would be low (Table 4.2-17), which would be the same as existing conditions (Subsection 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout]). Under Alternative 2, hatchery production would be the same as under Alternative 1 (Table 2.4-1), and the overall viability benefit would also be the same (low). Compared to Alternative 1, the 8 percent decrease in hatchery production under Alternative 3 (Table 2.4-1) would reduce the viability benefit to bull trout, whereas the 16 percent increase in hatchery production under Alternative 4 would increase the viability benefit. However, the effects from these changes in hatchery production would not be substantial enough to change the viability benefit to bull trout from low (Table 4.2-17), because hatchery production under all alternatives would form a relatively minor component of the overall prey base for bull trout, including in marine areas.

4.2.7.7 Summary of Risks and Benefits by Alternative

Risks and benefits for bull trout within the analysis area under each alternative are summarized in Table 4.2-17. As described in Subsection 4.2.7.1, Methods for Analysis, risk levels in the table reflect averages from the 13 hatchery programs evaluated in 9 core areas, and benefit levels are based on analysis at the analysis area scale only. Considering current risks, under all alternatives, the hatchery facilities and operation risk to bull trout posed by hatchery-related migration barriers would be low, because operation and use of the facilities would be the same under all alternatives, and changes in hatchery production among the alternatives would not affect operation of existing migration barriers. Similarly, considering current benefits, under all alternatives, the viability benefit from hatchery-origin salmon and steelhead as prey for bull trout in marine areas would be low, because hatchery production under all alternatives would form a relatively minor component of the overall prey base for bull trout, including in marine areas.

4.2.7.8 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks or benefits to other fish or resources. For example, a measure intended to reduce risks to natural-origin salmon and steelhead by decreasing hatchery production would also reduce the potential benefits to bull trout afforded by increasing their prey base, and would also reduce the negative impacts to human health associated with hatchery chemicals. A proposed potential mitigation measure for bull trout is summarized in Table 4.2-18.

Table 4.2-18. Example of a potential mitigation measure for hatchery programs beneficial to bull trout that would be applicable under adaptive management.

Mitigation Measure	Alternative			
	Alternative 1 (No Action)	**Alternative 2 (Proposed Action)**	**Alternative 3 (Reduced Production)**	**Alternative 4 (Increased Production)**
Upgrade all intakes, when feasible, to current standards **Value**[1] - Reduces hatchery facility and operations risks **Constraints**[2] - None		√	√	√

[1] Value describes how the measure may reduce risks.
[2] Constraints describe how the measure may reduce benefits.

Under adaptive management, in addition to applicable updated or new BMPs that may become available, the primary proposed mitigation measure implemented to reduce or eliminate negative impacts to fish resources that would also be beneficial to bull trout would be the measure associated with upgrading water intakes (e.g., at the Dungeness Hatchery). In general, this measure would reduce negative impacts to bull trout by improving hatchery facilities and operation risk. This mitigation measure would be beneficial in reducing an impact identified as a limiting factor (i.e., migratory corridors) to bull trout.

4.2.8 Puget Sound/Strait of Georgia Coho Salmon ESU

Described in this subsection are the effects of salmon and steelhead hatchery programs on the non-listed Puget Sound/Strait of Georgia Coho Salmon ESU. The effects analysis for coho salmon was based on coho salmon life history traits (Subsection 3.2.9.1, Life History of Natural-origin Coho Salmon), and its distribution and abundance (Subsection 3.2.9.2, Distribution and Abundance of Natural-origin Coho Salmon) relative to hatchery program releases (Appendix A, Puget Sound Hatchery Programs and Facilities, and Subsection 3.2.9.3, Description of Hatchery-origin Coho Salmon) and hatchery program risks and benefits to coho salmon (Subsection 3.2.9.4, Hatchery Program Risks and Benefits). As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for non-listed salmon as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. As described in Subsection 3.2.9, Puget Sound/Strait of Georgia Coho Salmon ESU, factors for the decline of Puget Sound coho salmon include hatchery production (which has affected genetic risks such as hybridization and introgression, and indirect changes from competition, predation and disease, and loss of locally adapted populations), harvest, logging, agriculture, urbanization, dams and hydropower, flood control, pollution, drought, and unfavorable ocean production conditions. Except for genetic and competition risks to coho salmon associated with hatchery production, the alternatives would not alter the impact that the factors identified for the decline of coho salmon (NMFS 2009a) would continue to have on the Puget Sound/Strait of Georgia Coho Salmon ESU.

4.2.8.1 Life History, Distribution, and Abundance of Natural-origin Coho Salmon

None of the alternatives would affect natural-origin coho salmon life history attributes discussed in Subsection 3.2.9.1, Life History of Natural-origin Coho Salmon, because changes in hatchery production under the alternatives would not impact coho salmon aquatic habitat. As described in Subsection 3.2.9.2, Distribution and Abundance of Natural-origin Coho Salmon, the distribution of coho salmon would not be affected under the alternatives because hatchery-origin fish generally migrate directly to marine water once released and do not displace other natural-origin salmon and steelhead. However, hatchery production changes under the alternatives may affect risks and benefits to coho salmon (Subsection 3.2.9.4, Hatchery Program Risks and Benefits). Changes in risks and benefits associated with changes in hatchery production under the action alternatives could affect overall abundance of natural-origin coho salmon as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, and Subsection 3.2.9.2, Distribution and Abundance of Natural-origin Coho Salmon. However, changes in the abundance of natural-origin coho salmon associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the action alternatives would not be measurable because of the inherent variability in abundance of the ESU (Table 3.2-15), and would not be able to be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.8.2 Hatchery-origin Coho Salmon

Hatchery-origin coho salmon are currently released in the analysis area from 43 hatchery programs from April through June and predominantly as yearlings at an average size of 5.5 inches fork length (140 mm) (Table 3.2-4). None of the alternatives would affect the attributes of the hatchery-origin coho salmon released (Subsection 3.2.9.3, Description of Hatchery-origin Coho Salmon) because hatchery operations would not change under the alternatives.

4.2.8.3 Risks and Benefits

Releases of yearling hatchery-origin Chinook salmon, steelhead, and coho salmon result in the greatest risk of impacting natural-origin coho salmon through competition and predation in fresh water (Subsection 3.2.9.4.1, Risks - Competition) when the fish are released during the peak out-migration period for natural-origin coho salmon (Figure 3.2-9). In marine waters, competition risks to natural-origin coho salmon are greatest from hatchery-origin coho salmon yearlings (Subsection 3.2.9.4.1, Risks - Competition) while predation risks in marine waters are greatest from the large subadult Chinook and coho salmon (Subsection 3.2.9.4.2, Risks - Predation). In general, competition risks are greatest where large numbers of hatchery-origin coho salmon yearlings are released compared to the number of natural-origin coho salmon present. Similarly, predation risks are greatest when substantial numbers of larger hatchery-origin yearling and subyearling Chinook salmon, coho salmon, and steelhead are released, and especially when such releases are made high in watersheds, which increases the predation exposure time for natural-origin coho salmon.

Predation risks to natural-origin coho salmon in marine areas are greatest from hatchery-origin subadult (resident) Chinook salmon and coho salmon when the natural-origin coho salmon are of a small enough size to be vulnerable to predation. These risks are greatest where large numbers of hatchery-origin coho salmon yearlings are released compared to the number of natural-origin fish present. Hatchery-origin coho salmon may genetically impact natural-origin coho salmon when hatchery-origin coho salmon that have been affected by hatchery-induced selection stray into and spawn with natural-origin coho salmon in natural spawning areas (Subsection 3.2.9.4.3, Risks - Genetics). Hatchery facilities and operation risk to coho salmon is not substantial because compliance with BMPs at the ESU scale is generally good (Subsection 3.2.9.4.4, Risks - Hatchery Facilities and Operation). Production of hatchery-origin coho salmon that increases total returns benefits to fisheries harvest (Subsection 3.2.9.4.5, Benefits - Total Return), may benefit the viability of natural-origin coho salmon from integrated coho salmon programs (Subsection 3.2.9.4.6, Benefits - Viability), and provides a moderate benefit to marine-derived nutrients in watersheds from carcasses (Subsection 3.2.9.4.7, Benefits - Marine-derived Nutrients).

4.2.8.4 Alternative 1 (No Action) and Alternative 2 (Proposed Action)

Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to natural-origin coho salmon compared to existing conditions. Hatchery production under Alternative 1 has been cited as a factor for decline of natural-origin coho salmon. Under Alternative 2, the number of hatchery-origin coho salmon released would be the same as under Alternative 1, and the risks and benefits would be the same. Under Alternative 2, hatchery production would continue to be a factor for decline of coho salmon because hatchery production would be the same as under Alternative 1.

4.2.8.5 Alternative 3 (Reduced Production)

Under Alternative 3, hatchery production would decrease 22 percent for coho salmon, 18 percent for Chinook salmon, and 43 percent for steelhead, resulting in an overall decrease of 8 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Correspondingly, competition and predation risks with hatchery-origin Chinook salmon, coho salmon, and steelhead in fresh water and marine water, and hatchery facilities and operation risk would decrease. Genetic risks to natural-origin coho salmon would also decrease, which would be beneficial to natural-origin coho salmon. These reductions in risk would be beneficial to coho salmon because hatchery production has been cited as a factor for coho salmon decline (NMFS 2009a).

Under Alternative 3, the decreased production of coho salmon would reduce the beneficial effects on total returns of coho salmon that would be available for commercial, recreational, and tribal harvest, and decrease benefits to the viability of natural-origin coho salmon from integrated hatchery programs, compared to Alternative 1. In addition, decreased production of coho salmon would result in fewer fish carcasses available to provide moderate marine-derived nutrient benefits in watersheds used by coho salmon.

4.2.8.6 Alternative 4 (Increased Production)

Under Alternative 4, hatchery production would increase 27 percent for coho salmon, 13 percent for Chinook salmon, and 4 percent for steelhead, resulting in an overall increase of 16 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Under Alternative 4, competition and predation risks from hatchery-origin Chinook salmon, steelhead, and coho salmon, and genetic risks from hatchery-origin coho salmon would increase compared to Alternative 1. These increases in risk would not be beneficial to coho salmon because hatchery production has been cited as a factor for coho salmon decline (NMFS 2009a). Under Alternative 4, hatchery facilities and operation risk would not be expected to change because compliance with BMPs would not change substantially, compared to Alternative 1. The increase in hatchery production under Alternative 4 would increase total return benefits, and may increase benefits to the viability of natural-origin coho salmon by increasing the abundance and spatial structure of fish from integrated hatchery programs, compared to Alternative 1. In addition, under Alternative 4, the increased number of carcasses would continue to provide moderate marine-derived nutrient benefits to the ecosystem, compared to Alternative 1.

4.2.8.7 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources. For example, a measure intended to reduce risks to natural-origin fish (e.g., coho salmon) by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.9 Puget Sound/Strait of Georgia Chum Salmon ESU

Described in this subsection are the effects of salmon and steelhead hatchery programs on the Puget Sound/Strait of Georgia Chum Salmon ESU. As described in Subsection 3.2.10, Puget Sound/Strait of Georgia Chum Salmon ESU, the ESU does not warrant listing. This review focuses on fall-run chum salmon because they are abundantly distributed throughout the Puget Sound/Strait of Georgia Chum Salmon ESU, and because all chum salmon hatchery production in the ESU is of the fall-run type. The effects analysis for chum salmon was based on natural-origin fall-run chum salmon life history traits (Subsection 3.2.10.1, Life History of Natural-origin Chum Salmon) and its distribution and abundance (Subsection 3.2.10.2, Distribution and Abundance of Natural-origin Chum Salmon) relative to hatchery program releases (Appendix A, Puget Sound Hatchery Programs and Facilities; and Subsection 3.2.10.3, Description of Hatchery-origin Chum Salmon), and hatchery program risks and benefits to chum salmon (Subsection 3.2.10.4, Hatchery Program Risks and Benefits). As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for non-listed salmon and trout as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

4.2.9.1 Life History, Distribution, and Abundance of Natural-origin Chum Salmon

None of the alternatives would affect natural-origin chum salmon life history attributes discussed in Subsection 3.2.10.1, Life History of Natural-origin Chum Salmon, because changes in hatchery production under the alternatives would not impact chum salmon aquatic habitat. As described in Subsection 3.2.10.2, Distribution and Abundance of Natural-origin Chum Salmon, the distribution of chum salmon would not be affected under the alternatives because the hatchery-origin fish migrate directly to marine water once released. However, hatchery production changes under the alternatives may affect risks and benefits to chum salmon (Subsection 3.2.10.4, Hatchery Program Risks and Benefits). Changes in risks and benefits associated with changes in hatchery production under the action alternatives could affect overall abundance of natural-origin chum salmon as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, and Subsection 3.2.10.2, Distribution and Abundance of Natural-origin Chum Salmon. However, changes in the abundance of natural-origin chum salmon associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the action alternatives would not be measurable because of the inherent variability in abundance of the ESU (Table 3.2-16), and would not be able to be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.9.2 Hatchery-origin Chum Salmon

Hatchery-origin chum salmon are currently released in the analysis area from 14 hatchery programs as fry from mid-March through May at an average size of 2.0 inches fork length (50 mm) (Table 3.2-4). None of the alternatives would affect the attributes of the hatchery-origin chum salmon released (Subsection 3.2.10.3, Description of Hatchery-origin Chum Salmon) because hatchery operations would not change under the alternatives.

4.2.9.3 Risks and Benefits

Releases of hatchery-origin Chinook salmon, coho salmon, fall-run chum salmon, pink salmon, sockeye salmon, and steelhead may affect natural-origin fall-run chum salmon because of overlaps in space and time that lead to competition or predation effects. As described in Subsection 3.2.10.4, Hatchery Program Risks and Benefits, risks of competition from hatchery-origin fish to natural-origin fall-run chum salmon occur primarily from hatchery-origin pink salmon in fresh water and chum salmon in marine areas because of their similar size, and spatial and temporal overlap (Subsection 3.2.10.4.1, Risks - Competition). Competition effects from pink salmon are limited to Whatcom Creek near Bellingham Bay, Finch Creek near Hood Canal, and in the Elwha River, where pink salmon are released. Effects of competition with hatchery releases of chum salmon fry on natural-origin fall-run chum salmon are limited to estuarine and marine waters where the fish co-occur before migrating to the ocean (Subsection 3.2.10.4.1, Risks - Competition).

Predation risks occur from hatchery-origin Chinook salmon and coho salmon yearlings in fresh water (and possibly to a lesser extent in marine water) where the large Chinook salmon and coho salmon feed on the small chum salmon fry (Subsection 3.2.10.4.2, Risks - Predation). Predation risks from hatchery-origin Chinook salmon and coho salmon yearlings occur because the hatchery-origin fish are released during the peak out-migration period of natural-origin fall-run chum salmon (Figure 3.2-4), and are greatest where the numbers of hatchery-origin salmon released are large compared to the number of natural-origin fall-run chum salmon present in the areas of release (Subsection 3.2.10.4.2, Risks - Predation). Other hatchery releases have minimal impacts because of fish size at release, release timing, different interspecific diet preferences, and the rapid movement of natural-origin fall-run chum salmon fry to marine waters. Hatchery facilities and operation risk to chum salmon is low because compliance with BMPs at the ESU scale is generally good (Subsection 3.2.10.4.4, Risks - Hatchery Facilities and Operation).

Hatchery programs for fall-run chum salmon provide total return, viability, and marine-derived nutrient benefits. Hatchery production increases total returns that would benefit fisheries harvest as described under Subsection 3.2.10.4.5, Benefits - Total Return, may provide benefits to viability of natural-origin chum salmon as described under 3.2.10.4.6, Benefits - Viability, and contributes a negligible benefit to marine-derived nutrients in watersheds from carcasses (Subsection 3.2.10.4.7, Benefits - Marine-derived Nutrients).

4.2.9.4 Alternative 1 (No Action) and Alternative 2 (Proposed Action)

Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to natural-origin fall-run chum salmon compared to existing conditions. Under Alternative 2, the number of hatchery-origin chum salmon released would be the same as under Alternative 1, and the risks and benefits would be the same.

4.2.9.5 Alternative 3 (Reduced Production)

Under Alternative 3, hatchery production would decrease 1 percent for fall-run chum salmon, 18 percent for Chinook salmon, and 22 percent for coho salmon, and would not change for pink salmon, resulting in an overall decrease of 8 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Correspondingly, competition effects would not be expected to change compared to Alternative 1 because of the minimal or no change in fall-run chum salmon and pink salmon releases, respectively. Under Alternative 3, hatchery facilities and operation risks would also not be expected to change because of the small change in fall-run chum salmon releases, compared to Alternative 1. However, predation impacts from hatchery-origin fish would decrease under Alternative 3 because of the decrease in releases of Chinook salmon and coho salmon yearlings, which would be beneficial to natural-origin juvenile fall-run chum salmon. Under Alternative 3, decreases in production of fall-run chum salmon would not be sufficient to substantially decrease the total return benefits from hatchery-origin fall-run chum salmon available for harvest, decrease the likelihood of benefits to the viability of natural-origin fall-run chum salmon from integrated hatchery programs, or decrease marine-derived nutrient benefits in watersheds used by chum salmon, compared to Alternative 1.

4.2.9.6 Alternative 4 (Increased Production)

Under Alternative 4, hatchery production would increase 28 percent for fall-run chum salmon, 13 percent for Chinook salmon, 11 percent for pink salmon, and 27 percent for coho salmon, resulting in an overall increase of 16 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Under Alternative 4, these increases would result in greater competition and predation risks than under Alternative 1. These risks include an increase in competition with hatchery-origin pink salmon in fresh water and hatchery-origin chum salmon in marine water, as well as an increase in predation on natural-origin chum salmon from hatchery-origin yearling Chinook salmon and coho salmon in fresh water. Under Alternative 4, hatchery facilities and operation risk would not be expected to change because the increase in fall-run chum salmon production would be unsubstantial, and because compliance with BMPs would not change compared to Alternative 1. Under Alternative 4, the increases in hatchery fall-run chum salmon production would increase the total return benefits, and may increase benefits to the viability of natural-origin fall-run chum salmon by increasing the abundance and spatial structure of fish from integrated hatchery programs, compared to Alternative 1. In addition, under Alternative 4, the increase in fall-run chum salmon hatchery production and associated hatchery-origin carcasses would increase the marine-derived nutrient benefit from a negligible benefit to a low benefit.

4.2.9.7 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources. For example, a measure intended to reduce risks to natural-origin fish (e.g., chum salmon) by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.10 Odd-year and Even-year Pink Salmon ESUs

Described in this subsection are the effects of salmon and steelhead hatchery programs on the non-listed odd-year and even-year pink salmon ESUs. The majority of pink salmon in the analysis area return in odd-numbered years. The Even-year Pink Salmon ESU is confined to fish that spawn in even-numbered years in the Snohomish River. As described in Subsection 3.2.11, Odd-year and Even-year Pink Salmon ESUs, the ESUs are not listed. The effects analysis for pink salmon was based on pink salmon life history traits (Subsection 3.2.11.1, Life History of Natural-origin Pink Salmon) and pink salmon distribution and abundance (Subsection 3.2.11.2, Distribution and Abundance of Natural-origin Pink Salmon) relative to hatchery program releases (Subsection 3.2.11.3, Description of Hatchery-origin Pink Salmon), and hatchery program risks and benefits to pink salmon (Subsection 3.2.11.4, Hatchery Program Risks and Benefits). As described in Subsection 4.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for non-listed salmon and trout as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

4.2.10.1 Life History, Distribution, and Abundance of Natural-origin Pink Salmon

None of the alternatives would affect natural-origin pink salmon life history attributes discussed in Subsection 3.2.11.1, Life History of Natural-origin Pink Salmon, because changes in hatchery production under the alternatives would not impact pink salmon aquatic habitat. As described in Subsection 3.2.11.2, Distribution and Abundance of Natural-origin Pink Salmon, the distribution of pink salmon would not be affected under the alternatives because hatchery-origin pink salmon migrate directly to marine water once released. However, hatchery production changes under the alternatives may affect risks and benefits to pink salmon (Subsection 3.2.11.4, Hatchery Program Risks and Benefits). Changes in risks and benefits associated with changes in hatchery production under the action alternatives could affect overall abundance of natural-origin pink salmon as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, and Subsection 3.2.11.2, Distribution and Abundance of Natural-origin Pink Salmon. However, changes in the abundance of natural-origin pink salmon associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the action alternatives would not be measurable because of the inherent variability in abundance of the ESUs (Table 3.2-17), and would not be able to be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.10.2 Hatchery-origin Pink Salmon

Hatchery-origin pink salmon are currently released from three hatchery programs in the analysis area near marine waters as fry in April at an average size of 2.0 inches fork length (50 mm) (Table 3.2-4). None of the alternatives would affect the attributes of the hatchery-origin pink salmon released (Subsection 3.2.11.3, Description of Hatchery-origin Pink Salmon) because hatchery operations would not change under the alternatives.

4.2.10.3 Risks and Benefits

Hatchery programs for salmon present risks of competition and predation impacts to natural-origin pink salmon, and hatchery-origin pink salmon provide marine-derived nutrient benefits. Risks of effects from hatchery-origin fish to natural-origin pink salmon occur primarily from competition with similar-sized hatchery-origin chum salmon in fresh water and adjacent marine waters (Subsection 3.2.11.4.1, Risks - Competition), and from predation by large hatchery-origin yearling steelhead, yearling coho salmon, and subyearling and yearling Chinook salmon in freshwater and adjacent marine areas (Subsection 3.2.11.4.2, Risks - Predation). These releases occur during the peak out-migration period of natural-origin pink salmon (Figure 3.2-11). Hatchery releases of other species have unsubstantial impacts because of fish size at release, release timing, different diet preferences, and the prompt movement of pink salmon fry seaward. The competition and predation risks are highest where large numbers of hatchery-origin fish are released compared to the number of natural-origin pink salmon present in the areas of release. The overall hatchery facilities and operations risk is negligible, because there are few pink salmon hatchery programs and most of those programs operate in compliance with BMPs (Subsection 3.2.11.4.4, Risks - Hatchery Facilities and Operation). The contribution of hatchery-origin pink salmon to marine-derived nutrient benefits is negligible (Subsection 3.2.11.4.7, Benefits - Marine-derived Nutrients) because relatively few carcasses are from hatchery-origin pink salmon.

4.2.10.4 Alternative 1 (No Action) and Alternative 2 (Proposed Action)

Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to natural-origin pink salmon compared to existing conditions. Under Alternative 2, the number of hatchery-origin pink salmon released would be the same as under Alternative 1, and the risks and benefits would be the same.

4.2.10.5 Alternative 3 (Reduced Production)

Under Alternative 3, hatchery production would not change for pink salmon, but would decrease by 1 percent for chum salmon, 43 percent for steelhead, 22 percent for coho salmon, and 18 percent for Chinook salmon, resulting in an overall decrease of 8 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Correspondingly, competition and predation impacts from these hatchery-origin fish species would decrease (competition with chum salmon in fresh water and adjacent marine waters, and predation in fresh water and adjacent marine waters by yearling steelhead, yearling coho salmon, and yearling and subyearling Chinook salmon), which would be beneficial to natural-origin juvenile pink salmon. Hatchery facilities and operations would remain a negligible risk because there would be no change in hatchery production of pink salmon compared to Alternative 1. Under Alternative 3, marine-derived benefits from hatchery-origin pink salmon carcasses would be the same as Alternative 1 because hatchery production of pink salmon under Alternative 3 would be the same as under Alternative 1.

4.2.10.6 Alternative 4 (Increased Production)

Under Alternative 4, hatchery production would increase 11 percent for pink salmon, 28 percent for chum salmon, 13 percent for Chinook salmon, 4 percent for steelhead, and 27 percent for coho salmon, resulting in an overall increase of 16 percent for all salmon and steelhead, compared to Alternative 1 (Table 2.4-1). Under Alternative 4, competition with hatchery-origin chum salmon in fresh water and adjacent marine water, and predation in fresh water and adjacent marine water by hatchery-origin yearling steelhead, yearling coho salmon, and subyearling and yearling Chinook salmon would increase, compared to Alternative 1. However, effects from the 11 percent increase in pink salmon hatchery production under Alternative 4 would not be substantial enough to result in different hatchery facilities and operation or marine-derived nutrient benefit ratings, which would each remain negligible.

4.2.10.7 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources. For example, a measure intended to reduce risks to natural-origin fish (e.g., pink salmon) by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.11 Sockeye Salmon

Described in this subsection are the effects of salmon and steelhead hatchery programs on sockeye salmon in Puget Sound, which includes the Sockeye Salmon ESU (i.e., Baker River Sockeye Salmon ESU) and sockeye salmon that are not part of an ESU but occur within the analysis area (i.e., in the Lake Washington watershed). As described in Subsection 3.2.12, Sockeye Salmon, sockeye salmon in the analysis area are not listed. The effects analysis for sockeye salmon was developed based on sockeye salmon life history traits (Subsection 3.2.12.1, Life History of Natural-origin Sockeye Salmon) and sockeye salmon distribution and abundance (Subsection 3.2.12.2, Distribution and Abundance of Natural-origin Sockeye Salmon) relative to hatchery program releases (Appendix A, Puget Sound Hatchery Programs and Facilities, and Subsection 3.2.12.3, Description of Hatchery-origin Sockeye Salmon), and hatchery program risks and benefits to sockeye salmon (Subsection 3.2.12.4, Hatchery Program Risks and Benefits). As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for non-listed salmon and trout as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

4.2.11.1 Life History, Distribution, and Abundance of Natural-origin Sockeye Salmon

None of the alternatives would affect natural-origin sockeye salmon life history attributes discussed in Subsection 3.2.12.1, Life History of Natural-origin Sockeye Salmon, because changes in hatchery production under the alternatives would not impact sockeye salmon aquatic habitat. As described in Subsection 3.2.12.2, Distribution and Abundance of Natural-origin Sockeye Salmon, the distribution of sockeye salmon would not be affected under the alternatives because the hatchery-origin fish generally migrate to marine water once released. However, hatchery production changes under the alternatives may affect risks and benefits to sockeye salmon (Subsection 3.2.12.4, Hatchery Program Risks and Benefits). Changes in risks and benefits associated with changes in hatchery production under the action alternatives could affect overall abundance of natural-origin sockeye salmon as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, and Subsection 3.2.12.2, Distribution and Abundance of Natural-origin Sockeye Salmon. However, changes in the abundance of natural-origin sockeye salmon associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the action alternatives would not be measurable because of the inherent variability in abundance of sockeye salmon (Table 3.2-18), and would not be able to be isolated from the range of other factors known to influence overall abundance (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

4.2.11.2 Hatchery-origin Sockeye Salmon

Hatchery-origin sockeye salmon are currently released into two lake systems (Baker Lake, and Cedar River in the Lake Washington system) from two hatchery programs, primarily as fry from February through April at an average size of 1.2 inches fork length (30 mm) (Table 3.2-4). None of the alternatives would affect the attributes of the hatchery-origin sockeye salmon released (Subsection 3.2.12.3, Description of Hatchery-origin Sockeye Salmon) because hatchery operations would not change under the alternatives.

4.2.11.3 Risks and Benefits

Releases of hatchery-origin coho salmon yearlings have the greatest potential to affect the similarly-sized natural-origin sockeye salmon through competition in marine areas and in rivers and streams below lakes used by juvenile sockeye salmon for migration to marine areas (Subsection 3.2.12.4.1, Risks - Competition). In addition, releases of large hatchery-origin steelhead yearlings have the greatest potential to impact small natural-origin sockeye salmon through predation in fresh water (in rivers and streams below lakes used by juvenile sockeye salmon for migration to marine areas) (Subsection 3.2.12.4.2, Risks - Predation). In general, competition and predation risks are highest when the hatchery-origin fish are released during the peak out-migration period for natural-origin sockeye salmon (Figure 3.2-12), and where a large number of hatchery-origin fish are released relative to the number of natural-origin fish present in the area of release. The overall hatchery facilities and operation risk is negligible because sockeye salmon programs operate in compliance with BMPs, and there are only two hatchery programs for sockeye salmon in the entire project area. Production of hatchery-origin sockeye salmon likely contributes to total return benefits from harvest (Subsection 3.2.12.4.5, Benefits - Total Return), and may provide benefits to the viability of natural-origin sockeye salmon (Subsection 3.2.12.4.6, Benefits - Viability). In addition, hatchery-origin carcasses provide a moderate benefit to natural-origin sockeye salmon from carcasses distributed into watersheds in the analysis area (Subsection 3.2.12.4.7, Benefits - Marine-derived Nutrients).

4.2.11.4 Alternative 1 (No Action) and Alternative 2 (Proposed Action)

Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to natural-origin sockeye salmon compared to existing conditions. Under Alternative 2, the number of hatchery-origin sockeye salmon released would be the same as under Alternative 1, and the risks and benefits would be the same.

4.2.11.5 Alternative 3 (Reduced Production)

Under Alternative 3, hatchery production would not change for sockeye salmon, but would decrease 22 percent for coho salmon and 43 percent for steelhead, resulting in an overall decrease of 8 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Correspondingly, competition risks to natural-origin sockeye salmon from similar-sized hatchery-origin coho salmon yearlings in fresh water and marine water, and predation risks to natural-origin sockeye salmon from large hatchery-origin steelhead in fresh water would decrease, compared to Alternative 1, which would be beneficial to natural-origin juvenile sockeye salmon. Under Alternative 3, there would be no change in hatchery facilities and operation risk, and total return, viability, and marine-derived nutrient benefits from hatchery-origin sockeye salmon compared to Alternative 1 because the number of hatchery-origin sockeye salmon released would be the same.

4.2.11.6 Alternative 4 (Increased Production)

Under Alternative 4, hatchery production would increase 27 percent for coho salmon and 4 percent for steelhead, resulting in an overall increase of 16 percent for all salmon and steelhead, compared to Alternative 1 (Table 2.4-1). Under Alternative 4, competition risks to natural-origin sockeye salmon from similarly-sized hatchery-origin yearling coho salmon in fresh water and marine water, and predation risks to natural-origin sockeye salmon from large hatchery-origin yearling steelhead in fresh water would increase, compared to Alternative 1. Under Alternative 4, there would be no change in hatchery facilities and operation risk, and total return, viability, and marine-derived nutrient benefits from hatchery-origin sockeye salmon compared to Alternative 1 because the number of hatchery-origin sockeye salmon released would be the same.

4.2.11.7 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources. For example, a measure intended to reduce risks to natural-origin fish (e.g., sockeye salmon) by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.12 Rainbow Trout

Described in this subsection are the effects of salmon and steelhead hatchery programs on rainbow trout, which is the non-anadromous form of the *O. mykiss* species (steelhead are the anadromous form). As described in Subsection 3.2.13, Rainbow Trout, these fish are not listed. The effects analysis for rainbow trout is based on rainbow trout life history traits (Subsection 3.2.13.1, Life History of Rainbow Trout) and rainbow trout distribution and abundance (Subsection 3.2.13.2, Distribution and Abundance of Rainbow Trout) relative to hatchery program releases (Appendix A, Puget Sound Hatchery Programs and Facilities), and hatchery program risks and benefits to rainbow trout (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Rainbow Trout]). As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for trout as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Life History, Distribution, and Abundance of Rainbow Trout. None of the alternatives would affect rainbow trout life history or distribution attributes discussed in Subsection 3.2.13.1, Life History of Rainbow Trout, and Subsection 3.2.13.2, Distribution and Abundance of Rainbow Trout, because changes in hatchery production under the alternatives would not impact rainbow trout aquatic habitat. Changes in hatchery production under the alternatives may affect risks and benefits to rainbow trout (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Rainbow Trout]), and could affect rainbow trout abundance (Subsection 3.2.13.2, Distribution and Abundance of Rainbow Trout), as discussed below. Potential changes in the abundance of rainbow trout associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the action alternatives would not be able to be isolated from the range of other factors that likely influence overall abundance of rainbow trout (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

Risks and Benefits. As described in Subsection 3.2.13.3, Relationship to Salmon and Steelhead (Rainbow Trout), salmon and steelhead present competition, predation, and genetic risks to rainbow trout. Competition risks would be greatest when large numbers of hatchery-origin fish are released high in watersheds and in large numbers, and spatial and temporal overlap occurs. Competition would not be expected when rainbow trout are larger than hatchery-origin fish because of differences in food preferences and space requirements. Hatchery-origin yearling Chinook salmon, coho salmon, and steelhead are potential predators of smaller juvenile rainbow trout because of their relatively large size (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Rainbow Trout]). However, hatchery-origin salmon and steelhead would be released in streams downstream from areas used by rainbow trout; thus, it is likely that competition and predation risks would be unsubstantial between hatchery-origin salmon and steelhead and rainbow trout.

Available information suggests genetic risk to rainbow trout may occur from steelhead hatchery programs, and that it would be expected to be greatest from steelhead hatchery programs that use fish of Chambers Creek and Skamania lineage as broodstocks, because fish from those hatchery programs are substantially diverged from natural-origin *O. mykiss* in the project area (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Rainbow Trout]).

Hatchery production can benefit the viability of rainbow trout when the rainbow trout are considerably larger than the hatchery-origin salmon and steelhead (e.g., hatchery-origin fry) and the rainbow trout use them as a food resource. Although releases of hatchery-origin salmon fry could serve as prey for rainbow trout, this benefit is likely unsubstantial under all alternatives primarily because of spatial separation (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Rainbow Trout]).

Alternative 1 (No Action) and Alternative 2 (Proposed Action). Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to rainbow trout compared to existing conditions. Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits would be the same.

Alternative 3 (Reduced Production). Under Alternative 3, hatchery releases would decrease 22 percent for coho salmon, 18 percent for Chinook salmon, and 43 percent for steelhead, resulting in an overall 8 percent decrease for all salmon and steelhead, compared to Alternative 1 (Table 2.4-1). Correspondingly, potential competition, predation, and genetic risks from hatchery-origin fish (although unsubstantial) would decrease, which would be beneficial to rainbow trout. Under Alternative 3, benefits to rainbow trout viability from decreases in hatchery-origin salmon fry as food would decrease, but would remain unsubstantial, as under Alternative 1.

Alternative 4 (Increased Production). Under Alternative 4, hatchery production would increase 13 percent for Chinook salmon, 27 percent for coho salmon, and 4 percent for steelhead, resulting in an overall increase of 16 percent for all salmon and steelhead, compared to Alternative 1 (Table 2.4-1). Under Alternative 4, these increases would result in greater competition and predation risks to rainbow trout than under Alternative 1, especially from hatchery-origin Chinook salmon, coho salmon, and steelhead. The relatively small increase (4 percent) in steelhead releases would not be expected to substantially change genetic risks for rainbow trout compared to Alternative 1. Under Alternative 4, benefits to rainbow trout viability from increases in hatchery-origin salmon fry as food would increase but would remain unsubstantial, as under Alternative 1, because of spatial separation.

Mitigation Measures and Adaptive Management. As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks or benefits to other resources. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18. Applying adaptive management under the action alternatives would not be expected to measurably affect rainbow trout.

4.2.13 Coastal Cutthroat Trout

Described in this subsection are the effects of salmon and steelhead hatchery programs on coastal cutthroat trout, particularly of the freshwater-migratory and anadromous forms because these two forms of coastal cutthroat trout co-occur with salmon and steelhead in freshwater and marine areas (Subsection 3.2.14.1, Life History of Coastal Cutthroat Trout). As described in Subsection 3.2.14, Coastal Cutthroat Trout, these fish are not listed. The effects analysis for coastal cutthroat trout is based on coastal cutthroat trout life history traits (Subsection 3.2.14.1, Life History of Coastal Cutthroat Trout) and coastal cutthroat trout distribution and abundance (Subsection 3.2.14.2, Distribution and Abundance of Coastal Cutthroat Trout) relative to hatchery program releases (Appendix A, Puget Sound Hatchery Programs and Facilities), and hatchery program risks and benefits to coastal cutthroat trout (Subsection 3.2.14.3, Relationship to Salmon and Steelhead [Coastal Cutthroat Trout]). As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for trout as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Life History, Distribution, and Abundance of Coastal Cutthroat Trout. None of the alternatives would affect coastal cutthroat trout life history or distribution attributes discussed in Subsection 3.2.14.1, Life History of Coastal Cutthroat Trout, and Subsection 3.2.14.2, Distribution and Abundance of Coastal Cutthroat Trout, because changes in hatchery production under the alternatives would not impact coastal cutthroat trout aquatic habitat. Changes in hatchery production under the alternatives may affect risks and benefits to coastal cutthroat trout (Subsection 3.2.14.3, Relationship to Salmon and Steelhead [Coastal Cutthroat Trout]), and could affect coastal cutthroat trout abundance as discussed below. Potential changes in the abundance of coastal cutthroat trout associated with risks and benefits specifically attributable to hatchery salmon and steelhead production under the alternatives would not be able to be isolated from the range of other factors known to influence overall abundance of coastal cutthroat trout (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead).

Risks and Benefits. As described in Subsection 3.2.14.3, Relationship to Salmon and Steelhead (Coastal Cutthroat Trout), competition between coastal cutthroat trout and salmon and steelhead is minimized because cutthroat trout use a variety of habitat-partitioning techniques and exhibit a variety of life histories that are different from other salmon and steelhead. However, freshwater-migratory and anadromous coastal cutthroat trout can compete with similarly-sized hatchery-origin Chinook salmon and steelhead yearlings because of similarities in size and areas of overlap during the spring juvenile coastal cutthroat trout out-migration period in freshwater and marine areas (competition in marine areas involves only the anadromous coastal cutthroat trout form). In addition, small freshwater-migratory and juvenile anadromous coastal cutthroat trout are potential prey of larger hatchery-origin juvenile salmon and steelhead where the species overlap, but this effect is likely transitory as the hatchery-origin fish migrate to and through marine areas into the ocean (Subsection 3.2.14.3, Relationship to Salmon and Steelhead [Coastal Cutthroat Trout]).

In summary, hatchery-origin Chinook salmon and steelhead yearlings pose risks of competition to freshwater-migratory and anadromous coastal cutthroat trout, although these risks are likely minimal because spatial and temporal overlaps are limited. In addition, these hatchery-origin species and relatively large coho salmon yearlings pose predation risks to freshwater-migratory and anadromous coastal cutthroat trout juveniles, although these risks are likely minimal as the hatchery-origin fish move through marine areas into the ocean.

Genetic effects occur naturally when coastal cutthroat trout hybridize with rainbow trout and natural-origin steelhead (Subsection 3.2.14.3, Relationship to Salmon and Steelhead [Coastal Cutthroat Trout]).

These natural genetic effects of hybridization can be affected when hatchery-origin steelhead interbreed with coastal cutthroat trout. However, the potential for hybridization between hatchery-origin steelhead and coastal cutthroat trout is unsubstantial because anadromous coastal cutthroat trout tend to spawn in areas upstream from those used by steelhead.

Hatchery production can benefit the viability of coastal cutthroat trout when the coastal cutthroat trout are large enough to use the co-occurring hatchery-origin salmon and steelhead as a food source. This benefit is likely greatest from releases of small hatchery-origin coho salmon, chum salmon, and pink salmon fry, and primarily in areas (e.g., lower river and estuary areas) where large juvenile and adult coastal cutthroat trout are present (Subsection 3.2.13.3, Relationship to Salmon and Steelhead [Coastal Cutthroat Trout]).

Alternative 1 (No Action) and Alternative 2 (Proposed Action). Under Alternative 1, hatchery operations and production of salmon and steelhead would be the same as under existing conditions. As a result, Alternative 1 would not alter risks and benefits to coastal cutthroat trout compared to existing conditions. Coastal cutthroat trout limiting factors, as described in Subsection 3.2.14, Coastal Cutthroat Trout, would not be affected by hatchery production; thus, Alternative 1 would not affect coastal cutthroat trout limiting factors. Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits would be the same. Similar to Alternative 1, coastal cutthroat trout limiting factors would not be affected under Alternative 2.

Alternative 3 (Reduced Production). Under Alternative 3, hatchery releases would decrease 18 percent for Chinook salmon, 22 percent for coho salmon, 43 percent for steelhead, 1 percent for chum salmon, and no change for pink salmon, resulting in an overall 8 percent decrease for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Correspondingly, potential competition and predation risks from hatchery-origin salmon and steelhead, and genetic risks from hybridization with hatchery-origin steelhead would decrease, which would be beneficial to coastal cutthroat trout. Under Alternative 3, benefits to coastal cutthroat trout viability from decreased availability of hatchery-origin salmon fry as prey in lower river and estuary areas would decrease compared to Alternative 1. As under Alternative 1, coastal cutthroat trout limiting factors would not be affected under Alternative 3.

Alternative 4 (Increased Production). Under Alternative 4, hatchery production would increase 13 percent for Chinook salmon, 27 percent for coho salmon, 4 percent for steelhead, 28 percent for chum salmon, and 11 percent for pink salmon, resulting in an overall increase of 16 percent for all salmon and steelhead compared to Alternative 1 (Table 2.4-1). Under Alternative 4, increases in hatchery releases would result in greater competition, predation, and genetic risks, compared to Alternative 1. Under

Alternative 4, benefits to coastal cutthroat trout viability from increased availability of hatchery-origin salmon fry as prey in lower river and estuary areas would increase compared to Alternative 1. Similar to Alternative 1, coastal cutthroat trout limiting factors would not be affected under Alternative 4.

Mitigation Measures and Adaptive Management. As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks or benefits to other resources. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18. Applying adaptive management under the action alternatives would not be expected to measurably affect coastal cutthroat trout.

4.2.14 Sturgeon and Lamprey

This subsection describes effects of the alternatives on sturgeon and lamprey species described in Subsection 3.2.15, Sturgeon and Lamprey, including green sturgeon, white sturgeon, Pacific lamprey, river lamprey, and western brook lamprey. As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for other fish species as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

In general, sturgeon species have the potential to be affected by hatchery-origin salmon and steelhead through bycatch in salmon net fisheries. The few sturgeon incidentally caught in fisheries in Puget Sound have been captured in trawl fisheries directed at groundfish. However, the risk to sturgeon from incidental harvest is unsubstantial, because the presence of sturgeon species is rare to uncommon in Puget Sound. White sturgeon may benefit from salmon carcasses in river systems. Adult Pacific lamprey and river lamprey prey on salmon and steelhead, while salmon and steelhead prey on juveniles of all three lamprey species.

None of the alternatives would affect sturgeon and lamprey life history or distribution because changes in hatchery production under the alternatives would not impact aquatic habitat of sturgeon and lamprey. Effects of changes in hatchery production under the alternatives may affect sturgeon and lamprey abundance, as discussed below. Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to sturgeon and lamprey or their abundance, compared to existing conditions (Subsection 3.2.15, Sturgeon and Lamprey). Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits to, and the abundance of, sturgeon and lamprey would be the same.

Under Alternative 3, overall hatchery production would be reduced by 8 percent compared to Alternative 1 (Table 2.4-1), which may decrease the number of salmon available for harvest and reduce the associated risk of sturgeon bycatch in salmon fisheries, as well as decrease salmon carcass benefits to white sturgeon. The decreases in hatchery production under Alternative 3 would also decrease opportunities for adult lamprey to feed on salmon and steelhead (which would then reduce the benefit to lamprey), and decrease impacts of salmon and steelhead that feed on juvenile lamprey (which would then be a decreased risk to lamprey), compared to Alternative 1. Potential changes in the abundance of sturgeon and lamprey associated with risks and benefits specifically attributable to reductions in hatchery production under Alternative 3 would not be measurable, and would not be able to be isolated from the range of other factors that influence the overall abundance of sturgeon and lamprey (Subsection 3.2.15, Sturgeon and Lamprey).

Under Alternative 4, overall hatchery production would increase by 16 percent compared to Alternative 1 (Table 2.4-1), which may increase the number of fish available for harvest and potentially increase the sturgeon bycatch in salmon fisheries, and may lead to a small increase in salmon carcass benefits to white sturgeon, compared to Alternative 1. The increase in hatchery production under Alternative 4 would result in greater benefits to adult lamprey that prey on salmon and steelhead, compared to Alternative 1; however, the increase in hatchery production under Alternative 4 would also result in an increased risk of salmon and steelhead predation on juvenile lamprey compared to Alternative 1. Changes in the abundance of sturgeon and lamprey associated with risks and benefits specifically attributable to increases in hatchery production under Alternative 4 would not be measurable, and would not be able to be isolated from the range of other factors that influence the overall abundance of sturgeon and lamprey (Subsection 3.2.15, Sturgeon and Lamprey).

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect other fish species and other resources. For example, a measure intended to reduce competition risks from hatchery-origin salmon and steelhead to groundfish by decreasing hatchery production would also reduce the benefit to adult Pacific lamprey and river lamprey from hatchery-origin salmon and steelhead as food, and may reduce socioeconomic benefits from harvest of hatchery-origin fish. Proposed mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.15 Forage Fish

This subsection describes effects of the alternatives on forage fish species described in Subsection 3.2.16, Forage Fish, including Pacific eulachon, Pacific herring, Pacific sandlance, northern anchovy, smelt, and Pacific sardine. Relatively little management and biological information is available on most forage fish stocks, which largely occur in the marine waters of Puget Sound. As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for other fish species as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

As described in Subsection 3.2.16, Forage Fish, the primary risk to forage fish from hatchery-origin salmon and steelhead is predation. Other risks include longfin smelt competition with sockeye salmon for food in Lake Washington (Subsection 3.2.16.5, Smelt [Surf Smelt and Longfin Smelt]), and anchovies that are used by recreational fishermen as bait fish (Subsection 3.2.16.4, Northern Anchovy). Finally, fisheries for sardines may result in bycatch of salmon (Subsection 3.2.15.6, Pacific Sardine).

Forage fish (including eulachon, Pacific herring, Pacific sandlance, and surf smelt) are food sources for all piscivorous fish in Puget Sound and are especially important to salmon. As described in

Subsection 3.2.16, Forage Fish, Chinook salmon and coho salmon are particularly reliant on Pacific herring and other forage fish species as prey items. Given the considerable numbers of salmon and steelhead that are of hatchery-origin, these fish may impact forage fish. Species most likely to be affected by hatchery-origin fish would be Pacific herring, Pacific sandlance, and surf smelt, which tend to spend the majority of their lives within Puget Sound, and are at the greatest risk as they reside in areas where hatchery-origin fish would be most concentrated after they are released.

None of the alternatives would affect forage fish life history and distribution because changes in hatchery production under the alternatives would not impact forage fish habitat. Some action alternatives may affect forage fish abundance, as discussed below. Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to forage fish or their abundance, compared to existing conditions (Subsection 3.2.16, Forage Fish). Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits to, and the abundance of, forage fish would be the same.

Under Alternative 3, overall hatchery production would be reduced by 8 percent compared to Alternative 1, although hatchery production of sockeye salmon would not change (Table 2.4-1). Correspondingly, under Alternative 3, predation impacts and risks to forage fish would decrease compared to Alternative 1, which could help to increase forage fish abundance. Also under Alternative 3, competition risks from sockeye salmon to longfin smelt would be the same as under Alternative 1, because sockeye salmon hatchery production would not change. Alternative 3 would not be expected to affect the risk to salmon from bycatch in sardine fisheries, compared to Alternative 1.

Under Alternative 4, overall hatchery production would increase by 16 percent compared to Alternative 1, although hatchery production of sockeye salmon would not change (Table 2.4-1). The increases under Alternative 4 would impact forage fish by increasing predation risks and potentially decreasing forage fish abundance, compared to Alternative 1. The effect of Alternative 4 on longfin smelt competition risks with sockeye salmon would be the same as under Alternative 1, because hatchery production of sockeye salmon would be the same. Use of sardines as bait for recreational harvest of salmon may increase risks to sardines based on the increased hatchery production under Alternative 4 compared to Alternative 1. Alternative 4 would not be expected to affect the potential risk for bycatch of salmon in sardine fisheries.

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect other fish species and other resources. For example, a measure intended to reduce predation risks from hatchery-origin salmon and steelhead to forage fish by decreasing hatchery production would also reduce the benefit to adult Pacific lamprey and river lamprey from hatchery-origin salmon and steelhead as food, and may reduce socioeconomic benefits from harvest of hatchery-origin fish. Proposed mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.16 Groundfish

This subsection describes effects of the alternatives on groundfish described in Subsection 3.2.17, Groundfish, which is a broad group of marine fishes that includes bocaccio, rockfish, hake, cod, flatfish, perch, and others. As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for other fish species as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

As described in Subsection 3.2.17, Groundfish, hatchery-origin salmon and steelhead present competition and predation risks to groundfish species in marine areas of Puget Sound. In addition, groundfish have the potential to be taken incidentally in salmon fisheries, and groundfish may prey on salmon. In general, groundfish can be impacted by hatchery-origin fish through competition for food to the extent the species rely on the same scarce prey and habitats (Subsection 3.2.17.3, Relationship with Salmon and Steelhead [Groundfish]). Depending on the species and life stage, groundfish may rely on the same food resources as salmon and steelhead. Small size classes of groundfish are most likely to be impacted by competition. In addition, competition risks are likely to be greatest from hatchery-origin Chinook salmon and coho salmon because these salmon share similar food resources and rear for a considerable time within and near habitats where groundfish species reside for at least some of their life cycle. In contrast, hatchery-origin sockeye salmon, pink salmon, and chum salmon out-migrate seaward soon after leaving fresh water, dispersing into areas removed from rearing groundfish. Thus, those salmon species do not present competition risks. Similarly, steelhead disperse into offshore areas for rearing in the ocean and are not likely to present substantial competition risks to any groundfish species in Puget Sound.

As described in Subsection 3.2.17.3, Relationship with Salmon and Steelhead (Groundfish), hatchery-origin salmon pose a predation risk and threat to groundfish species. In particular, hatchery-origin Chinook salmon and coho salmon are piscivorous as subadults and adults, and tend to rear within Puget Sound and coastal marine waters where they may prey on juvenile rockfish.

As described in Subsection 3.2.10, Puget Sound/Strait of Georgia Chum Salmon ESU, Subsection 3.2.11, Odd-year and Even-year Pink Salmon ESUs, and Subsection 3.2.12, Sockeye Salmon, chum salmon, pink salmon, and sockeye salmon have a varied, less piscivorous diet and tend to migrate northward into the ocean to rear and are removed from Puget Sound marine waters where predation on groundfish might otherwise occur. Therefore, risks of predation effects on groundfish species from these hatchery-origin salmon species are considered unsubstantial. Similarly, releases of hatchery-origin steelhead are unlikely to exert predation risks on juvenile groundfish because steelhead reside offshore for the majority of their life span (Subsection 3.2.7, Puget Sound Steelhead DPS).

Bycatch of rockfish in salmon fisheries may be a significant source of mortality for threatened and endangered groundfish in Puget Sound and is considered a high to very high threat in NMFS' groundfish status review (Drake et al. 2010). As described in Subsection 3.2.17.3, Relationship with Salmon and Steelhead (Groundfish), ongoing harvest management actions to decrease groundfish bycatch include identifying rockfish conservation areas and then closing these areas for use by specific fishing gear that impacts groundfish, as well as promoting use of fishing gear and techniques elsewhere that decrease groundfish bycatch. Other *Sebastes* species, Pacific hake, sablefish, flatfish, and sculpins are the most abundant of the species reviewed in this subsection in terms of numbers and biomass. The status of these species is generally healthy.

There are benefits to groundfish from hatchery-origin juvenile and adult salmon because of the contribution that hatchery-origin fish provide to the groundfish prey base (Subsection 3.2.17.3, Relationship with Salmon and Steelhead (Groundfish).

None of the alternatives would affect groundfish life histories and distribution because changes in hatchery production under the alternatives would not impact groundfish habitat. Changes in hatchery production under the alternatives may affect groundfish abundance, as described below. Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the risks and benefits to groundfish or their abundance, compared to existing conditions (Subsection 3.2.17, Groundfish). Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits to, and abundance of, groundfish would be the same.

Under Alternative 3, salmon and steelhead hatchery releases would decrease 8 percent overall, with an 18 percent decrease for Chinook salmon and 22 percent decrease for coho salmon (Table 2.4-15), compared to Alternative 1. These decreases would be expected to reduce competition, predation, and bycatch risks to groundfish compared to Alternative 1, and competition and predation risks from Chinook salmon and coho salmon in particular, which would likely be advantageous to groundfish abundance and viability. The decreases in releases of hatchery-origin salmon under Alternative 3 would reduce the benefit to adult rockfish provided by the salmon prey base, compared to Alternative 1.

Under Alternative 4, hatchery production to provide fishing opportunities would increase 16 percent overall, including increases of 13 percent for Chinook salmon and 27 percent for coho salmon (Table 2.4-1), compared to Alternative 1. These increases would result in increased risks to groundfish from competition with salmon and steelhead (particularly from Chinook salmon and coho salmon), increased risks of groundfish predation by salmon and steelhead (particularly from Chinook salmon and coho salmon), and increased risks of groundfish bycatch in salmon fisheries, thereby potentially affecting abundance of groundfish compared to Alternative 1. The increases in releases of hatchery-origin salmon under Alternative 4 would increase the benefit of hatchery-origin salmon to the prey base for adult rockfish, compared to Alternative 1.

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect other fish species and other resources. For example, a measure intended to reduce competition risks from hatchery-origin salmon and steelhead to groundfish by decreasing hatchery production would also reduce the benefit to adult Pacific lamprey and river lamprey from hatchery-origin salmon and steelhead as food, and may reduce socioeconomic benefits from harvest of hatchery-origin fish. Proposed mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.2.17 Resident Freshwater Fish

This subsection describes effects of the alternatives on a variety of resident freshwater fish species as described in Subsection 3.2.18, Resident Freshwater Fish, including kokanee, whitefish, sculpins, suckers, pikeminnows, minnows, and Olympic mudminnows. As described in Subsection 3.2.1, Introduction (Fish), and Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analysis is qualitative and relies on inferences from available information for other fish species as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

As described in Subsection 3.2.18, Resident Freshwater Fish, hatchery-origin salmon and steelhead may present risks of competition, predation, genetic impacts, and incidental harvest to some species of resident freshwater fish. Hatchery-origin salmon and steelhead most likely compete for food resources with three freshwater fish species (kokanee, sculpins, and Olympic mudminnows), but the overall risk of competition effects is unsubstantial. Risks of competition effects depend on the locations of hatchery releases relative to areas inhabited by the freshwater fish species, the similarity in niches between the hatchery-origin fish and resident fish inhabiting those areas, and availability of shared food resources. Competition risks between hatchery-origin fish and rearing resident fish for food and space would most likely occur when the hatchery-origin fish out-migrate downstream after release.

In addition to risks of competition, as described in Subsection 3.2.18, Resident Freshwater Fish, hatchery-origin salmon and steelhead present a predation risk to suckers and minnows. Hatchery-origin salmon and steelhead predation may occur when the hatchery-origin fish are of a sufficiently large size to be able to consume the smaller resident fish. However, the adult sizes of some resident fish species (e.g., kokanee and suckers) are too large to be consumed by even the largest hatchery-origin fish, and only juvenile resident fish would be vulnerable. While the overall risk of predation to minnows and suckers by hatchery-origin fish is unlikely, predation effects are greatest from hatchery-origin Chinook salmon, coho salmon, and steelhead that are released relatively high in streams. Hatchery-origin fish released in those locations would have the greatest potential for spatial and temporal overlap with resident fish species, and thus have the highest likelihood for impacts. For the Olympic mudminnow, which resides in slow moving waters, competition and predation risks are considered unsubstantial because hatchery-origin coho salmon (a species that also resides in slow-moving waters) migrate quickly downstream to marine waters rather than reside in habitat typically occupied by the Olympic mudminnow.

As described in Subsection 3.2.18.1, Kokanee, hatchery production of sockeye salmon presents an unsubstantial risk of genetic impacts to kokanee, primarily because the sockeye salmon hatchery broodstock used in Baker Lake is genetically indistinguishable from residualizing sockeye salmon that might be considered kokanee, and because the introduced hatchery-origin sockeye salmon in the Cedar River spawn in areas that are not kokanee spawning areas. Concerning harvest, returns from releases of hatchery-origin fish are the target of commercial and recreational salmon and steelhead fisheries in Baker Lake and Lake Washington. These fisheries expose kokanee to incidental harvest and result in corresponding reductions in kokanee abundance. The susceptibility of kokanee to incidental harvest in fisheries aimed at hatchery-origin fish depends on the location and degree of spatial overlap where fisheries occur, the type of gear used to harvest salmon and steelhead, and the size and life stages of kokanee present when and where fisheries occur.

Several resident freshwater species benefit from hatchery production (Subsection 3.2.18, Resident Freshwater Fish). These benefits occur when piscivorous resident species such as mountain whitefish, sculpins, and northern pikeminnow prey on hatchery-origin fish. Eggs deposited by naturally spawning hatchery-origin adults are also consumed by these species. For example, coast range sculpin and reticulate sculpin prey on salmon eggs deposited in redds, and prickly sculpin and torrent sculpin are predators of juvenile salmon, including newly released hatchery-origin subyearlings.

For resident freshwater fish species overall, hatchery production presents competition and predation risks, especially when hatchery-origin fish are released high in watersheds, and when hatchery-origin fish are sufficiently large to prey on resident fish. In general, the overall risks of genetic effects to kokanee from hatchery-origin sockeye salmon are unsubstantial. Benefits to some resident fish species occur because of the contribution of hatchery-origin fish to the prey base.

Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions (Subsection 3.2.18, Resident Freshwater Fish). As a result, Alternative 1 would not alter the risks and benefits to resident freshwater fish or their abundance compared to existing conditions. Under Alternative 2, the number of hatchery-origin fish released would be the same as under Alternative 1, and the risks and benefits to, and abundance of, freshwater fish would be the same.

Under Alternative 3, salmon and steelhead hatchery releases would decrease 8 percent (Table 2.4-1), compared to Alternative 1. These decreases would be expected to reduce competition, predation, and incidental harvest risks, and would reduce the benefits to resident fish provided by the salmon and steelhead prey base, compared to Alternative 1. There would be no changes in sockeye salmon hatchery production under Alternative 3 compared to Alternative 1; thus, there would be no changes in abundance of kokanee, genetic risks from sockeye salmon, or incidental harvest risks to kokanee in salmon fisheries. Potential changes in the abundance of resident freshwater fish associated with risks and benefits specifically attributable to decreases in hatchery production under Alternative 3 would not be measurable, and would not be able to be isolated from the range of other factors that influence the overall abundance of resident freshwater fish (Subsection 3.2.18, Resident Freshwater Fish).

Under Alternative 4, hatchery production would increase 16 percent (Table 2.4-1), compared to Alternative 1. These increases would increase competition, predation, and incidental harvest risks, but also increase benefits for resident fish that prey on salmon and steelhead, compared to Alternative 1. There would be no changes in sockeye salmon hatchery production under Alternative 4 compared to Alternative 1; thus, there would be no change in abundance of kokanee, genetic risks from sockeye salmon, or incidental harvest risks to kokanee in salmon fisheries. Potential changes in the abundance of other resident freshwater fish associated with risks and benefits specifically attributable to increases in hatchery production under Alternative 4 would not be measurable, and would not be able to be isolated from the range of other factors that influence the overall abundance of resident freshwater fish (Subsection 3.2.18, Resident Freshwater Fish).

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish), and would likely also affect other fish species and other resources. For example, a measure intended to reduce salmon and steelhead competition risks to resident freshwater fish by decreasing hatchery production would also reduce the benefit to adult lamprey from hatchery-origin salmon and steelhead as food, and may reduce socioeconomic benefits from harvest of hatchery-origin fish. Proposed mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

4.3 Socioeconomics

4.3.1 Introduction

The socioeconomic analysis address effects of salmon and steelhead hatchery programs on existing socioeconomic conditions of regional and local economies described in Subsection 3.3, Socioeconomics, when combined with effects anticipated under each alternative. This assessment of the socioeconomic effects of the alternatives evaluates predicted changes in values for indicators of commercial harvest, recreational trips, gross economic value of commercial fishing, net economic value of commercial and recreational fishing, hatchery operational cost values (e.g., procurement of goods and services needed to operate hatcheries), and regional and local economic impacts specific to salmon and steelhead fisheries (e.g., personal income and jobs). Described in this subsection are the effects of the alternatives on these socioeconomic indicators. Although the analysis focuses on harvest-related effects, hatchery operational effects (such as effects on jobs and personal income generated by changes in hatchery production) are also considered.

4.3.2 Analysis Area

As described in Subsection 3.3.5, Regional and Subregional Economic Conditions, data used to describe socioeconomic conditions are from within the 12 counties and the salmon management catch reporting areas (catch areas) in Puget Sound as designated by Washington State statute (WAC 220-22-030). These catch areas extend from the Canadian border to and including the western end of the Strait of Juan de Fuca and include the 10 major salmon management catch reporting areas (herein referred to as catch areas 4B through 13) (Figure 3.3-1) and their subareas (Figure 3.3-2). These areas represent the socioeconomic analysis area. The counties in the socioeconomic analysis area (Clallam, Jefferson, Mason, and Thurston Counties) include areas that extend outside the Puget Sound drainage. Because data describing socioeconomic conditions are available only county-wide, the socioeconomic analysis area is larger than the EIS project area described in Subsection 1.4, Project and Analysis Areas, which includes Puget Sound marine and fresh waters westerly along the Strait of Juan de Fuca, up to and including the Elwha River watershed.

Although salmon produced in the project area may also be harvested along the outer coast of Washington, Oregon, British Columbia, and Alaska, harvest data from those outer areas is generally not used for the socioeconomic analysis as described in Subsection 3.3.5, Regional and Subregional Economic Conditions, and Appendix I, Socioeconomic Impact Methods. This is because most of the commercial and recreational harvest of salmon and steelhead produced by hatcheries in the project area occurs in

Puget Sound marine and freshwater areas. As described in Subsection 3.3.5, Regional and Subregional Economic Conditions, harvest of hatchery-origin Puget Sound salmon outside of the socioeconomic analysis area averaged from 0 to 9 percent (range 0 to 17 percent) from 2002 to 2006, depending on species, location of harvest, and year. These percentages likely overestimate the actual contributions of Puget Sound hatchery-origin fish in some areas (i.e., southeast Alaska and British Columbia fisheries), because not all fisheries in those areas (e.g., those having negligible harvests of Puget Sound fish) are included in the harvest estimates (Appendix I, Socioeconomic Impact Methods). Other salmon species produced in Puget Sound (pink salmon, sockeye salmon, and chum salmon) are also harvested along the outer coast of Alaska, British Columbia, Washington, and Oregon, but most of the commercial and recreational harvest of those species also occurs in Puget Sound marine and freshwater areas. Hatchery-origin steelhead from Puget Sound are not targeted in fisheries outside the socioeconomic analysis area.

Although there are limits on the harvest impacts to listed Puget Sound Chinook salmon from certain fisheries in southeast Alaska and British Columbia, harvest and harvest rate targets for fisheries outside the socioeconomic analysis area vary largely independently of Puget Sound hatchery production. Thus, changes in production at project area hatcheries under the alternatives analyzed in this EIS would not be expected to have substantial effects on fisheries outside of the socioeconomic analysis area. For more detailed information on Puget Sound salmon and fisheries outside of the socioeconomic analysis area, refer to Appendix I, Socioeconomic Impact Methods.

As described in Subsection 3.3.1.2, Subregion Socioeconomic Conditions, the Puget Sound region is represented by the entire socioeconomic analysis area, and is subdivided into three subregions: 1) north Puget Sound subregion, 2) south Puget Sound subregion, and 3) Strait of Juan de Fuca subregion. The subregions encompass counties, river systems, and catch areas as shown in Figure 3.3-1, Figure 3.3-2, Table 3.3-1, and Table 3.3-2.

4.3.3 Methods for Analysis

This subsection provides an overview of socioeconomic impact methods used to analyze socioeconomic effects for this EIS. The analysis begins with an overview of effects from existing hatchery programs in the project area. These effects are then analyzed when combined with each alternative. More detail on socioeconomic indicators and impact methods is provided in Appendix I, Socioeconomic Impact Methods.

In addition to the value that salmon and steelhead resources have to commercial and recreational fisheries and to regional and local economies, these resources are valuable to people that do not directly use or consume the resources. Such values are typically referred to as non-use or passive use values. Avoiding extinction of endangered species is recognized as a source of passive use values (Randall and Stoll 1983; Stoll and Johnson 1984). Natural-origin salmon and steelhead in Puget Sound fit into the definition of non-use or passive use values for many public sectors. Non-use values associated with salmon and steelhead existence and recovery are theoretically measurable and may differ among the alternatives. For this analysis, it is assumed that non-use values would benefit from increases in salmon and steelhead as a result of recovery efforts because the presence of these fish are valuable to some public, non-use, sectors. Decreases or continued declines in salmon and steelhead populations are assumed to have a negative effect on non-use values because the presence of these fish would be declining even though public, non-use sectors do not actively interact with these species.

The alternatives would affect the number of salmon and steelhead released from hatcheries in the project area (Subsection 1.4, Project and Analysis Areas), which in turn would affect the number of returning hatchery-origin adults available for harvest and resulting economic impacts in the socioeconomic analysis area. As shown in Table 2.4-1, compared to Alternative 1 (No Action), hatchery production would not change under Alternative 2, whereas under Alternative 3, hatchery production of Chinook salmon, coho salmon, chum salmon, and steelhead would decrease, and under Alternative 4, hatchery production of Chinook salmon, coho salmon, chum salmon, pink salmon, and steelhead would increase. Compared to Alternative 1, the number of juvenile salmon and steelhead released would decrease 8 percent under Alternative 3 (Table 2.4-1). Under Alternative 4, the number of juvenile salmon and steelhead released would increase 16 percent (Table 2.4-1).

For the purposes of quantitative assessment of how changes in hatchery production associated with the alternatives would affect salmon and steelhead fisheries in the socioeconomic analysis area, it is assumed that the numbers and distribution of natural-origin fish harvested (as described in Subsection 3.3, Socioeconomics), would remain the same as existing conditions under all alternatives.

4.3.3.1 Commercial Harvest and Recreational Trips

Commercial harvest estimates for the socioeconomic analysis area are developed as described in Subsection 3.3.3, Commercial Salmon and Steelhead Fishing. Recreational trips are used to describe economic effects of the alternatives associated with recreational salmon and steelhead fisheries. Use of recreational harvest information to estimate recreational trips and related economic effects under the alternatives are described in Appendix I, Socioeconomic Impact Methods.

Effects of harvest under the alternatives are derived from results of fishery simulation modeling using the Fishery Regulation Assessment Model (FRAM) (PFMC 2008). Additional details of the fishery simulation modeling are described in Appendix I, Socioeconomic Impact Methods.

Fishery simulation modeling for analysis of the alternatives focuses on estimates in the Puget Sound region only. As described in Subsection 4.3.2, Analysis Area, some effects on fisheries outside of the socioeconomic analysis area would also be expected under the alternatives, but those effects would generally be considered unsubstantial and were not modeled.

4.3.3.2 Gross and Net Economic Values

Gross and net economic values associated with the commercial and recreational harvest of salmon and steelhead (Subsection 3.3.3, Commercial Salmon and Steelhead Fishing), are based on estimates of alternative-specific harvest in the socioeconomic analysis area. Different approaches are used for commercial and recreational fisheries.

For commercial fisheries, and as described in Subsection 3.3.4, Recreational Salmon and Steelhead Fishing, gross economic values are defined in terms of the total gross economic value of salmon and steelhead commercially harvested by tribal and non-tribal fishers. Net economic value for commercial fisheries are defined as the net income or profit (gross economic value minus costs) derived by both commercial fishers and fish processors. Economic factors for estimating the gross and net economic values of changes in harvest are derived based on different assumptions and data sources, as described in Appendix I, Socioeconomic Impact Methods. In contrast to data for commercial fisheries, limitations in data for recreational fisheries preclude species-specific estimates of net economic value.

4.3.3.3 Hatchery Operations Cost Values

Operational cost values at salmon and steelhead hatcheries are estimated under each alternative. Cost estimates by species are applied to all hatcheries and the different levels of hatchery production under the alternatives. Additional details concerning the methods used to estimate hatchery operational costs are described in Appendix I, Socioeconomic Impact Methods.

4.3.3.4 Regional and Subregional Economic Impacts

The comparative analysis of regional and subregional economic impacts in the socioeconomic analysis area focuses on estimating the amount of personal income and number of jobs generated by harvest and hatchery operations under the alternatives. In terms of harvest, regional and subregional economic impacts (personal income and jobs) are generated by commercial fishing activity of tribal and non-tribal fishers, and by recreational fishing activities. In terms of hatchery production, estimates of personal income and number of jobs are based on the direct and indirect effects associated with hatchery operational cost values (Subsection 4.3.3.3, Hatchery Operations Cost Values). It is assumed that no direct changes in jobs and personal income at the hatcheries would occur under the alternatives because changes in operational costs would only affect the procurement of supplies (e.g., fish food), materials, services (e.g., pathology services, repair and maintenance services), and utilities. Additional details concerning estimating subregional economic impacts are described in Appendix I, Socioeconomic Impact Methods.

4.3.3.5 Local Economic Impacts

The assessment of impacts on local economic conditions considers harvest-related effects of changes in hatchery production on commercial and recreational fishing activity in river systems and in nearby marine terminal areas, and on ports and fishing communities throughout the socioeconomic analysis area. The contribution of hatchery-origin salmon and steelhead to local fisheries, as identified in Table 3.3-7, is considered in estimating the expected relative effect (major, minor, or none[1]) on in-river fisheries and harvests under the alternatives. Jobs and personal income impacts associated with the estimated harvest of salmon and steelhead in tribal and non-tribal commercial fisheries and in recreational fisheries are estimated at the county level, based on factors described in Appendix I, Socioeconomic Impact Methods. Information on communities potentially vulnerable to changes in fishing activity, as described in Subsection 3.3.7, Ports and Fishing Communities, is also considered in assessing the incidence of expected changes in harvest and hatchery operations on affected communities. The personal income and jobs information at the county level is used to describe economic effects of the alternatives associated with the ports and fishing communities.

[1] Major means there would be substantial contributions from hatcheries to extensive commercial and/or recreational fisheries in marine and/or freshwater areas associated with a river. Minor means there would be low or intermittent contribution from hatcheries to local commercial or recreational fisheries in marine or freshwater areas associated with a river. None means there would be no or negligible contribution from hatchery programs associated with a river.

4.3.4 Commercial Salmon and Steelhead Fishing

Commercial fishers are consumptive users of fishery resources and place monetary value on their fishing activities (Subsection 3.3.3, Commercial Salmon and Steelhead Fishing). The following subsections summarize estimated changes in gross and net economic values for the region and its three subregions under each alternative. At the regional and subregional levels, gear use and the locations and distribution of tribal and non-tribal fishing for salmon and steelhead would not change from existing conditions in the socioeconomic analysis area under any alternative and thus are not analyzed. This analysis assumes that fishing effort among the different salmon and steelhead species would not vary based on hatchery production. Changes in local socioeconomic effects associated with fisheries in major river systems and ports and fishing communities (e.g., businesses and local economies) under the alternatives are described in Subsection 4.3.7, Fisheries in Major River Systems, and Subsection 4.3.8, Ports and Fishing Communities, respectively.

4.3.4.1 Puget Sound Region

As described in Subsection 3.3.3.1, Puget Sound Region, salmon and steelhead from many river systems in the socioeconomic analysis area contribute to harvest. The total estimated average annual commercial salmon and steelhead harvest is 2,679,392 fish (Table 3.3-4). Of all species harvested, fish caught in the socioeconomic analysis area are almost equally divided between tribal and non-tribal commercial fishers (Table 3.3-4). Chum salmon represent the largest share (1,190,995) of the total harvest, followed by pink salmon (720,613), sockeye salmon (375,272), coho salmon (314,060), Chinook salmon (77,847), and steelhead (604) (Table 3.3-4). Commercial harvest generates an estimated $15,577,897 in gross economic value, of which tribal fishers receive $9,148,467, or 59 percent (Table 3.3-4).

The estimated net economic value (net income) associated with the harvest of salmon and steelhead in the Puget Sound region is $10,346,702, with chum salmon representing the highest net economic value of $4,418,591 (Table 3.3-4).

4.3.4.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the harvest and economic impacts from commercial salmon and steelhead fishing in the socioeconomic analysis area compared to the affected environment (Subsection 3.3.3.1, Puget Sound Region). Under Alternative 1, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 2,679,392 fish (Table 4.3-1) with a total gross economic value of $15,577,897 (Table 4.3-2), which would be the same as the affected environment. Of this total gross economic value under Alternative 1, tribal value would represent 59 percent of the total value, while the non-tribal value would represent 41 percent of the total value (Table 4.3-2), which would be the same as the affected environment. Similarly, as described in Subsection 3.3.3.1, Puget Sound Region, chum salmon and pink salmon would represent the primary species harvested, and chum salmon would also provide the highest net economic value (Table 4.3-3).

4.3.4.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from commercial salmon and steelhead fishing in the Puget Sound region, which would be the same as under Alternative 1 (Table 4.3-1, Table 4.3-2, and Table 4.3-3), because the number of fish released would be the same. Under Alternative 2, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 2,679,392 fish (Table 4.3-1) with a total gross economic value of $15,577,897 (Table 4.3-2), which is the same as Alternative 1. Of this total gross economic value, tribal value would represent 59 percent of the total value, while the non-tribal value would represent 41 percent of the total value (Table 4.3-2), which is the same as under Alternative 1. Similarly, chum salmon and pink salmon would represent the primary species harvested, and chum salmon would also provide the highest net economic value (Table 4.3-3).

Table 4.3-1. Effects on non-tribal and tribal commercial harvest (in number of fish) of salmon and steelhead in Puget Sound subregions by alternative.

		Alternative 2 (Proposed Action)			**Alternative 3 (Reduced Production)**			**Alternative 4 (Increased Production)**		
	Alternative 1 (No Action)		**Change from Alternative 1**			**Change from Alternative 1**			**Change from Alternative 1**	
Subregion	**Number of Fish**	**Number of Fish**	**Number of Fish**	**Percent**	**Number of Fish**	**Number of Fish**	**Percent**	**Number of Fish**	**Number of Fish**	**Percent**
North Puget Sound										
Non-tribal	922,254	922,254	0	0	916,061	-6,193	-1	968,423	46,169	5
Tribal	790,399	790,399	0	0	759,568	-30,831	-4	833,455	43,056	5
Total	**1,712,653**	**1,712,653**	**0**	**0**	**1,675,628**	**-37,025**	**-2**	**1,801,878**	**89,225**	**5**
South Puget Sound										
Non-tribal	426,443	426,443	0	0	425,497	-945	-0.2	459,163	32,720	8
Tribal	434,935	434,935	0	0	387,239	-47,696	-11	494,797	59,862	14
Total	**861,378**	**861,378**	**0**	**0**	**812,736**	**-48,642**	**-6**	**953,960**	**92,582**	**11**
Strait of Juan de Fuca										
Non-tribal	9,539	9,539	0	0	9,396	-142	-2	10,414	876	9
Tribal	95,822	95,822	0	0	84,725	-11,098	-12	100,265	4,442	5
Total	**105,361**	**105,361**	**0**	**0**	**94,121**	**-11,240**	**-11**	**110,679**	**5,318**	**5**
PUGET SOUND TOTALS										
Non-tribal	**1,358,236**	**1,358,236**	**0**	**0**	**1,350,955**	**-7,281**	**-1**	**1,438,001**	**79,765**	**6**
Tribal	**1,321,156**	**1,321,156**	**0**	**0**	**1,231,531**	**-89,625**	**-7**	**1,428,516**	**107,360**	**8**
Total	**2,679,392**	**2,679,392**	**0**	**0**	**2,582,486**	**-96,906**	**-4**	**2,866,517**	**187,125**	**7**

Source: Estimates developed by the Puget Sound Hatchery EIS Technical Work Group.
Note: Harvest totals do not include fish caught in Puget Sound marine waters but landed in ports outside of Puget Sound. Therefore, the harvest totals for Alternative 1 and Alternative 2 do not match the totals in Table 3.3-3, which includes Puget Sound catch landed in ports outside of Puget Sound (e.g., Washington and Oregon coasts).

Table 4.3-2. Effects on non-tribal and tribal commercial gross economic value (in dollars) of salmon and steelhead in Puget Sound subregions by alternative.

		Alternative 2 (Proposed Action)			**Alternative 3 (Reduced Production)**			**Alternative 4 (Increased Production)**		
	Alternative 1 (No Action)		**Change from Alternative 1**			**Change from Alternative 1**			**Change from Alternative 1**	
Subregion	**Gross Economic Value ($)**	**Gross Economic Value ($)**	**Gross Economic Value ($)**	**Percent**	**Gross Economic Value ($)**	**Gross Economic Value ($)**	**Percent**	**Gross Economic Value ($)**	**Gross Economic Value ($)**	**Percent**
North Puget Sound										
Non-tribal	4,089,767	4,089,767	0	0	4,022,257	-67,510	-2	4,391,226	301,459	7
Tribal	4,455,730	4,455,730	0	0	4,142,349	-313,380	-7	4,847,447	391,718	9
Total	**8,545,496**	**8,545,496**	**0**	**0**	**8,164,606**	**-380,890**	**-5**	**9,238,673**	**693,177**	**8**
South Puget Sound										
Non-tribal	2,282,131	2,282,131	0	0	2,272,785	-9,347	-0.4	2,469,923	187,792	8
Tribal	3,890,770	3,890,770	0	0	3,337,720	-553,051	-14	4,467,302	576,532	15
Total	**6,172,902**	**6,172,902**	**0**	**0**	**5,610,504**	**-562,397**	**-9**	**6,937,225**	**764,324**	**12**
Strait of Juan de Fuca										
Non-tribal	57,532	57,532	0	0	56,124	-1,408	-2	62,903	5,371	9
Tribal	801,967	801,967	0	0	621,282	-180,685	-23	864,794	62,827	8
Total	**859,499**	**859,499**	**0**	**0**	**677,406**	**-182,093**	**-21**	**927,697**	**68,198**	**8**
PUGET SOUND TOTALS										
Non-tribal	**6,429,430**	**6,429,430**	**0**	**0**	**6,351,165**	**-78,265**	**-1**	**6,924,052**	**494,622**	**8**
Tribal	**9,148,467**	**9,148,467**	**0**	**0**	**8,101,351**	**-1,047,116**	**-11**	**10,179,544**	**1,031,077**	**11**
Total	**15,577,897**	**15,577,897**			**14,452,516**	**-1,125,381**	**-7**	**17,103,596**	**1,525,699**	**10**

Source: Estimates are derived by TCW Economics using harvest estimates provided by the Puget Sound Hatchery EIS Technical Work Group.

Note: Gross economic value totals do not include the value of fish caught in Puget Sound marine waters but landed in ports outside of Puget Sound.

Table 4.3-3. Number of fish harvested and net economic values (in dollars) of Puget Sound commercial salmon and steelhead fisheries by subregion, species, and alternative.

Subregion and Species	Alternative 1 (No Action)		Alternative 2 (Proposed Action)				Alternative 3 (Reduced Production)				Alternative 4 (Increased Production)			
					Change from Alternative 1				Change from Alternative 1				Change from Alternative 1	
	Number of Fish	Net Economic Value ($)	Number of Fish	Net Economic Value ($)	Number of Fish and Percent	Net Economic Value ($) and Percent	Number of Fish	Net Economic Value ($)	Number of Fish and Percent	Net Economic Value ($) and Percent	Number of Fish	Net Economic Value ($)	Number of Fish and Percent	Net Economic Value ($) and Percent
North Puget Sound														
Chinook salmon	26,305	462,959	26,305	462,959	0 (0)	0 (0)	24,981	439,665	-1,324 (-5)	-23,294 (-5)	29,790	524,300	3,485 (14)	61,341 (14)
Coho salmon	115,681	747,296	115,681	747,296	0 (0)	0 (0)	79,980	516,668	-35,701 (-31)	-230,628 (-31)	145,056	937,060	29,375 (25)	189,764 (25)
Sockeye salmon	307,925	1,758,254	307,925	1,758,254	0 (0)	0 (0)	307,925	1,758,254	0 (0)	0 (0)	307,925	1,758,254	0 (0)	0 (0)
Pink salmon	626,435	332,011	626,435	332,011	0 (0)	0 (0)	626,435	332,011	0 (0)	0 (0)	626,435	332,011	0 (0)	0 (0)
Chum salmon	636,089	2,359,890	636,089	2,359,890	0 (0)	0 (0)	636,089	2,359,890	0 (0)	0 (0)	692,346	2,568,604	56,257 (9)	208,714 (9)
Steelhead	218	1,607	218	1,607	0 (0)	0 (0)	218	1,607	0 (0)	0 (0)	326	2,397	108 (50)	790 (49)
Total	**1,712,653**	**5,662,016**	**1,712,653**	**5,662,016**	**0 (0)**	**0 (0)**	**1,675,629**	**5,408,093**	**-37,024 (-2)**	**-253,923 (-2)**	**1,801,878**	**6,122,626**	**89,225 (5)**	**460,610 (8)**
South Puget Sound														
Chinook salmon	40,346	710,103	40,346	710,103	0 (0)	0 (0)	34,647	609,789	-5,699 (-14)	-100,314 (-14)	42,572	749,263	2,226 (6)	39,160 (6)
Coho salmon	174,512	1,127,345	174,512	1,127,345	0 (0)	0 (0)	131,570	849,930	-42,942 (-25)	-277,415 (-25)	215,911	1,394,782	41,399 (24)	267,437 (24)
Sockeye salmon	37,457	213,881	37,457	213,881	0 (0)	0 (0)	37,457	213,881	0 (0)	0 (0)	46,951	268,088	9,494 (25)	54,207 (25)
Pink salmon	64,548	34,210	64,548	34,210	0 (0)	0 (0)	64,548	34,210	0 (0)	0 (0)	64,548	34,210	0 (0)	0 (0)
Chum salmon	544,334	2,019,480	544,334	2,019,480	0 (0)	0 (0)	544,334	2,019,480	0 (0)	0 (0)	583,700	2,165,527	39,366 (7)	146,047 (7)
Steelhead	181	1,331	181	1,331	0 (0)	0 (0)	181	1,331	0 (0)	0 (0)	280	2,059	99 (5)	728 (5)
Total	**861,378**	**4,106,350**	**861,378**	**4,106,350**	**0** (0)	**0** (0)	**812,736**	**3,728,630**	**-48,642 (-6)**	**-377,720 (-9)**	**953,960**	**4,613,929**	**92,582 (11)**	**507,579 (12)**

Table 4.3-3. Number of fish harvested and net economic values (in dollars) of Puget Sound commercial salmon and steelhead fisheries by subregion, species, and alternative, continued.

Subregion and Species	Alternative 1 (No Action) Number of Fish	Alternative 1 (No Action) Net Economic Value ($)	Alternative 2 (Proposed Action) Number of Fish	Alternative 2 (Proposed Action) Net Economic Value ($)	Alternative 2 Change from Alternative 1: Number of Fish and Percent	Alternative 2 Change from Alternative 1: Net Economic Value ($) and Percent	Alternative 3 (Reduced Production) Number of Fish	Alternative 3 (Reduced Production) Net Economic Value ($)	Alternative 3 Change from Alternative 1: Number of Fish and Percent	Alternative 3 Change from Alternative 1: Net Economic Value ($) and Percent	Alternative 4 (Increased Production) Number of Fish	Alternative 4 (Increased Production) Net Economic Value ($)	Alternative 4 Change from Alternative 1: Number of Fish and Percent	Alternative 4 Change from Alternative 1: Net Economic Value ($) and Percent
Strait of Juan de Fuca														
Chinook salmon	11,195	197,045	11,195	197,045	0 (0)	0 (0)	6,548	115,241	-4,647 (-42)	-81,804 (-42)	12,492	219,862	1,297 (12)	22,817 (12)
Coho salmon	23,868	154,187	23,868	154,187	0 (0)	0 (0)	17,545	111,602	-6,323 (-26)	-42,585 (-28)	26,903	173,793	3,035 (13)	19,606 (13)
Sockeye salmon	29,890	170,671	29,890	170,671	0 (0)	0 (0)	29,890	170,671	0 (0)	0 (0)	29,957	171,053	67 (< 1)	382 (< 1)
Pink salmon	29,631	15,704	29,631	15,704	0 (0)	0 (0)	29,631	15,704	0 (0)	0 (0)	29,631	15,704	0 (0)	0 (0)
Chum salmon	10,572	39,221	10,572	39,221	0 (0)	0 (0)	10,572	39,221	0 (0)	0 (0)	11,492	42,633	920 (9)	3,412 (9)
Steelhead	205	1,507	205	1,507	0 (0)	0 (0)	205	1,507	0 (0)	0 (0)	205	1,507	0 (0)	0 (0)
Total	**105,361**	**578,336**	**105,361**	**578,336**	**0** (0)	**0** (0)	**94,121**	**453,947**	**-11,240 (-11)**	**-124,389 (-22)**	**110,409**	**624,553**	**5,048** (5)	**46,217** (8)
PUGET SOUND TOTALS														
Chinook salmon	**77,847**	**1,370,107**	**77,847**	**1,370,107**	**0 (0)**	**0 (0)**	**66,175**	**1,164,694**	**-11,672 (-15)**	**-205,413 (-15)**	**84,854**	**1,493,425**	**7,007 (9)**	**123,318 (9)**
Coho salmon	**314,060**	**2,028,827**	**314,060**	**2,028,827**	**0 (0)**	**0 (0)**	**228,825**	**1,478,209**	**-85,235 (-27)**	**-550,618 (-27)**	**387,869**	**2,505,634**	**73,809 (24)**	**476,807 (24)**
Sockeye salmon	**375,272**	**2,142,806**	**375,272**	**2,142,806**	**0 (0)**	**0 (0)**	**375,272**	**2,142,806**	**0 (0)**	**0 (0)**	**384,833**	**2,197,395**	**9,561 (3)**	**54,589 (3)**
Pink salmon	**720,613**	**381,925**	**720,613**	**381,925**	**0 (0)**	**0 (0)**	**720,613**	**381,925**	**0 (0)**	**0 (0)**	**720,613**	**381,925**	**0 (0)**	**0 (0)**
Chum salmon	**1,190,995**	**4,418,591**	**1,190,995**	**4,418,591**	**0 (0)**	**0 (0)**	**1,190,995**	**4,418,591**	**0 (0)**	**0 (0)**	**1,287,537**	**4,776,764**	**96,542 (8)**	**358,173 (8)**
Steelhead	**604**	**4,445**	**604**	**4,445**	**0 (0)**	**0 (0)**	**604**	**4,445**	**0 (0)**	**0 (0)**	**810**	**5,964**	**206 (34)**	**1,519 (34)**
Total	**2,679,392**	**10,346,702**	**2,679,392**	**10,346,702**	**0** (0)	**0** (0)	**2,582,486**	**9,590,671**	**-96,906 (-4)**	**-756,031 (-7)**	**2,866,517**	**11,361,108**	**187,125 (7)**	**1,014,406 (10)**

Source: Estimates are derived by TCW Economics using harvest estimates provided by the Puget Sound Hatchery EIS Technical Work Group and net economic value factors identified in Appendix I, Socioeconomic Impact Methods.

Note: Net economic value totals do not include the value of fish caught in Puget Sound marine waters but landed in ports outside of Puget Sound.

4.3.4.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest would be less under Alternative 3 than under Alternative 1. Under Alternative 3, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 2,582,486 fish (Table 4.3-1). This harvest level would represent an overall reduction of 96,906 fish, or 4 percent, relative to harvest levels under Alternative 1. All of the harvest reduction under Alternative 3 would be attributable to decreases in harvests of Chinook salmon (15 percent decrease) and coho salmon (27 percent decrease) (Table 4.3-3). For non-tribal fishers, reductions in harvests under Alternative 3 would be minor, representing less than 1 percent of Alternative 1 levels (Table 4.3-1). For tribal fishers, however, the reduction in harvest would be larger, estimated at 89,625 fish, or 7 percent of the tribal harvest compared to Alternative 1.

The total gross economic values of salmon and steelhead harvests would decrease 7 percent under Alternative 3, with tribal fishers experiencing an 11 percent reduction and non-tribal fishers experiencing a 1 percent reduction (Table 4.3-2). Overall gross economic value would decline by $1,125,381 (7 percent), with tribal reductions accounting for 93 percent of this total. Similarly, under Alternative 3, net economic values to commercial fishers would decrease by $756,031, or 7 percent, compared to Alternative 1, with Chinook salmon ($205,413) and coho salmon ($550,618) accounting for the decrease (Table 4.3-3).

4.3.4.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1. Under Alternative 4, commercial harvest of salmon and steelhead in the socioeconomic analysis area would increase by 187,125 fish, an increase of 7 percent over Alternative 1 (Table 4.3-1). Harvests for both the tribal and non-tribal fisheries would increase under Alternative 4, with tribal harvest increasing by 8 percent and non-tribal harvest increasing by 6 percent relative to Alternative 1 (Table 4.3-1). With the exception of pink salmon, harvests of all species would increase under Alternative 4, with the largest increase in numbers anticipated to occur for chum salmon (96,542 fish) and coho salmon (73,809 fish) compared to Alternative 1 (Table 4.3-3).

As a result of larger commercial harvests, gross economic values under Alternative 4 would increase in the socioeconomic analysis area by $1,525,699, or 10 percent, relative to Alternative 1 (Table 4.3-2). A total of $1,031,077 (68 percent) of this increase in gross economic value would accrue to tribal fishers (Table 4.3-2). Net economic values to commercial fishers would increase by an estimated $1,014,406, or 10 percent, compared to Alternative 1 (Table 4.3-3), with the largest increases in net economic values anticipated to occur for coho salmon ($476,807) and chum salmon ($358,173) (Table 4.3-3).

4.3.4.2 North Puget Sound Subregion

As described in (Subsection 3.3.3.2, North Puget Sound Subregion), an estimated 1,712,653 salmon and steelhead are commercially harvested in the north Puget Sound subregion (Table 3.3-4), which represents 64 percent of the harvest in the socioeconomic analysis area. Pink salmon and chum salmon represent the largest share (1,262,524) of the total harvest in the north Puget Sound subregion, followed by sockeye salmon (307,925), coho salmon (115,681), Chinook salmon (26,305), and steelhead (218) (Table 3.3-4). Within the north Puget Sound subregion, non-tribal fishers account for 54 percent of the harvest, and tribal fishers account for 46 percent of the harvest (Table 3.3-4). Commercial harvest generates an estimated $8,545,496 in gross economic value, of which tribal fishers receive $4,455,730, or 52 percent (Table 3.3-4). The net economic value associated with the harvest of salmon and steelhead in the north Puget Sound subregion is $5,662,016, with chum salmon representing the highest net economic value (Table 3.3-4).

4.3.4.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the north Puget Sound subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from commercial salmon and steelhead fishing in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.3.2, North Puget Sound Subregion). Under Alternative 1, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 1,712,653 fish (Table 4.3-1) with a total gross economic value of $8,545,496 (Table 4.3-2), which would be the same as the affected environment. Of this total gross economic value under Alternative 1, tribal value would represent 52 percent of the total value, while the non-tribal value would represent 48 percent of the total value (Table 4.3-2), which would be the same as existing conditions. Chum salmon and pink salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the north Puget Sound subregion under Alternative 1 would be $5,662,016, the same as the affected environment, and chum salmon would have the highest net economic value (Table 4.3-3).

4.3.4.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from commercial salmon and steelhead fishing in the north Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-1, Table 4.3-2, and Table 4.3-3), because the number of fish released would be the same. Under Alternative 2, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 1,712,653 fish (Table 4.3-1) with a total gross economic value of $8,545,496 (Table 4.3-2), which is the same as Alternative 1. Of this total gross economic value under Alternative 2, tribal value would represent 52 percent of the total value, while the non-tribal value would represent 48 percent of the total value (Table 4.3-2), which is the same as Alternative 1. Similarly, chum salmon and pink salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the north Puget Sound subregion under Alternative 2 would be $5,662,016, the same as Alternative 1, and chum salmon would continue to have the highest net economic value (Table 4.3-3).

4.3.4.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, commercial harvests of salmon and steelhead in the north Puget Sound subregion would total 1,675,628 fish (Table 4.3-1). This harvest level would represent an overall reduction of 37,025 fish, or 2 percent, relative to harvest levels under Alternative 1. This decrease would be attributable to reduced harvest of coho salmon (31 percent) and Chinook salmon (5 percent) under Alternative 3 (Table 4.3-3). Harvest reductions under Alternative 3 would be most substantial for tribal fishers, whose harvest would decrease 4 percent, whereas harvests for non-tribal fishers would decrease less than 1 percent (Table 4.3-1). The total gross economic value of salmon and steelhead harvest in the north Puget Sound subregion would decrease under Alternative 3, with tribal fishers experiencing a 7 percent reduction and non-tribal fishers experiencing a 2 percent reduction (Table 4.3-2).

Overall, gross economic value would decrease by $380,890 (5 percent), with tribal reductions accounting for 82 percent of this total in the north Puget Sound subregion (Table 4.3-2). Net economic value to commercial fishers in the north Puget Sound subregion would decrease by an estimated $253,923, or 2 percent, compared to Alternative 1 (Table 4.3-3), with the largest decrease in net economic value anticipated to occur for coho salmon ($230,628) (Table 4.3-3).

4.3.4.2.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, commercial harvests of salmon and steelhead in the north Puget Sound subregion would total 1,801,878 fish (Table 4.3-1). This harvest level would represent an overall increase of 89,225 fish, a 5 percent increase over Alternative 1. This increase would be attributable to increased harvest of all species except sockeye salmon and pink salmon (Table 4.3-3). Harvest increases would be similar for tribal (5 percent increase) and non-tribal (5 percent increase) fishers (Table 4.3-1). The total gross economic value of salmon and steelhead harvest in the north Puget Sound subregion would increase under Alternative 4, with tribal fishers experiencing a 9 percent increase and non-tribal fishers experiencing a 7 percent increase (Table 4.3-2).

Overall, gross economic value would increase by $693,177 (8 percent), with tribal increases accounting for 56 percent of this total in the north Puget Sound subregion (Table 4.3-2). Under Alternative 4, net economic value to commercial fishers in the north Puget Sound subregion would increase by an estimated $460,610, or 8 percent, compared to Alternative 1 (Table 4.3-3), with the largest increases in net economic value anticipated to occur for chum salmon ($208,714) and coho salmon ($189,764) (Table 4.3-3).

4.3.4.3 South Puget Sound Subregion

As described in Subsection 3.3.3.3, South Puget Sound Subregion, an estimated 861,378 salmon and steelhead are commercially harvested in the south Puget Sound subregion (Table 3.3-4), which represents

32 percent of the harvest in the socioeconomic analysis area. Chum salmon represent the largest share (544,344) of the total harvest in the south Puget Sound subregion, followed by coho salmon (174,512), pink salmon (64,548), Chinook salmon (40,346), sockeye salmon (37,457), and steelhead (181) (Table 3.3-4). Within the south Puget Sound subregion, non-tribal fishers account for 50 percent of the harvest and tribal fishers account for 50 percent of the harvest (Table 3.3-4). Commercial harvest generates an estimated $6,172,902 in gross economic value, of which tribal fishers receive $3,890,770, or 63 percent (Table 3.3-4). The net economic value associated with the harvest of salmon and steelhead in the south Puget Sound subregion is $4,106,350, with chum salmon representing the highest net economic value (Table 3.3-4).

4.3.4.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the south Puget Sound subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from commercial salmon and steelhead fishing in the south Puget Sound subregion compared to the affected environment (Subsection 3.3.3.3, South Puget Sound Subregion). Under Alternative 1, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 861,378 fish (Table 4.3-1) with a total gross economic value of $6,172,902 (Table 4.3-2), which would be the same as the affected environment. Of this total gross economic value under Alternative 1, tribal value would represent 63 percent of the total value, while the non-tribal value would represent 37 percent of the total value (Table 4.3-2), which would be the same as the affected environment. Chum salmon and coho salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the south Puget Sound subregion under Alternative 1 would be $4,106,350, which would be the same as the affected environment, and chum salmon would have the highest net economic value (Table 4.3-3).

4.3.4.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from commercial salmon and steelhead fishing in the south Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-1, Table 4.3-2, and Table 4.3-3), because the number of fish released would be the same. Under Alternative 2, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 861,378 fish (Table 4.3-1) with a total gross economic value of $6,172,902 (Table 4.3-2), which is the same as Alternative 1. Of this total gross economic value under Alternative 2, tribal value would represent 63 percent of the total value, while the non-tribal value would represent 37 percent of the total value (Table 4.3-2), which is the same as Alternative 1. Chum salmon and coho salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the south Puget Sound subregion under Alternative 1 would be $4,106,350, the same as Alternative 1, and chum salmon would continue to have the highest net economic value (Table 4.3-3).

4.3.4.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, commercial harvests of salmon and steelhead in the south Puget Sound subregion would total 812,736 fish (Table 4.3-1). This harvest level would represent an overall reduction of 48,642 fish, or 6 percent, relative to harvest levels under Alternative 1. This harvest level would be attributable solely to reduced catch of Chinook salmon (14 percent) and coho salmon (25 percent) (Table 4.3-3). Harvest reductions would be most substantial for tribal fishers, whose harvest would decline by 12 percent, compared to a less than 1 percent reduction for non-tribal fishers (Table 4.3-1). The total gross economic value of salmon and steelhead harvest in the south Puget Sound subregion would decrease under Alternative 3, with tribal fishers experiencing a 14 percent reduction and non-tribal fishers experiencing a less than 1 percent reduction (Table 4.3-2). Overall, gross economic value would decrease by $562,397 (9 percent), with tribal reductions accounting for 98 percent of this total in the south Puget Sound subregion (Table 4.3-2). Net economic value to commercial fishers in the south Puget Sound subregion would decline by an estimated $377,720, or 9 percent, compared to Alternative 1 (Table 4.3-3), with the largest decrease in net economic value anticipated to occur for coho salmon ($277,415) (Table 4-3.3).

4.3.4.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, commercial harvests of salmon and steelhead in the south Puget Sound subregion would total 953,960 fish (Table 4.3-1). This harvest level would represent an overall increase of 92,582 fish, an 11 percent increase over Alternative 1. This increase would be attributable to increased harvest of all species except pink salmon (Table 4.3-3). Harvest increases would be most substantial for tribal fishers, whose harvest would increase by 14 percent, compared to an 8 percent increase for non-tribal fishers (Table 4.3-1). The total gross economic values of salmon and steelhead harvest in the south Puget Sound subregion would increase under Alternative 4, with tribal fishers experiencing a 15 percent increase and non-tribal fishers experiencing an 8 percent increase (Table 4.3-2). Overall, gross economic value would increase by $764,324 (12 percent), with tribal increases accounting for 75 percent of this total in the south Puget Sound subregion (Table 4.3-2). Under Alternative 4, net economic value to commercial fishers in the south Puget Sound subregion would increase by an estimated $507,579, or 12 percent, compared to Alternative 1 (Table 4.3-3), with the largest increase in net economic value anticipated to occur for coho salmon ($267,437) (Table 4.3-3).

4.3.4.4 Strait of Juan de Fuca Subregion

As described in Subsection 3.3.3.4, Strait of Juan de Fuca Subregion, an estimated 105,361 salmon and steelhead are harvested in the Strait of Juan de Fuca subregion, representing 4 percent of the harvest in the socioeconomic analysis area (Table 3.3-4). Sockeye salmon and pink salmon represent the largest shares (about 30,000 each) of the total harvest in the Strait of Juan de Fuca subregion, followed by coho salmon (23,868), Chinook salmon and chum salmon (about 11,000 each), and steelhead (205) (Table 3.3-4). Within the Strait of Juan de Fuca subregion, non-tribal fishers account for 9 percent of the harvest and tribal fishers account for 91 percent of the harvest (Table 3.3-4). Commercial harvest generates an estimated $859,499 in gross economic value, of which tribal fishers receive $801,967, or 93 percent (Table 3.3-4). The net economic value associated with the harvest of salmon and steelhead in the Strait of Juan de Fuca subregion is $578,336, with Chinook salmon representing the highest net economic value (Table 3.3-4).

4.3.4.4.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the Strait of Juan de Fuca subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from commercial salmon and steelhead fishing in the Strait of Juan de Fuca subregion compared to the affected environment (Subsection 3.3.3.4, Strait of Juan de Fuca Subregion). Under Alternative 1, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 105,361 fish

(Table 4.3-1) with a total gross economic value of $859,499 (Table 4.3-2), which would be the same as the affected environment. Of this total gross economic value under Alternative 1, tribal value would represent 93 percent of the total value ($859,499), while the non-tribal value would represent 7 percent of the total value (Table 4.3-2), which would be the same as existing conditions. Pink salmon and sockeye salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the Strait of Juan de Fuca subregion under Alternative 1 would be $578,336, the same as the affected environment, and Chinook salmon would have the highest net economic value (Table 4.3-3).

4.3.4.4.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from commercial salmon and steelhead fishing in the Strait of Juan de Fuca subregion, which would be the same as under Alternative 1 (Table 4.3-1, Table 4.3-2, and Table 4.3-3), because the number of fish released would be the same. Under Alternative 2, commercial salmon and steelhead harvests in the socioeconomic analysis area would total 105,361 fish (Table 4.3-1) with a total gross economic value of $859,499 (Table 4.3-2), which is the same as Alternative 1. Of this total gross economic value under Alternative 2, tribal value would represent 93 percent of the total value, while the non-tribal value would represent 7 percent of the total value (Table 4.3-2), which is the same as Alternative 1. Pink salmon and sockeye salmon would represent the primary species harvested (Table 4.3-3). The net economic value associated with the harvest of salmon and steelhead in the Strait of Juan de Fuca subregion under Alternative 2 would be $578,336, the same as Alternative 1, and Chinook salmon would continue to have the highest net economic value (Table 4.3-3).

4.3.4.4.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, commercial harvests of salmon and steelhead in the Strait of Juan de Fuca subregion would total 94,121 fish (Table 4.3-1). This harvest level would represent an overall reduction of 11,240 fish, or 11 percent, relative to harvest levels under Alternative 1. This decrease would be attributable to reduced harvest of Chinook salmon (42 percent) and coho salmon (26 percent) under Alternative 3 (Table 4.3-3). Harvest reductions under Alternative 3 would be most substantial for tribal fishers, whose harvest would decrease 12 percent, whereas harvests for non-tribal fishers would decrease 2 percent (Table 4.3-1). The total gross economic value of salmon and steelhead harvest in the Strait of Juan de Fuca subregion would decrease under Alternative 3, with tribal fishers experiencing a 23 percent reduction and non-tribal fishers experiencing a 2 percent reduction (Table 4.3-2). Overall, gross economic value would decrease by $182,093 (21 percent), with tribal reductions accounting for 99 percent of this total in the Strait of Juan de Fuca subregion (Table 4.3-2). Net economic value to commercial fishers in the Strait of Juan de Fuca subregion would decrease by $124,389, or 22 percent, compared to Alternative 1 (Table 4.3-3), with the largest decrease in net economic value anticipated to occur for Chinook salmon ($81,804) (Table 4.3-3).

4.3.4.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, commercial harvests of salmon and steelhead in the Strait of Juan de Fuca subregion would total 110,409 fish (Table 4.3-1). This harvest level would represent an overall increase of 5,318 fish, a 5 percent increase over Alternative 1. With the exception of pink salmon, harvests of all species would increase under Alternative 4, with the largest increases in numbers anticipated to occur for coho salmon (3,035 fish), Chinook salmon (1,297 fish), and chum salmon (920 fish) compared to Alternative 1 (Table 4.3-3). Harvest increases would be most substantial for non-tribal fishers, whose harvest would increase by 9 percent, compared to a 5 percent increase for tribal fishers (Table 4.3-1). The total gross economic value of salmon and steelhead harvest in the Strait of Juan de Fuca subregion would increase under Alternative 4, with tribal fishers experiencing an 8 percent increase and non-tribal fishers experiencing a 9 percent increase (Table 4.3-2). Overall, gross economic value would increase by $68,198 (8 percent), with tribal increases accounting for 92 percent of this total in the Strait of Juan de Fuca subregion (Table 4.3-2). Under Alternative 4, net economic value to commercial fishers in the Strait of Juan de Fuca subregion would increase by an estimated $46,217, or 8 percent, compared to Alternative 1 (Table 4.3-3), with the largest increases in net economic values anticipated to occur for Chinook salmon and coho salmon ($22,817 and $19,606, respectively) (Table 4.3-3).

4.3.5 Recreational Salmon and Steelhead Fishing

As described in Subsection 3.3.4, Recreational Salmon and Steelhead Fishing, recreational fishers are consumptive users of fishery resources and place monetary value on their fishing activities. The following subsections describe estimated changes under the alternatives in gross and net economic values associated with recreational fishing for salmon and steelhead in the socioeconomic analysis area and its three subregions. Gross economic values for recreational fisheries are defined in terms of total trip-related expenditures made by recreational fishers and net economic values are defined as fishers' willingness to pay over and above expenditures for these fishing opportunities. In contrast to economic data for commercial fisheries, limitations in economic data for recreational fisheries in all subregions preclude species-specific estimates of net economic values. At regional and subregional levels, gear use and the locations and distribution of recreational fishing for salmon and steelhead would not change from existing conditions in the socioeconomic analysis area under any alternative and thus are not analyzed. Changes in local effects associated with fisheries in major river systems and ports and fishing communities under the alternatives, such as support to businesses and local economies, are described in Subsection 4.3.7, Fisheries in Major River Systems, and Subsection 4.3.8, Ports and Fishing Communities, respectively.

4.3.5.1 Puget Sound Region

As described in Subsection 3.3.4.1, Puget Sound Region, recreational fishers make an estimated 997,380 annual trips in the socioeconomic analysis area and $70,245,440 in trip-related expenditures, and accrue $58,965,077 in net economic value supporting local businesses and economies (Table 3.3-5).

4.3.5.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from recreational salmon and steelhead fishing in the socioeconomic analysis area compared to the affected environment (Subsection 3.3.4.1, Puget Sound Region). Under Alternative 1, the number of recreational fishing trips in the socioeconomic analysis area would total 997,380 trips (Table 4.3-4), which would be the same as the affected environment.

Under Alternative 1, trip-related expenditures would total $70,245,440 (Table 4.3-4), which would be the same as the affected environment. Net economic value for Alternative 1, which is associated with recreational fishing for salmon and steelhead in the socioeconomic analysis area, would be $58,965,077 with 51 percent attributed to the south Puget Sound subregion, 43 percent attributed to the north Puget

Sound subregion, and 6 percent attributed to the Strait of Juan de Fuca subregion (Table 4.3-5), which is the same as the affected environment (Table 3.3-5).

4.3.5.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from recreational salmon and steelhead fishing in the socioeconomic analysis area, which would be the same as under Alternative 1 (Table 4.3-4 and Table 4.3-5), because the number of fish released would be the same. The number of recreational fishing trips, trip expenditures, and net economic value from recreational fishing would be the same as under Alternative 1.

Under Alternative 2, the number of recreational fishing trips in the socioeconomic analysis area would total 997,380 trips (Table 4.3-4), which would be the same as under Alternative 1. Under Alternative 2, trip-related expenditures would total $70,245,440 (Table 4.3-4) as described under Alternative 1. Net economic value for Alternative 2, which is associated with recreational fishing for salmon and steelhead in the socioeconomic analysis area, would be $58,965,077 with 51 percent attributed to the south Puget Sound subregion, 43 percent attributed to the north Puget Sound subregion, and 6 percent attributed to the Strait of Juan de Fuca subregion (Table 4.3-5), which is the same as existing conditions (Table 3.3-5).

4.3.5.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. Under Alternative 3, the number of recreational fishing trips in the socioeconomic analysis area would total 922,224 trips, which would be 75,156 (8 percent) fewer than under Alternative 1 (Table 4.3-4).

Under Alternative 3, trip-related expenditures would total $64,952,226, which would be $5,293,214 less (8 percent) than under Alternative 1 (Table 4.3-4). Under Alternative 3, net economic value associated with recreational fishing for salmon and steelhead in the socioeconomic analysis area would be $54,521,874, which would be $4,443,203 (8 percent) less than under Alternative 1, with 52 percent attributed to the south Puget Sound subregion, 43 percent attributed to the north Puget Sound subregion, and 5 percent attributed to the Strait of Juan de Fuca subregion (Table 4.3-5).

Table 4.3-4. Impacts on recreational fishing trips and expenditures in Puget Sound by subregion and alternative.

Subregion	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Number or $	Number or $	Number or $	Percent	Number or $	Number or $	Percent	Number or $	Number or $	Percent
North Puget Sound										
Trips (Number)	430,757	430,757	0	0	394,072	-36,685	-9	461,281	30,524	7
Expenditures ($)	30,338,222	30,338,222	0	0	27,754,490	-2,583,732	-9	32,488,011	2,149,789	7
South Puget Sound										
Trips (Number)	512,878	512,878	0	0	479,929	-32,948	-6	659,112	146,234	29
Expenditures ($)	36,121,982	36,121,982	0	0	33,801,422	-2,320,559	-6	46,421,228	10,299,246	29
Strait of Juan de Fuca										
Trips (Number)	53,745	53,745	0	0	48,223	-5,522	-10	60,086	6,341	12
Expenditures ($)	3,785,236	3,785,236	0	0	3,396,314	-388,922	-10	4,231,847	446,611	12
PUGET SOUND TOTALS										
Trips (Number)	**997,380**	**997,380**	**0**	**0**	**922,224**	**-75,156**	**-8**	**1,180,478**	**183,099**	**18**
Expenditures ($)	**70,245,440**	**70,245,440**	**0**	**0**	**64,952,226**	**-5,293,214**	**-8**	**83,141,086**	**12,895,647**	**18**

Source: Estimates of trips were derived by the Puget Sound Hatchery EIS Technical Work Group, and estimates of expenditures are derived by TCW Economics using trip estimates. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

Table 4.3-5. Net economic values (in dollars) of recreational fisheries in Puget Sound by subregion and alternative.

		Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
	Alternative 1 (No Action)		Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
Subregion and Species	**Net Economic Value ($)**	**Net Economic Value ($)**	**Net Economic Value ($)**	**Percent**	**Net Economic Value ($)**	**Net Economic Value ($)**	**Percent**	**Net Economic Value ($)**	**Net Economic Value ($)**	**Percent**
North Puget Sound	25,466,359	25,466,359	0	0	23,297,536	-2,168,823	-9	27,270,924	1,804,565	7
South Puget Sound	30,321,334	30,321,334	0	0	28,373,422	-1,947,912	-6	38,966,676	8,645,342	29
Strait of Juan de Fuca	3,177,384	3,177,384	0	0	2,850,917	-326,467	-10	3,552,276	374,892	12
PUGET SOUND TOTAL	**58,965,077**	**58,965,077**	**0**	**0**	**54,521,874**	**-4,443,203**	**-8**	**69,789,877**	**10,824,800**	**18**

Source: Estimates are derived by TCW Economics using trip estimates provided by the Puget Sound Hatchery Technical Fish Work Group (see Table 4.3-4). Refer to Appendix I, Socioeconomic Impact Methods, for additional details.
Note: Effects do not include those associated with fish caught in Puget Sound marine waters but landed in ports outside of Puget Sound.

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4.3.5.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the number of recreational fishing trips in the socioeconomic analysis area would total 1,180,478, which would represent 183,099 (or 18 percent) more trips than under Alternative 1 (Table 4.3-4). Under Alternative 4, trip-related expenditures would be $83,141,086 (or 18 percent) more than under Alternative 1 (Table 4.3-4). Under Alternative 4, net economic value associated with recreational fishing for salmon and steelhead in the socioeconomic analysis area would be $69,789,877, which would be $10,824,800 (or 18 percent) greater than under Alternative 1, with 56 percent attributed to the south Puget Sound subregion, 39 percent attributed to the north Puget Sound subregion, and 5 percent attributed to the Strait of Juan de Fuca subregion (Table 4.3-5).

4.3.5.2 North Puget Sound Subregion

As described in Subsection 3.3.4.2, North Puget Sound Subregion, recreational fishers make an estimated 430,757 annual trips in the north Puget Sound subregion and $30,338,222 in trip-related expenditures supporting local businesses and economies (Table 3.3-5). Recreational fishing trips in the north Puget Sound subregion account for 43 percent of all salmon and steelhead trips occurring in the socioeconomic analysis area (Table 3.3-5). Net economic value associated with recreational fishing for salmon and steelhead in the north Puget Sound subregion totals an estimated $25,466,359 (Table 3.3-5) (Subsection 3.3.4.2, North Puget Sound Subregion).

4.3.5.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the north Puget Sound subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from recreational salmon and steelhead fishing in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.4.2, North Puget Sound Subregion).

Under Alternative 1, trip-related expenditures would total $30,338,222 (Table 4.3-4), which would be the same as the affected environment. Net economic value for Alternative 1, which is associated with recreational fishing for salmon and steelhead in the north Puget Sound subregion of the socioeconomic analysis area, would be $25,466,359 (Table 4.3-5), which is the same as existing conditions (Table 3.3-5).

4.3.5.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from recreational salmon and steelhead fishing in the north Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-4 and Table 4.3-5), because the number of fish released would be the same. Under Alternative 2, the number of recreational fishing trips in the socioeconomic analysis area for the north Puget Sound subregion would total 430,757 trips (Table 4.3-4), which would be the same as Alternative 1.

Under Alternative 2, trip-related expenditures would total $30,338,222 (Table 4.3-4), as described under Alternative 1. Net economic value for Alternative 2, which is associated with recreational fishing for salmon and steelhead in the north Puget Sound subregion of the socioeconomic analysis area, would be $25,466,359 (Table 4.3-5), which is the same as Alternative 1 (Table 3.3-5).

4.3.5.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. Under Alternative 3, the number of recreational fishing trips in the north Puget Sound subregion would total 394,072 trips, which would be 36,685 (9 percent) fewer than under Alternative 1 (Table 4.3-4).

Under Alternative 3, trip-related expenditures would total $27,754,490, which would be $2,583,732 less (9 percent) than under Alternative 1 (Table 4.3-4). Under Alternative 3, net economic value associated with recreational fishing for salmon and steelhead in the north Puget Sound subregion would be $23,297,536, which would be $2,168,823 (9 percent) less than under Alternative 1 (Table 4.3-5).

4.3.5.2.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the number of recreational fishing trips in the north Puget Sound subregion would total 461,281, which would represent 30,524 (or 7 percent) more trips than under Alternative 1 (Table 4.3-4). Under Alternative 4, trip-related expenditures would be $32,488,011, which would represent $2,149,789 (or 7 percent) more than under Alternative 1 (Table 4.3-4). Under Alternative 4, net economic value associated with recreational fishing for salmon and steelhead in the north Puget Sound subregion would be $27,270,924, which would be $1,804,565 (or 7 percent) greater than under Alternative 1 (Table 4.3-5).

4.3.5.3 South Puget Sound Subregion

As described in Subsection 3.3.4.3, South Puget Sound Subregion, recreational fishers make an estimated 512,878 annual trips in the south Puget Sound subregion and $36,121,982 in trip-related expenditures supporting local businesses and economies (Table 3.3-5). Recreational fishing trips in the south Puget Sound subregion account for 51 percent of all salmon and steelhead trips occurring in the socioeconomic analysis area (Table 3.3-5). Net economic value associated with recreational fishing for salmon and steelhead in the south Puget Sound subregion totals an estimated $30,321,334 (Table 3.3-5) (Subsection 3.3.4.3, South Puget Sound Subregion).

4.3.5.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the south Puget Sound subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from recreational salmon and steelhead fishing in the south Puget Sound subregion compared to the affected environment (Subsection 3.3.4.3, South Puget Sound Subregion). Under Alternative 1, the number of recreational fishing trips in the socioeconomic analysis area for the south Puget Sound subregion would total 512,878 trips (Table 4.3-4), which would be the same as the affected environment.

Under Alternative 1, trip-related expenditures would total $36,121,982 (Table 4.3-4), which would be the same as the affected environment. Net economic value for Alternative 1, which is associated with recreational fishing for salmon and steelhead in the south Puget Sound subregion of the socioeconomic analysis area, would be $30,321,334 (Table 4.3-5), which would be the same as the affected environment (Table 3.3-5).

4.3.5.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from recreational salmon and steelhead fishing in the south Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-4 and Table 4.3-5), because the number of fish released would be the same. Under Alternative 2, the number of recreational fishing trips in the socioeconomic analysis area for the south Puget Sound subregion would total 512,878 trips (Table 4.3-4), which would be the same as Alternative 1.

Under Alternative 2, trip-related expenditures would total $36,121,982 (Table 4.3-4), as described under Alternative 1. Net economic value for Alternative 2, which is associated with recreational fishing for salmon and steelhead in the south Puget Sound subregion of the socioeconomic analysis area, would be $30,321,334 (Table 4.3-5), which is the same as Alternative 1 (Table 3.3-5).

4.3.5.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. Under Alternative 3, the number of recreational fishing trips in the south Puget Sound subregion would total 479,929 trips, which would be 32,948 (6 percent) fewer than under Alternative 1 (Table 4.3-4).

Under Alternative 3, trip-related expenditures would total $33,801,422, which would be $2,320,559 less (6 percent) than under Alternative 1 (Table 4.3-4). Under Alternative 3, net economic value associated with recreational fishing for salmon and steelhead in the south Puget Sound subregion would be $28,373,422, which would be $1,947,912 (6 percent) less than under Alternative 1 (Table 4.3-5).

4.3.5.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1. Under Alternative 4, the number of recreational fishing trips in the south Puget Sound subregion would total 659,112, which would represent 146,234 (29 percent) more trips than under Alternative 1 (Table 4.3-4).

Under Alternative 4, trip-related expenditures would be $46,421,228, which would represent $10,299,246 (29 percent) more than under Alternative 1 (Table 4.3-4). Under Alternative 4, net economic value associated with recreational fishing for salmon and steelhead in the south Puget Sound subregion would be $38,966,676, which would be $8,645,342 (29 percent) greater than under Alternative 1 (Table 4.3-5).

4.3.5.4 Strait of Juan de Fuca Subregion

As described in Subsection 3.3.4.4, Strait of Juan de Fuca Subregion, recreational fishers make an estimated 53,745 annual trips in the Strait of Juan de Fuca subregion and $3,785,236 in trip-related expenditures supporting local businesses and economies (Table 3.3-5). Recreational fishing trips in the Strait of Juan de Fuca subregion account for 5 percent of all salmon and steelhead trips occurring in the socioeconomic analysis area (Table 3.3-5). Net economic value associated with recreational fishing for salmon and steelhead in the Strait of Juan de Fuca subregion totals an estimated $3,177,384 (Table 3.3-5) (Subsection 3.3.4.4, Strait of Juan de Fuca Subregion).

4.3.5.4.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead in the Strait of Juan de Fuca subregion under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts from recreational salmon and steelhead fishing in the Strait of Juan de Fuca subregion compared to the affected environment (Subsection 3.3.4.4, Strait of Juan de Fuca Subregion). Under Alternative 1, the number of recreational fishing trips in the socioeconomic analysis area for the Strait of Juan de Fuca subregion would total 53,745 trips (Table 4.3-4), which would be the same as the affected environment.

Under Alternative 1, trip-related expenditures would total $3,785,236 (Table 4.3-4), which would be the same as the affected environment. Net economic value for Alternative 1, which is associated with recreational fishing for salmon and steelhead in the Strait of Juan de Fuca subregion of the socioeconomic analysis area, would be $3,177,384 (Table 4.3-5), which would be the same as the affected environment (Table 3.3-5).

4.3.5.4.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change economic impacts from recreational salmon and steelhead fishing in the Strait of Juan de Fuca subregion, which would be the same as under Alternative 1 (Table 4.3-4 and Table 4.3-5), because the number of fish released would be the same. Under Alternative 2, the number of recreational fishing trips in the socioeconomic analysis area for the Strait of Juan de Fuca subregion would total 53,745 trips (Table 4.3-4), which would be the same as Alternative 1.

Under Alternative 2, trip-related expenditures would total $3,785,236 (Table 4.3-4), as described under Alternative 1. Net economic value for Alternative 2, which is associated with recreational fishing for salmon and steelhead in the Strait of Juan de Fuca subregion of the socioeconomic analysis area, would be $3,177,384 (Table 4.3-5), which is the same as Alternative 1 (Table 3.3-5).

4.3.5.4.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. Under Alternative 3, the number of recreational fishing trips in the Strait of Juan de Fuca subregion would total 48,223 trips, which would be 5,522 (10 percent) fewer than under Alternative 1 (Table 4.3-4).

Under Alternative 3, trip-related expenditures would total $3,396,314, which would be $388,922 less (10 percent) than under Alternative 1 (Table 4.3-4). Under Alternative 3, net economic value associated with recreational fishing for salmon and steelhead in the Strait of Juan de Fuca subregion would be $2,850,917, which would be $326,467 (10 percent) less than under Alternative 1 (Table 4.3-5).

4.3.5.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the number of recreational fishing trips in the Strait of Juan de Fuca subregion would total 60,086, which would represent 6,341 (or 12 percent) more trips than under Alternative 1 (Table 4.3-4). Under Alternative 4, trip-related expenditures would be $4,231,847, which would represent $446,611 (or 12 percent) more than under Alternative 1 (Table 4.3-4). Under Alternative 4, net economic value associated with recreational fishing for salmon and steelhead in the Strait of Juan de Fuca subregion would be $3,552,276, which would be $374,892 (or 12 percent) greater than under Alternative 1 (Table 4.3-5).

4.3.6 Regional and Subregional Economic Impacts

Commercial and recreational fisheries generate personal income and support jobs throughout the socioeconomic analysis area (Subsection 3.3.5, Regional and Subregional Economic Conditions). Economic impacts for personal income and jobs are evaluated by alternative in this subsection at the regional and subregional levels, and personal income and jobs are subdivided into fisheries harvest (commercial and recreational) and hatchery operations. Note that personal income differs from net economic value, as described in Subsection 4.3.4, Commercial Salmon and Steelhead Fishing, and Subsection 4.3.5, Recreational Salmon and Steelhead Fishing.

Commercial and recreational fisheries generate personal income and jobs in economies through the export of products and services to outside economies. Fish from commercial harvests are frequently sold directly, or after processing, to individuals or businesses located outside the regional economy. Similarly, non-local recreational fishers (i.e., fishers who do not live locally) spend money on guide services, lodging, and other goods and services that generate household income and jobs. This transfer of money supports payments to labor that are then re-spent regionally, resulting in a multiplier effect. In addition, hatchery facilities and their operations (or hatchery operations cost values, defined to include jobs for hatchery workers and procurement of goods and services for hatchery operations), directly and indirectly generate economic impacts in the socioeconomic analysis area (Subsection 3.3.5, Regional and Subregional Economic Conditions).

The following subsections identify expected incremental changes in the socioeconomics analysis area and the three subregions in total (direct and indirect) economic activity, as represented by personal income (which includes the salmon processing and buying sector) and jobs associated with fisheries and hatchery operations, by alternative. Potential impacts on local communities, including ports that are dependent on commercial and recreational fisheries, are discussed in Subsection 4.3.8, Ports and Fishing Communities.

4.3.6.1 Puget Sound Region

As described in Subsection 3.3.5.1, Puget Sound Region, the total economic effect from hatchery operations and harvest-related personal income in the socioeconomic analysis area is $106,888,559 (Table 3.3-6). Personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations contributes $94,249,981 ($84,544,408 in harvest-related personal income and $9,705,573 in hatchery operations-related personal income) (Table 3.3-6), and hatchery operations costs contribute another $12,638,777 (Table 3.3-6). More than half (59 percent, or $55,755,262) of the total personal income of $94,249,981 is generated by recreational fishing, while commercial fishing accounts for 31 percent ($28,789,147) and hatchery operations account for 10 percent ($9,705,573) (Table 3.3-6).

Across the subregions, most of the economic effects from hatchery operations and harvest-related personal income in the socioeconomic analysis area occur in the south Puget Sound subregion. The south Puget Sound subregion generates 50 percent ($54,430,443) of the total economic effect of $106,888,559. Another 43 percent ($45,587,730) is attributable to the north Puget Sound subregion, and 7 percent ($6,870,584) is attributable to the Strait of Juan de Fuca subregion (Subsection 3.3.5, Regional and Subregional Economic Conditions) (Table 3.3-6).

Of the total of 2,060 jobs related to hatchery operations and harvest in the socioeconomic analysis area, 1,195 jobs (58 percent) are attributable to recreational fishing, 32 percent (656 jobs) are attributable to commercial fishing, and 10 percent (209 jobs) are attributable to hatchery operations (Table 3.3-6).

Most of the jobs generated by fishing and hatchery operations in the socioeconomic analysis area occur in the north Puget Sound and south Puget Sound subregions. The north Puget Sound subregion generates 47 percent (975 jobs) of the total number of jobs in the socioeconomic analysis area (2,060 jobs), and the south Puget Sound subregion generates 44 percent (912 jobs). Jobs generated in the Strait of Juan de Fuca subregion account for 8 percent (173 jobs) of the jobs in the socioeconomic analysis area (Subsection 3.3.5, Regional and Subregional Economic Conditions) (Table 3.3-6).

4.3.6.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts in the socioeconomic analysis area compared to the affected environment (Subsection 3.3.5.1, Puget Sound Region). Under Alternative 1, the amount of total personal income ($94,249,981) (Table 4.3-6), harvest-related income ($28,789,146 for commercial harvest and $55,755,262 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($9,705,573) (Table 4.3-7), hatchery operations cost values ($12,638,777) (Table 4.3-6 and Table 4.3-8), and jobs (2,060 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as the affected environment.

4.3.6.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter economic impacts in the socioeconomic analysis area, which would be the same as under Alternative 1 (Table 4.3-6, Table 4.3-7, and Table 4.3-9), because the number of fish released would be the same. Under Alternative 2, the amount of total personal income ($94,249,981) (Table 4.3-6), harvest-related income ($28,789,146 for commercial harvest and $55,755,262 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($9,705,573) (Table 4.3-7), hatchery operations cost values ($12,638,777) (Table 4.3-6 and Table 4.3-8), and jobs (2,060 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as Alternative 1.

4.3.6.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Table 4.3-6. Summary of economic effects from Puget Sound hatchery operations and harvest on total personal income, jobs, and hatchery operations cost values by subregion and alternative.

Subregion	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Number or $	Number or $	Number or $	Percent	Number or $	Number or $	Percent	Number or $	Number or $	Percent
North Puget Sound										
Total Number of Jobs	975	975	0	0	919	-57	-6	1,069	94	10
Total Personal Income ($)	41,724,837	41,724,837	0	0	919	-2,584,854	-6	1,069	94	10
Hatchery Operations Cost Value ($)	3,862,893	3,862,893	0	0	2,909,992	-952,901	-25	5,483,766	1,620,872	42
Total Personal Income Plus Hatchery Operations Cost Value ($)	**45,587,730**	**45,587,730**	**0**	**0**	**42,049,975**	**-3,537,755**	**-8**	**51,312,157**	**5,724,426**	**13**
South Puget Sound										
Total Number of Jobs	912	912	0	0	832	-80	-9	1,070	158	17
Total Personal Income ($)	46,838,604	46,838,604	0	0	42,635,431	-4,203,173	-9	55,689,959	8,851,355	19
Hatchery Operations Cost Value ($)	7,591,839	7,591,839	0	0	6,115,604	-1,476,235	-19	8,683,959	1,092,119	14
Total Personal Income Plus Hatchery Operations Cost Value ($)	**54,430,443**	**54,430,443**	**0**	**0**	**48,751,035**	**-5,679,408**	**-10**	**64,373,918**	**9,943,474**	**18**

Table 4.3-6. Summary of economic effects from Puget Sound hatchery operations and harvest on total personal income, jobs, and hatchery operations cost values by subregion and alternative, continued.

Subregion	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Number or $	**Number or $**	**Number or $**	**Percent**	**Number or $**	**Number or $**	**Percent**	**Number or $**	**Number or $**	**Percent**
Strait of Juan de Fuca										
Total Number of Jobs	173	173	0	0	152	-21	-12	193	20	12
Total Personal Income ($)	5,686,540	5,686,540	0	0	5,013,808	-672,733	-12	6,308,656	622,116	11
Hatchery Operations Cost Value ($)	1,184,044	1,184,044	0	0	924,711	-259,333	-22	1,268,732	84,688	7
Total Personal Income Plus Hatchery Operations Cost Value ($)	**6,870,584**	**6,870,584**	**0**	**0**	**5,938,519**	**-932,066**	**-14**	**7,577,388**	**706,804**	**10**
PUGET SOUND TOTAL										
Total Number of Jobs	**2,060**	**2,060**	**0**	**0**	**1,903**	**-157**	**-8**	**2,332**	**272**	**13**
Total Personal Income ($)	**94,249,981**	**94,249,981**	**0**	**0**	**86,789,221**	**-7,460,760**	**-8**	**107,827,005**	**13,577,025**	**14**
Hatchery Operations Cost Value ($)	**12,638,777**	**12,638,777**	**0**	**0**	**9,950,307**	**-2,688,469**	**-21**	**15,436,456**	**2,797,679**	**22**
Total Personal Income Plus Hatchery Operations Cost Value ($)	**106,888,758**	**106,888,758**	**0**	**0**	**96,739,528**	**-10,149,229**	**-10**	**123,263,461**	**16,374,704**	**15**

Sources: Estimates of jobs and personal income derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details. Estimates of hatchery operations cost values are shown in Table 4.3-8, and were derived by the Puget Sound Hatchery EIS Technical Work Group (D. Schmitt, pers. comm., NWIFC, Salmon Recovery Projects Coordinator, February 17, 2010).

Table 4.3-7. Total (direct and indirect) impacts on personal income (in dollars) by subregion and alternative.

Subregion	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Personal Income ($[1])	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent
North Puget Sound										
Commercial	16,715,540	16,715,540	0	0	16,258,897	-456,642	-3	17,867,217	1,151,677	7
Recreational	22,249,969	22,249,969	0	0	20,651,908	-1,598,061	-7	23,998,636	1,748,667	8
Hatchery Facility Operations	2,759,328	2,759,328	0	0	2,229,178	-530,150	-19	3,962,538	1,203,210	44
Total	**41,724,837**	**41,724,837**	**0**		**39,139,983**	**-2,584,854**	**-6**	**45,828,391**	**4,103,554**	**10**
South Puget Sound										
Commercial	11,049,458	11,049,458	0	0	10,331,223	-718,235	-7	12,262,663	1,213,205	11
Recreational	29,581,949	29,581,949	0	0	27,458,371	-2,123,578	-7	36,213,379	6,631,430	22
Hatchery Facility Operations	6,207,197	6,207,197	0	0	4,845,837	-1,361,360	-22	7,213,917	1,006,720	16
Total	**46,838,604**	**46,838,604**	**0**	**0**	**42,635,431**	**-4,203,173**	**-9**	**55,689,959**	**8,851,355**	**19**
Strait of Juan de Fuca										
Commercial	1,024,148	1,024,148	0	0	853,251	-170,898	-17	1,094,184	70,036	7
Recreational	3,923,344	3,923,344	0	0	3,555,489	-367,855	-9	4,430,764	507,420	13
Hatchery Facility Operations	739,048	739,048	0	0	605,068	-133,980	-18	783,708	44,660	6
Total	**5,686,540**	**5,686,540**	**0**	**0**	**5,013,808**	**-672,733**	**-12**	**6,308,656**	**622,116**	**11**
PUGET SOUND TOTAL										
Commercial	**28,789,146**	**28,789,146**	**0**	**0**	**27,443,371**	**-1,345,776**	**-5**	**31,224,064**	**2,434,918**	**9**
Recreational	**55,755,262**	**55,755,262**	**0**	**0**	**51,665,767**	**-4,089,494**	**-7**	**64,642,778**	**8,887,517**	**16**
Hatchery Facility Operations	**9,705,573**	**9,705,573**	**0**	**0**	**7,680,083**	**-2,025,490**	**-21**	**11,960,163**	**2,254,590**	**23**
Total	**94,249,981**	**94,249,981**	**0**	**0**	**86,789,221**	**-7,460,760**	**-8**	**107,827,005**	**13,577,025**	**14**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] All values are expressed in 2007 dollars.

Table 4.3-8. Total hatchery operations cost values (in dollars) supporting commercial and recreational fisheries by subregion and alternative.

Subregion and Hatchery Operator	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Hatchery Operations Cost Value ($[1])	Hatchery Operations Cost Value ($)	Hatchery Operations Cost Value ($)	Percent	Hatchery Operations Cost Value ($)	Hatchery Operations Cost Value ($)	Percent	Hatchery Operations Cost Value ($)	Hatchery Operations Cost Value ($)	Percent
North Puget Sound										
Tribal	1,451,275	1,451,275	0	0	1,223,428	-227,846	-16	2,866,323	1,415,048	98
Tribal/WDFW	41,433	41,433	0	0	41,433	0	0	61,163	19,730	48
Tribal Total[2]	1,471,992	1,471,992	0	0	1,244,145	-227,847	-15	2,896,905	1,424,913	97
WDFW	2,356,386	2,356,386	0	0	1,631,331	-725,055	-31	2,530,520	174,134	7
Co-op	13,800	13,800	0	0	13,800	0	0	25,760	11,960	87
Total	**3,862,893**	**3,862,893**	**0**	**0**	**2,909,992**	**-952,901**	**-25**	**5,483,766**	**1,620,872**	**42**
South Puget Sound										
Tribal	2,123,757	2,123,757	0	0	1,592,582	-531,175	-25	2,338,083	214,326	10
Tribal/WDFW	901,581	901,581	0	0	901,581	0	0	1,104,831	203,250	23
Tribal Total[2]	2,574,548	2,574,548	0	0	2,043,373	-531,175	-21	2,890,499	315,951	12
WDFW	4,548,744	4,548,744	0	0	3,603,684	-945,060	-21	5,223,288	674,543	15
University of Washington	17,757	17,757	0	0	17,757	0	0	17,757	0	0
Total	**7,591,839**	**7,591,839**	**0**	**0**	**6,115,604**	**-1,476,235**	**-19**	**8,683,959**	**1,092,119**	**14**
Strait of Juan de Fuca										
Tribal	411,747	411,747	0	0	240,078	-171,670	-42	496,435	84,688	21
WDFW	636,797	636,797	0	0	549,133	-87,663	-14	636,797	0	0
USFWS	135,500	135,500	0	0	135,500	0	0	135,500	0	0
Total	**1,184,044**	**1,184,044**	**0**	**0**	**924,711**	**-259,333**	**-22**	**1,268,732**	**84,688**	**7**

Table 4.3-8. Total hatchery operations cost values (in dollars) supporting commercial and recreational fisheries by subregion and alternative, continued.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
Subregion and Hatchery Operator	**Hatchery Operations Cost Value ($[1])**	**Hatchery Operations Cost Value ($)**	**Hatchery Operations Cost Value ($)**	**Percent**	**Hatchery Operations Cost Value ($)**	**Hatchery Operations Cost Value ($)**	**Percent**	**Hatchery Operations Cost Value ($)**	**Hatchery Operations Cost Value ($)**	**Percent**
PUGET SOUND TOTALS										
Tribal	**3,986,778**	**3,986,778**	**0**	**0**	**3,056,087**	**-930,691**	**-23**	**5,700,840**	**1,714,062**	**43**
Tribal /WDFW	**943,014**	**943,014**	**0**	**0**	**943,014**	**0**	**0**	**1,165,994**	**222,980**	**24**
Tribal Total[2]	**4,458,285**	**4,458,285**	**0**	**0**	**3,527,594**	**930,691**	**-21**	**6,283,837**	**1,825,552**	**41**
WDFW	**7,541,927**	**7,541,927**	**0**	**0**	**5,784,149**	**-1,757,778**	**-23**	**8,390,604**	**848,677**	**11**
Co-op	**13,800**	**13,800**	**0**	**0**	**13,800**	**0**	**0**	**25,760**	**11,960**	**87**
University of Washington	**17,757**	**17,757**	**0**	**0**	**17,757**	**0**	**0**	**17,757**	**0**	**0**
USFWS	**135,500**	**135,500**	**0**	**0**	**135,500**	**0**	**0**	**135,500**	**0**	**0**
Total	**12,638,777**	**12,638,777**	**0**	**0**	**9,950,307**	**-2,688,469**	**-21**	**15,436,456**	**2,797,679**	**22**

Source: Estimates were derived by the Puget Sound Hatchery EIS Technical Work Group (D. Schmitt, pers. comm., NWIFC, Salmon Recovery Projects Coordinator, February 17, 2010). Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] All values are expressed in 2007 dollars.

[2] Tribal total equals the tribal amount plus 50 percent of the tribal/WDFW amount. These tribal totals are not added separately into subregional totals; the tribal and tribal/WDFW amounts are already summed to derive the subregional totals.

Note: Under Alternative 1 and Alternative 2, hatchery operations cost values for tribes shown in this table do not match those shown in Table 3.3-6 for current hatchery operations cost values. Operations cost values associated with hatcheries co-managed by the tribes and WDFW are split equally between the two entities. As shown in Table 3.3-6, this allocation results in total estimated tribal hatchery operations costs values for all of Puget Sound of $4,458,285 for Alternative 1 and 2, $3,527,594 for Alternative 3, and $6,283,837 for Alternative 4.

Table 4.3-9. Total (direct and indirect) impacts on jobs in Puget Sound subregions by alternative.

		Alternative 2 (Proposed Action)			**Alternative 3 (Reduced Production)**			**Alternative 4 (Increased Production)**		
	Alternative 1 (No Action)		**Change from Alternative 1**			**Change from Alternative 1**			**Change from Alternative 1**	
Subregion	**Number of Jobs**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**
North Puget Sound										
Commercial	416	416	0	0	404	-12	-3	445	29	7
Recreational	497	497	0	0	463	-34	-7	536	39	8
Hatchery Facility Operations	62	62	0	0	51	-11	-18	88	26	42
Total	**975**	**975**	**0**	**0**	**918**	**-57**	**-6**	**1069**	**94**	**10**
South Puget Sound										
Commercial	209	209	0	0	193	-16	-8	232	23	11
Recreational	575	575	0	0	534	-41	-7	691	116	20
Hatchery Facility Operations	129	129	0	0	106	-23	-18	147	18	14
Total	**913**	**913**	**0**	**0**	**833**	**-80**	**-9**	**1070**	**157**	**17**
Strait of Juan de Fuca										
Commercial	32	32	0	0	27	-5	-17	34	2	7
Recreational	123	123	0	0	112	-11	-9	139	16	13
Hatchery Facility Operations	18	18	0	0	14	-4	-22	20	2	11
Total	**173**	**173**	**0**	**0**	**153**	**-20**	**-12**	**193**	**20**	**12**
Puget Sound Total										
Commercial	**656**	**656**	**0**	**0**	**624**	**-33**	**-5**	**711**	**54**	**8**
Recreational	**1,195**	**1,195**	**0**	**0**	**1,108**	**-86**	**-7**	**1,366**	**171**	**14**
Hatchery Facility Operations	**209**	**209**	**0**	**0**	**171**	**-38**	**-18**	**255**	**46**	**22**
Total	**2,060**	**2,060**	**0**	**0**	**1,903**	**-157**	**-8**	**2,332**	**271**	**13**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

Under Alternative 3, the total economic effect from hatchery operations and harvest-related personal income would be $96,739,528 (Table 4.3-6). Of this total, $86,789,221 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($79,109,138 in harvest-related personal income and $7,680,083 in hatchery operations-related personal income) (Table 4.3-7). In addition, $9,950,307 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 3 would be $10,149,229 (10 percent) and $7,460,760 (8 percent) less, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 3, the direct effects on personal income and jobs at hatchery facilities would be the same as under Alternative 1. However, under Alternative 3, secondary income related to hatchery operation cost values (procurement of goods and services) would be $9,950,307, or $2,688,469 (21 percent) less than under Alternative 1 (Table 4.3-6). Overall, under Alternative 3, $51,665,767 (60 percent) of the total personal income of $86,789,221 would be generated by recreational fishing, $27,443,371 (32 percent) would be generated by commercial fishing, and hatchery operations would contribute $7,680,083 (9 percent) (Table 4.3-7). Under Alternative 3, the personal income generated from recreational fishing, commercial fishing, and hatchery operations would be $4,089,494 (7 percent), $1,345,776 (5 percent), and $2,025,490 (21 percent) less, respectively, than under Alternative 1 (Table 4.3-7).

Under Alternative 3, a total of 1,903 jobs would support fisheries activities and hatchery operations (Table 4.3-6 and Table 4.3-9). This would represent 157 (8 percent) fewer jobs than under Alternative 1. A total of 1,108 jobs (58 percent) would be attributable to recreational fisheries, 624 (33 percent) would be attributable to commercial fishing, and 171 (9 percent) would be attributable to hatchery operations (Table 4.3-9). Under Alternative 3, the number of recreational, commercial, and hatchery operations-related jobs would be 86 fewer jobs (7 percent), 33 fewer jobs (5 percent), and 38 fewer jobs (18 percent), respectively, than under Alternative 1 (Table 4.3-9).

Under Alternative 3, the largest reductions in overall levels of personal income and jobs would result from decreases associated with recreational fishing, which would account for 55 percent of the $7,460,760 reduction in personal income and 55 percent of the 157 fewer jobs throughout the socioeconomic analysis area (Table 4.3-7 and Table 4.3-9, respectively), compared to Alternative 1.

Across the socioeconomic analysis area, personal income and jobs under Alternative 3 would decrease to the greatest extent in the south Puget Sound subregion, where income and jobs would decrease by

$4,203,173 and 80 jobs (Table 4.3-7 and Table 4.3-9, respectively). This decrease would be driven largely by the reductions associated with recreational fishing activity. On a percentage basis, across the socioeconomic analysis area the decline of personal income and jobs would be largest in the Strait of Juan de Fuca subregion, where income and jobs would decrease 12 percent ($672,733 and 21 jobs) relative to Alternative 1 (Table 4.3-7 and Table 4.3-9, respectively). A reduction in economic activity would also occur in the north Puget Sound subregion, where income and jobs would decrease by 6 percent ($2,584,854 and 57 jobs) compared to Alternative 1 (Table 4.3-7 and Table 4.3-9, respectively).

4.3.6.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the socioeconomic analysis area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total economic effect from hatchery operations and harvest-related personal income in the socioeconomic analysis area would be $123,263,461 (Table 4.3-6). Of this total, $107,827,005 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($95,866,842 in harvest-related personal income and $11,960,163 in hatchery operations-related personal income) (Table 4.3-7), and $15,436,456 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 4 would be $16,374,704 (15 percent) and $13,577,025 (14 percent) greater, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 4, the direct effects on personal income and jobs at hatchery facilities would be the same as under Alternative 1. However, under Alternative 4, secondary income related to hatchery operation cost values (procurement of goods and services) would be $15,436,456, or $2,797,679 (22 percent) greater than under Alternative 1 (Table 4.3-8). Under Alternative 4, $64,642,778 (60 percent) of the total personal income of $107,827,005 would be generated by recreational fishing, while commercial fishing would account for $31,224,064 (29 percent), and hatchery operations would account for $11,960,163 (11 percent) (Table 4.3-7). Under Alternative 4, the personal income generated from recreational fishing, commercial fishing, and hatchery operations would be $8,887,517 (16 percent), $2,434,918 (9 percent), and $2,254,590 (23 percent) greater, respectively, than under Alternative 1 (Table 4.3-7).

Under Alternative 4, a total of 2,332 jobs would support fisheries activities and hatchery operations (Table 4.3-6 and Table 4.3-9). This would represent 272 (13 percent) more jobs than under Alternative 1. A total of 1,366 jobs (59 percent) would be attributable to recreational fisheries, 711 (30 percent) would be attributable to commercial fishing, and 255 (11 percent) would be attributable to hatchery operations (Table 4.3-9). Under Alternative 4, the number of recreational, commercial, and hatchery operations-related jobs would be 171 more jobs (14 percent), 54 more jobs (8 percent), and 46 more jobs (22 percent), respectively, than under Alternative 1 (Table 4.3-9).

Under Alternative 4, the largest increases in overall levels of personal income and jobs would result from increases associated with recreational fishing, which would account for 65 percent of the $13,577,025 increase in personal income and 63 percent of the 272 increase in jobs throughout the socioeconomic analysis area (Table 4.3-7 and Table 4.3-9, respectively), compared to Alternative 1.

Across the socioeconomic analysis area, increases in personal income and jobs under Alternative 4 would be largest in the south Puget Sound subregion, where income would increase by $8,851,355 and jobs would increase by 158 jobs relative to Alternative 1 (Table 4.3-7 and Table 4.3-9, respectively). These changes would represent increases of 19 and 17 percent, respectively, over levels of personal income and jobs under Alternative 1. Changes in the north Puget Sound subregion would also be relatively large, with increases of $4,103,554 in personal income and 94 jobs. Although increases in income and jobs in the Strait of Juan de Fuca subregion would be smaller, the percentage increase would be relatively large, with personal income and jobs increasing by 11 and 12 percent, respectively, relative to Alternative 1 (Table 4.3-7 and Table 4.3-9, respectively).

4.3.6.2 North Puget Sound Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the north Puget Sound subregion are intermediate among the three subregions in the socioeconomic analysis area (Subsection 3.3.5.2, North Puget Sound Subregion). The total economic effect from hatchery operations and harvest-related personal income in the north Puget Sound subregion would be $45,587,730, as described in Subsection 3.3.5.2, north Puget Sound Subregion, and Table 3.3-6. Personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations contributes $41,724,837 ($38,965,509 in harvest-related personal income and $2,759,328 in hatchery operations-related personal income) (Table 3.3-6), and hatchery operations costs contribute another $3,862,893 (Table 3.3-6). More than half (52 percent, or $22,249,969) of the total personal income of $41,724,837 is generated by recreational fishing, while commercial fishing accounts for 40 percent ($16,715,540), and hatchery operations account for 8 percent ($2,759,328) (Table 3.3-6).

Of the total of 975 jobs related to hatchery operations and harvest in the north Puget Sound subregion, 497 jobs (51 percent) are attributable to recreational fishing, 416 jobs (43 percent) are attributable to commercial fishing, and 62 jobs (6 percent) are attributable to hatchery operations (Table 3.3-6).

Although, as mentioned above, recreational fishing is the largest contributor to economic effects within the north Puget Sound subregion, contributions from commercial fishing are also important, contributing more personal income and jobs than in either of the other two Puget Sound subregions (Table 3.3-6).

4.3.6.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.5.2, North Puget Sound Subregion). Under Alternative 1, the amount of total personal income ($41,724,837) (Table 4.3-6), harvest-related income ($16,715,540 for commercial harvest and $22,249,969 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($2,759,328) (Table 4.3-7), hatchery operations cost values ($3,862,893) (Table 4.3-6 and Table 4.3-8), and jobs (975 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as the affected environment.

4.3.6.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter economic impacts in the north Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-6, Table 4.3-7, and Table 4.3-9), because the number of fish released would be the same. Under Alternative 2, the amount of total personal income ($41,724,837) (Table 4.3-6), harvest-related income ($16,715,540 for commercial harvest and $22,249,969 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($2,759,328) (Table 4.3-7), hatchery operations cost values ($3,862,893) (Table 4.3-6 and Table 4.3-8), and jobs (975 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as Alternative 1.

4.3.6.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the total economic effect from hatchery operations and harvest-related personal income in the north Puget Sound subregion would be $42,049,975 (Table 4.3-6). Of this total, $39,139,983 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($36,910,805 in harvest-related personal income and $2,229,178 in hatchery operations-related personal income) (Table 4.3-7), and $2,909,992 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 3 would be $3,537,755 (8 percent) and $2,584,854 (6 percent) less, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 3, the direct effects on personal income and jobs at hatchery facilities would be the same as under Alternative 1. However, under Alternative 3, secondary income related to hatchery operations cost values (procurement of goods and services) would be $2,909,992, or $952,901 (25 percent) less than under Alternative 1 (Table 4.3-8). Overall, under Alternative 3, $20,651,908 (53 percent) of the total personal income of $39,139,983 would be generated by recreational fishing, $16,258,897 (41 percent) would be generated by commercial fishing, and hatchery operations would contribute $2,229,178 (6 percent) (Table 4.3-7). Under Alternative 3, the personal income generated from recreational fishing, commercial fishing, and hatchery operations would be $1,598,061 (7 percent), $456,642 (3 percent), and $530,150 (19 percent) less, respectively, than under Alternative 1 (Table 4.3-7).

Under Alternative 3, a total of 919 jobs would support fisheries activities and hatchery operations in the north Puget Sound subregion (Table 4.3-6 and Table 4.3-9). This would represent 57 (6 percent) fewer jobs than under Alternative 1. A total of 463 jobs (50 percent) would be attributable to recreational fisheries, 404 jobs (44 percent) would be attributable to commercial fishing, and 51 jobs (6 percent) would be attributable to hatchery operations (Table 4.3-9). Under Alternative 3, the number of recreational, commercial, and hatchery operations-related jobs would be 34 fewer jobs (7 percent), 12 fewer jobs (3 percent), and 11 fewer jobs (18 percent), respectively, than under Alternative 1 (Table 4.3-9).

4.3.6.2.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total economic effect from hatchery operations and harvest-related personal income in the north Puget Sound subregion would be $51,312,157 (Table 4.3-6). Of this total, $45,828,391 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($41,865,863 in harvest-related personal income and $3,962,538 in hatchery operations-related personal income) (Table 4.3-7), and $5,483,766 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 4 would be $5,724,426 (13 percent) and $4,103,554 (10 percent) greater, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 4, a total of 1,069 jobs would support fisheries activities and hatchery operations in the north Puget Sound subregion (Table 4.3-6 and Table 4.3-9). This would represent 94 (10 percent) more jobs than under Alternative 1. A total of 536 jobs (50 percent) would be attributable to recreational fisheries, 445 jobs (41 percent) would be attributable to commercial fishing, and 88 jobs (8 percent) would be attributable to hatchery operations (Table 4.3-9).

Compared to Alternative 1, the overall increases in personal income and jobs under Alternative 4 for the north Puget Sound subregion would be smaller than for the south Puget Sound subregion, but larger than for the Strait of Juan de Fuca subregion (Table 4.3-6, Table 4.3-7, and Table 4.3-9, respectively).

4.3.6.3 South Puget Sound Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the south Puget Sound subregion are the largest among the three subregions in the socioeconomic analysis area. The total economic effect from hatchery operations and harvest-related personal income in the south Puget Sound subregion is $54,430,443, as described in Subsection 3.3.5.3, South Puget Sound Subregion, and Table 3.3-6. Personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations contributes $46,838,604 ($40,631,407 in harvest-related personal income and $6,207,197 in hatchery operations-related personal income) (Table 3.3-6), and hatchery operations costs contribute another $7,591,839 (Table 3.3-6). Overall, most (64 percent, or $29,581,949) of the total personal income of $46,838,604 is generated by recreational fishing, while commercial fishing accounts for 23 percent ($11,049,458), and hatchery operations account for 13 percent ($6,207,197) (Table 3.3-6).

Of the total of 912 jobs related to hatchery operations and harvest in the south Puget Sound subregion, 574 jobs (63 percent) are attributable to recreational fishing, 209 jobs (23 percent) are attributable to commercial fishing, and 129 jobs (14 percent) are attributable to hatchery operations (Table 3.3-6).

4.3.6.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.5.3, South Puget Sound Subregion). Under Alternative 1, the amount of total personal income ($46,838,604) (Table 4.3-6), harvest-related income ($11,049,458 for commercial harvest and $29,581,949 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($6,207,197) (Table 4.3-7), hatchery operations cost values ($7,591,839) (Table 4.3-6 and Table 4.3-8), and jobs (912 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as the affected environment.

4.3.6.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter economic impacts in the south Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-6, Table 4.3-7, and Table 4.3-9), because the number of fish released would be the same. Under Alternative 2, the amount of total personal income ($46,838,604) (Table 4.3-6), harvest-related income ($11,049,458 for commercial harvest and $29,581,949 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($6,207,197) (Table 4.3-7), hatchery operations cost values ($7,591,839) (Table 4.3-6 and Table 4.3-8), and jobs (912 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as Alternative 1.

4.3.6.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the total economic effect from hatchery operations and harvest-related personal income in the south Puget Sound subregion would be $48,751,035 (Table 4.3-6). Of this total, $42,635,431 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($37,789,594 in harvest-related personal income and $4,845,837 in hatchery operations-related personal income) (Table 4.3-7), and $6,115,604 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 3 would be $5,679,408 (10 percent) and $4,203,173 (9 percent) less, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 3, the direct effects on personal income and jobs at hatchery facilities would be the same as under Alternative 1. However, under Alternative 3, secondary income related to hatchery operations cost values (procurement of goods and services) would be $6,115,604, or $1,476,235 (19 percent) less than under Alternative 1 (Table 4.3-8). Overall, under Alternative 3, $27,458,371 (64 percent) of the total personal income of $42,635,431 would be generated by recreational fishing, $10,331,223 (24 percent) would be generated by commercial fishing, and hatchery operations would contribute $4,845,837 (12 percent) (Table 4.3-7). Under Alternative 3, the personal income generated from recreational fishing, commercial fishing, and hatchery operations would be $2,123,578 (7 percent), $718,235 (7 percent), and $1,361,360 (22 percent) less, respectively, than under Alternative 1 (Table 4.3-7).

Under Alternative 3, a total of 832 jobs would support fisheries activities and hatchery operations in the south Puget Sound subregion (Table 4.3-6 and Table 4.3-9). This would represent 80 (9 percent) fewer jobs than under Alternative 1. A total of 534 jobs (64 percent) would be attributable to recreational fisheries, 193 jobs (23 percent) would be attributable to commercial fishing, and 106 jobs (13 percent) would be attributable to hatchery operations (Table 4.3-9). Under Alternative 3, the number of recreational, commercial, and hatchery operations-related jobs would be 41 fewer jobs (7 percent), 16 fewer jobs (8 percent), and 23 fewer jobs (18 percent), respectively, than under Alternative 1 (Table 4.3-9).

4.3.6.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by

16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total economic effect from hatchery operations and harvest-related personal income in the south Puget Sound subregion would be $64,373,918 (Table 4.3-6). Of this total, $55,689,959 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($48,476,042 in harvest-related personal income and $7,213,917 in hatchery operations-related personal income) (Table 4.3-7), and $8,683,959 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 4 would be $9,943,474 (18 percent) and $8,851,355 (19 percent) greater, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 4, a total of 1,070 jobs would support fisheries activities and hatchery operations in the south Puget Sound subregion (Table 4.3-6 and Table 4.3-9). This would represent 158 (17 percent) more jobs than under Alternative 1. A total of 691 jobs (64 percent) would be attributable to recreational fisheries, 232 jobs (22 percent) would be attributable to commercial fishing, and 147 jobs (14 percent) would be attributable to hatchery operations (Table 4.3-9).

4.3.6.4 Strait of Juan de Fuca Subregion

The economic effects generated by commercial and recreational fishing and hatchery facility operations in the Strait of Juan de Fuca subregion are the smallest of any subregion in the socioeconomic analysis area. The total economic effect from hatchery operations and harvest-related personal income in the Strait of Juan de Fuca subregion is $6,870,584, as described in Subsection 3.3.5.4, Strait of Juan de Fuca Subregion, and Table 3.3-6. Personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations, contributes $5,686,540 ($4,947,492 in harvest-related personal income and $739,048 million in hatchery operations-related personal income) (Table 3.3-6), and hatchery operations costs contribute another $1,184,044 (Table 3.3-6). Overall, $3,923,344 (69 percent) of the total personal income of $5,686,540 is generated by recreational fishing, while commercial fishing accounts for 18 percent ($1,024,148), and hatchery operations account for 13 percent ($739,048) (Table 3.3-6).

Of the total of 173 jobs related to hatchery operations and harvest in the Strait of Juan de Fuca subregion, 123 jobs (71 percent) were attributable to recreational fishing, 32 jobs (19 percent) were attributable to commercial fishing, and 18 jobs (10 percent) were attributable to hatchery operations (Table 3.3-6).

4.3.6.4.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change economic impacts in the Strait of Juan de Fuca subregion compared to the affected environment (Subsection 3.3.5.4, Strait of Juan de Fuca Subregion). Under Alternative 1, the amount of total personal income ($5,686,540) (Table 4.3-6), harvest-related income ($1,024,148 for commercial harvest and $3,923,344 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($739,048) (Table 4.3-7), hatchery operations cost values ($1,184,044) (Table 4.3-6 and Table 4.3-8), and jobs (173 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as the affected environment.

4.3.6.4.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter economic impacts in the Strait of Juan de Fuca subregion, which would be the same as under Alternative 1 (Table 4.3-6, Table 4.3-7, and Table 4.3-9), because the number of fish released would be the same. Under Alternative 2, the amount of total personal income ($5,686,540) (Table 4.3-6), harvest-related income ($1,024,148 for commercial harvest and $3,923,344 for recreational income) (Table 4.3-7), hatchery facility operations personal income ($739,048) (Table 4.3-7), hatchery operations cost values ($1,184,044) (Table 4.3-6 and Table 4.3-8), and jobs (173 jobs) (Table 4.3-6 and Table 4.3-9) would be the same as Alternative 1.

4.3.6.4.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the total economic effect from hatchery operations and harvest-related personal income in the Strait of Juan de Fuca subregion would be $5,938,519 (Table 4.3-6). Of this total, $5,013,808 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($4,408,740 in harvest-related personal income and $605,068 in hatchery operations-related personal income) (Table 4.3-7), and $924,711 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 3 would be $932,066 (14 percent) and $672,733 (12 percent) less, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 3, the direct effects on personal income and jobs at hatchery facilities would be the same as under Alternative 1. However, under Alternative 3, secondary income related to hatchery operations cost values (procurement of goods and services) would be $924,711, or $259,333 (22 percent) less than under Alternative 1 (Table 4.3-8). Overall, under Alternative 3, $3,555,489 (71 percent) of the total personal income of $5,013,808 would be generated by recreational fishing, $853,251 (17 percent) would be generated by commercial fishing, and hatchery operations would contribute $605,068 (12 percent) (Table 4.3-7). Under Alternative 3, the personal income generated from recreational fishing, commercial fishing, and hatchery operations would be $367,855 (9 percent), $170,898 (17 percent), and $133,980 (18 percent) less, respectively, than under Alternative 1 (Table 4.3-7).

Under Alternative 3, a total of 152 jobs would support fisheries activities and hatchery operations in the Strait of Juan de Fuca subregion (Table 4.3-6 and Table 4.3-9). This would represent 21 (12 percent) fewer jobs than under Alternative 1. A total of 111 jobs (73 percent) would be attributable to recreational fisheries, 27 jobs (18 percent) would be attributable to commercial fishing, and 14 jobs (9 percent) would be attributable to hatchery operations (Table 4.3-9). Under Alternative 3, the number of recreational, commercial, and hatchery operations-related jobs would be 11 fewer jobs (9 percent), 5 fewer jobs (17 percent), and 4 fewer jobs (22 percent), respectively, than under Alternative 1 (Table 4.3-9).

4.3.6.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total economic effect from hatchery operations and harvest-related personal income in the Strait of Juan de Fuca subregion would be $7,577,388 (Table 4.3-6). Of this total, $6,308,656 would be from personal income generated by commercial and recreational salmon and steelhead fishing, including the salmon processing and buying sector, and from hatchery facility operations ($5,524,948 in harvest-related personal income and $783,708 in hatchery operations-related personal income) (Table 4.3-7), and $1,268,732 would be from hatchery operations costs (Table 4.3-8). The total economic impact and total personal income under Alternative 4 would be $706,804 (10 percent) and $622,116 (11 percent) greater, respectively, than under Alternative 1 (Table 4.3-6).

Under Alternative 4, a total of 193 jobs would support fisheries activities and hatchery operations in the Strait of Juan de Fuca subregion (Table 4.3-6 and Table 4.3-9). This would represent 20 (12 percent) more jobs than under Alternative 1. A total of 139 jobs (72 percent) would be attributable to recreational fisheries, 34 jobs (18 percent) would be attributable to commercial fishing, and 20 jobs (10 percent) would be attributable to hatchery operations (Table 4.3-9).

4.3.7 Fisheries in Major River Systems

Described in this subsection are the potential local economic effects of the alternatives on terminal area fisheries in the socioeconomic analysis area, including effects on freshwater fisheries and key marine fisheries adjacent to river mouths. Major river systems are described in Subsection 3.3.6, Fisheries in Major River Systems. Hatchery facilities and the watersheds where the hatcheries are located, and hatchery production levels corresponding with the alternatives are found in Appendix A, Puget Sound Hatchery Programs and Facilities.

The analysis of potential effects on local economic conditions focuses on effects in terminal area fisheries. For purposes of this analysis, terminal area fisheries are in-river and adjacent marine area fisheries where changes in the number of hatchery-origin fish released under the alternatives would have the most substantial effects on commercial and recreational fishing activity, or are quantifiable with the tools used for this analysis. As a result of modeling limitations, potential effects in certain nearby mixed stock marine areas, although considered to be likely minor, could not be evaluated quantitatively. In instances where such effects are considered probable, the expected effects are described based on professional judgment, but are not quantified.

Because of the availability of information, the description of effects of the alternatives on terminal area fisheries and major river systems in this subsection relies on qualitative information and inferences using best professional judgment, rather than modeling analyses as used in other socioeconomic subsections.

4.3.7.1 North Puget Sound Subregion

As described in Subsection 3.3.6.1, North Puget Sound Subregion, hatchery production affects commercial and recreational salmon and steelhead fishing in the six major river systems (Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers) in the north Puget Sound subregion (Table 3.3-7). Under all alternatives, hatcheries that enhance fisheries in the Nooksack and Samish River systems and nearby marine terminal areas include the Samish Hatchery, Lummi Bay Hatchery, Skookum Creek Hatchery, Kendall Creek Hatchery, and Whatcom Creek Hatchery; hatcheries in the Skagit River system include Marblemount and Upper Skagit Hatcheries, and Baker Lake and Barnaby Slough facilities; hatcheries in the Stillaguamish River system include the Harvey Creek Hatchery and Whitehorse Pond; and in the Snohomish and Skykomish River systems include the Wallace River Hatchery and Tokul Creek Hatchery. In general, the relative contribution of hatchery production in most major rivers in the north Puget Sound subregion is highest for Chinook salmon and steelhead fisheries, moderate for coho salmon fisheries, and low for chum salmon fisheries (Table 3.3-7).

4.3.7.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.6.1, North Puget Sound Subregion). Under Alternative 1, major river systems in the north Puget Sound subregion having in-river or marine terminal area fisheries affected by hatchery production include the Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers as described under existing conditions (Table 3.3-1). The relative contribution of hatchery production in most major rivers in the north Puget Sound subregion under Alternative 1 would be highest for Chinook salmon and steelhead fisheries, moderate for coho salmon fisheries, and low for chum salmon fisheries, which would be the same as the affected environment (Table 3.3-7). Under Alternative 1, contributions of hatchery production to tribal and non-tribal fisheries in the Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers and marine terminal areas, and to fisheries by species, would be the same as the affected environment. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to the affected environment.

4.3.7.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the relative contribution of hatchery production to fisheries in the north Puget Sound subregion compared to Alternative 1 (Subsection 3.3.6.1, North Puget Sound Subregion), because the number of fish released would be the same. The contributions to tribal and non-tribal fisheries in major rivers and marine terminal areas, and to fisheries by species, would be the same as under Alternative 1. Under Alternative 2, major river systems in the north Puget Sound subregion having in-river or marine terminal area fisheries affected by hatchery production would include the Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers as described under Alternative 1. The relative contribution of hatchery production in most major rivers in the north Puget Sound subregion under Alternative 2 would be highest for Chinook salmon and steelhead fisheries, moderate for coho salmon fisheries, and low for chum salmon fisheries, which is the same as Alternative 1. Under Alternative 2, contributions of hatchery production to tribal and non-tribal fisheries in the Nooksack, Samish, Skagit, Stillaguamish, Snohomish, and Skykomish Rivers and marine terminal areas, and to fisheries by species, would be the same as Alternative 1. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to Alternative 1.

4.3.7.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. The analysis of effects under Alternative 3 presented below emphasizes fisheries associated with major river systems and hatcheries in the north Puget Sound subregion where reductions in hatchery production would occur. Where there would be no reductions in hatchery production under Alternative 3, fisheries would be the same as under Alternative 1, and those hatcheries and major river systems in the north Puget Sound subregion are not analyzed further.

Reductions in Chinook salmon production at the Lummi Bay Hatchery in the Nooksack River under Alternative 3 would have a minor effect on the commercial harvest in Chinook salmon marine terminal area fisheries compared to Alternative 1. The effects on the Chinook salmon commercial fishery in the Nooksack River would be minor (Table 4.3-10). The effects on the Nooksack River recreational fishery are difficult to assess because this fishery would be part of the larger adjacent marine area fishery.

Table 4.3-10. Relative decreases to in-river tribal commercial and recreational fisheries by subregion and major river system under Alternative 3, compared to Alternative 1.

Subregion and River	Chinook Salmon		Coho Salmon		Chum Salmon		Pink Salmon		Sockeye Salmon		Steelhead	
	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational
North Puget Sound												
Nooksack River	Minor[1]		Major	Major								Major
Samish River												
Skagit River			Minor	Minor							Major	Major
Stillaguamish River			Major	Major								Major
Snohomish River		Major		Major								Major
Skykomish River												
South Puget Sound												
Lake Washington												
Snoqualmie River												
Green River	Major		Major	Major								Major
Puyallup River	Major	Major	Major	Major								Major
White River												
Nisqually River	Major	Major	Major	Major								
Skokomish River	Major	Major	Major	Major								

Table 4.3-10. Relative decreases to in-river tribal commercial and recreational fisheries by subregion and major river system under Alternative 3, compared to Alternative 1, continued.

Subregion and River	Chinook Salmon		Coho Salmon		Chum Salmon		Pink Salmon		Sockeye Salmon		Steelhead	
	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational
Strait of Juan de Fuca												
Dungeness River			Major	Major								Minor
Elwha River												

Source: Estimates developed by the Puget Sound Hatchery EIS Technical Work Group.
[1] Major, minor, and blank cells reflect subjective estimates based on the expected relative impact to fisheries under the alternatives. The estimates are not directly related to numbers of fish harvested. Major means there would be substantial contribution from hatcheries to extensive commercial and/or recreational fisheries in marine and/or freshwater areas associated with the river. Minor means there would be low or intermittent contribution from hatcheries to local commercial or recreational fisheries in marine or freshwater areas associated with the river. Blank cells mean there would be negligible or no contribution from hatchery programs to fisheries associated with the river.

Under Alternative 3, reduced production at the Skookum Creek Hatchery, Kendall Creek Hatchery, and Lummi Bay Hatchery would substantially affect the terminal-area harvest of coho salmon in the Nooksack River for the commercial and recreational fisheries (Table 4.3-10). The reductions in steelhead production at the Kendall Creek Hatchery would substantially impact the recreational harvest in the Nooksack River, but would have no effect on the steelhead harvest by tribes because their harvest is currently very low (Table 4.3-10) (Subsection 3.3.6.1.1, Nooksack and Samish Rivers).

Alternative 3 would have a minor effect on tribal commercial and recreational harvest of coho salmon in the Skagit River because harvest opportunities in the Skagit River would be driven primarily by natural production of Chinook salmon and coho salmon (Subsection 3.3.6.1.2, Skagit River). The reduction in steelhead hatchery production at the Marblemount Hatchery under Alternative 3 would substantially reduce the recreational and commercial harvest of steelhead in the Skagit River (Table 4.3-10).

There would continue to be no in-river commercial harvest of Chinook salmon in the Stillaguamish River system (Subsection 3.3.6.1.3, Stillaguamish River). Under Alternative 3, reduced production at Harvey Creek Hatchery would substantially reduce the tribal commercial and non-tribal recreational harvests of coho salmon in the Stillaguamish River. Reductions of steelhead production at Whitehorse Pond would substantially reduce the steelhead recreational harvest in the Stillaguamish River (Table 4.3-10).

There would continue to be no in-river commercial harvest of Chinook salmon in the Snohomish River system (Subsection 3.3.6.1.4, Snohomish and Skykomish Rivers). Under Alternative 3, reduced Chinook salmon, coho salmon, and steelhead production at the Wallace River Hatchery would substantially reduce opportunities for recreational fishing in the Snohomish River system. Effects of Alternative 3 on mixed-stock commercial harvests in adjacent marine areas cannot be accurately predicted because commingled populations would be caught, and these areas would be managed primarily based on natural-origin coho salmon abundance.

4.3.7.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1. The analysis of effects under Alternative 4 presented below only pertains to major river systems and hatcheries in the north Puget Sound subregion where increases in hatchery production would occur. Where there would be no increases in hatchery production under Alternative 4, fisheries would be the same as under Alternative 1, and those hatcheries and major river systems in the north Puget Sound subregion are not analyzed further.

Under Alternative 4, increases in coho salmon production at the Skookum Creek Hatchery and Lummi Bay Hatchery would substantially benefit the in-river and marine terminal area commercial and recreational harvests of coho salmon in the Nooksack River, compared to Alternative 1 (Table 4.3-11). Increased chum salmon production at the Whatcom Creek Hatchery under Alternative 4 would not substantially increase tribal commercial harvest in the Nooksack River (Subsection 3.3.6.1.1, Nooksack and Samish Rivers), but would be expected to have a minor benefit to the commercial chum salmon fishery that would operate in Bellingham and Samish Bays, compared to Alternative 1 (Table 4.3-11). A modest increase in steelhead production at the Whatcom Creek Hatchery would have a minor benefit to the recreational steelhead fishery in the Nooksack River, compared to Alternative 1 (Table 4.3-11).

In the Skagit River (Subsection 3.3.6.1.2, Skagit River), increased steelhead production at the Marblemount Hatchery under Alternative 4 would substantially benefit the steelhead recreational and commercial fisheries, compared to Alternative 1 (Table 4.3-11).

In the Snohomish River (Subsection 3.3.6.1.4, Snohomish and Skykomish Rivers), increased coho salmon production at the Wallace River Hatchery under Alternative 4 would substantially benefit the commercial and recreational harvest of coho salmon, compared to Alternative 1 (Table 4.3-11). Compared to Alternative 1, effects from increased hatchery production on commercial harvest in marine catch area 8A (Possession Sound) or recreational harvest in catch area 8 under Alternative 4 cannot be accurately predicted because the fisheries in these areas harvest commingled populations (Subsection 3.3.6.1.4, Snohomish and Skykomish Rivers).

Table 4.3-11. Relative increases to in-river tribal commercial and recreational fisheries by subregion and major river system under Alternative 4, compared to Alternative 1.

Subregion and River	Chinook Salmon		Coho Salmon		Chum Salmon		Pink Salmon		Sockeye Salmon		Steelhead	
	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational	Commercial	Recreational
North Puget Sound												
Nooksack River			Major[1]	Major	Minor							Minor
Samish River												
Skagit River											Major	Major
Stillaguamish River												
Snohomish River			Major	Major								
Skykomish River												
South Puget Sound												
Lake Washington												
Snoqualmie River												
Green River			Major	Major							Major	Major
Puyallup River	Major	Major	Major	Major								
White River												
Nisqually River	Minor											
Skokomish River					Major							

Source: Estimates developed by the Puget Sound Hatchery EIS Technical Work Group.

[1] Major, minor, and blank cells reflect subjective estimates based on the expected relative impact to fisheries under the alternatives. The estimates are not directly related to numbers of fish harvested. Major means there would be substantial contribution from hatcheries to extensive commercial and/or recreational fisheries in marine and/or freshwater areas associated with the river. Minor means there would be low or intermittent contribution from hatcheries to local commercial or recreational fisheries in marine or freshwater areas associated with the river. Blank cells mean there would be negligible or no contribution from hatchery programs to fisheries associated with the river.

Note: The Strait of Juan de Fuca subregion is not shown in this table because there would be no increases in hatchery production or associated harvest benefits in the subregion under Alternative 4, compared to Alternative 1.

4.3.7.2 South Puget Sound Subregion

As described in Subsection 3.3.6.2, South Puget Sound Subregion, hatchery production affects commercial and recreational salmon and steelhead fishing in five of the seven major river systems (Lake Washington system, and the Green, Puyallup, Nisqually, and Skokomish Rivers) in the south Puget Sound subregion. The two exceptions are the Snoqualmie and White Rivers (Table 3.3-7). Under all alternatives, hatcheries that enhance fisheries in the Lake Washington system include Issaquah Hatchery and Cedar River Hatchery; hatcheries in the Green River system and nearby marine terminal areas include Crisp Creek Rearing Ponds, Soos Creek Hatchery, and Keta Creek Hatchery; hatcheries in the Puyallup River system include Voight's Creek Hatchery, Clark's Creek Hatchery, Diru Creek Hatchery, and White River Hatchery; hatcheries in the Nisqually River system include Clear Creek Hatchery and Kalama Creek Hatchery; and hatcheries in the Skokomish River system include George Adams Hatchery, Hoodsport Hatchery, and McKernan Hatchery.

Hatchery operations adjacent to and in marine waters of the south Puget Sound subregion also support marine commercial and recreational fisheries. Hatcheries in the southernmost parts of south Puget Sound include a system of south Puget Sound net pens (Agate Pass, Ballard, Elliot Bay, Laebugton, Squaxin Island), and Hupp Springs Hatchery, Minter Creek Hatchery, Garrison Springs Hatchery, Chambers Creek Hatchery, and Tumwater Falls Hatchery. The fisheries affected by these hatcheries are directed at Chinook salmon and coho salmon in the marine areas south of the Tacoma Narrows Bridge (commercial catch areas 13, 13A to K, and recreational catch area 13). Chinook salmon production at the Garrison Springs Hatchery affects the commercial fishery in Chambers Bay (catch area 13C), and Chinook salmon production at Tumwater Falls affects the commercial fishery in Budd Inlet (catch area 13F). Coho salmon production at the south Puget Sound net pens affects the commercial fishery in Peale Passage and vicinity (catch area 13D).

In general, the relative contribution of hatchery production in most major rivers in the south Puget Sound subregion is highest for Chinook salmon fisheries and moderate for coho salmon and chum salmon fisheries (Table 3.3-7). The relative contribution of steelhead hatchery production to fisheries is high in two river systems in the subregion (Table 3.3-7).

4.3.7.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries in the south Puget Sound subregion compared to the affected environment (Subsection 3.3.6.2, South Puget Sound Subregion). Under Alternative 1, major river systems in the south Puget Sound subregion having in-river or marine terminal area fisheries affected by hatchery production would include one lake and four river systems. These are, from north to south, Lake Washington, and the Green, Puyallup, Nisqually, and Skokomish Rivers as described for the affected environment (Table 3.3-1). The relative contribution of hatchery production in most major rivers in the south Puget Sound subregion under Alternative 1 would be highest for Chinook salmon fisheries, and moderate for coho salmon and chum salmon fisheries (Table 3.3-7), which would be the same as the affected environment. Similarly, under Alternative 1, the relative contribution of steelhead hatchery production to fisheries would be high in two river systems in the subregion as also described for the affected environment (Table 3.3-7). Under Alternative 1, contributions of hatchery production to tribal and non-tribal fisheries in Lake Washington; the Green, Puyallup, Nisqually, and Skokomish Rivers and marine terminal areas; and to fisheries by species would be the same as the affected environment. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to the affected environment.

4.3.7.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the relative contribution of hatchery production to fisheries in the south Puget Sound subregion compared to Alternative 1 (Subsection 3.3.6.2, South Puget Sound Subregion), because the number of fish released would be the same. The contributions to tribal and non-tribal fisheries in major rivers and marine terminal areas, and to fisheries by species, would be the same as under Alternative 1. Under Alternative 2, major river systems in the south Puget Sound subregion having in-river or marine terminal area fisheries affected by hatchery production include one lake and four river systems. These are, from north to south, Lake Washington, and the Green, Puyallup, Nisqually, and Skokomish Rivers as described under Alternative 1. The relative contribution of hatchery production in most major rivers in the south Puget Sound subregion under Alternative 2 would be highest for Chinook salmon fisheries, and moderate for coho salmon and chum salmon fisheries (Table 3.3-7), which is the same as Alternative 1. Similarly, under Alternative 2, the relative contribution of steelhead hatchery production to fisheries would be high in two river systems in the subregion as also described under Alternative 1. Under Alternative 2, contributions of hatchery production to tribal and non-tribal fisheries in Lake Washington; the Green, Puyallup, Nisqually, and Skokomish Rivers and marine terminal areas; and to fisheries by species would be the same as Alternative 1. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to Alternative 1.

4.3.7.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. The analysis of effects under Alternative 3 presented below emphasizes fisheries associated with major river systems and hatcheries in the south Puget Sound subregion where reductions in hatchery production would occur. Where there would be no reductions in hatchery production under Alternative 3, fisheries would be the same as under Alternative 1, and those hatcheries and major river systems in the south Puget Sound subregion are not analyzed further.

Reductions in Chinook salmon production at the Soos Creek Hatchery and Keta Creek Hatchery in the Green River system under Alternative 3 would substantially reduce the tribal commercial harvest (Table 4.3-10) in the river and in nearby Elliott Bay. The in-river recreational harvest of Chinook salmon is currently low relative to the commercial catch (Subsection 3.3.6.2.2, Green River); thus, it would not be affected by production changes under Alternative 3. The tribal commercial coho salmon harvest in the Duwamish River (part of the Green River system) and in nearby Elliott Bay, and the recreational coho salmon harvest in the river would be substantially reduced under Alternative 3 (Table 4.3-10) because of reduced production at Soos Creek Hatchery and Crisp Creek Rearing Ponds. Reductions of steelhead hatchery production in the Green River from Palmer Ponds, Icy Creek Hatchery, Soos Creek Hatchery, and Flaming Geyser Pond would substantially reduce recreational harvest, but would not affect the tribal commercial harvest, which is currently very low (Table 4.3-10).

Compared to Alternative 1, reductions in hatchery production at the Voights Creek Hatchery and Clarks Creek Hatchery under Alternative 3 would substantially reduce tribal commercial and recreational Chinook salmon and coho salmon harvest in the Puyallup River (Table 4.3-10) and in Commencement Bay (catch area 11A). Reductions in hatchery production at the Voights Creek Hatchery under Alternative 3 would substantially reduce the recreational steelhead fishery in the Puyallup River compared to Alternative 1 (Table 4.3-10). Because the tribal commercial harvest of steelhead in the Puyallup River is currently very low, comprising only incidental harvest during the tribal chum salmon fishery in the river (Subsection 3.3.6.2.3, Puyallup River), reduced steelhead production in the Puyallup River would not be expected to affect tribal steelhead harvest.

Compared to Alternative 1, reductions in hatchery production at the Clear Creek Hatchery and Kalama Creek Hatchery in the Nisqually River under Alternative 3 would substantially reduce in-river Chinook salmon and coho salmon tribal commercial and recreational harvests (Table 4.3-10). Commercial and recreational fisheries in adjacent marine areas (catch area 13) would not likely be substantially affected because those fisheries would be expected to primarily harvest Chinook salmon and coho salmon from other hatchery stocks originating in the south Puget Sound subregion (Subsection 3.3.6.2.4, Nisqually River).

Compared to Alternative 1, reduced Chinook salmon and coho salmon production at the George Adams Hatchery and Rick's Pond Hatchery in the Skokomish River system (Subsection 3.3.6.2.5, Skokomish River) under Alternative 3 would substantially affect tribal commercial and recreational fisheries (Table 4.3-10), and the tribal fishery in the nearby marine waters of southern Hood Canal.

Compared to Alternative 1, the recreational harvest of Chinook salmon in nearby marine catch area 12, which comprises all of Hood Canal south of the Hood Canal Bridge, would likely also be affected by reductions in hatchery releases under Alternative 3 (note that this marine catch area abuts the Strait of Juan de Fuca subregion).

4.3.7.2.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would increase the total number of juvenile hatchery-origin salmon and steelhead released in the analysis area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1. The analysis of effects under Alternative 4 presented below only pertains to major river systems and hatcheries in the south Puget Sound subregion where increases in hatchery production would occur. Where there would be no increases in hatchery production under Alternative 4, fisheries would be the same as under Alternative 1, and those hatcheries and major river systems in the south Puget Sound subregion are not analyzed further.

In the Green River (Subsection 3.3.6.2.2, Green River), increases in coho salmon production at Crisp Creek Rearing Ponds in the Green River system would substantially increase in-river and adjacent commercial and recreational marine area harvests of coho salmon under Alternative 4, compared to

Alternative 1 (Table 4.3-11). Under Alternative 4, increased steelhead production from the Palmer Ponds Hatchery would substantially benefit the steelhead commercial and recreational fishery in the Green River compared to Alternative 1 (Table 4.3-11).

In the Puyallup River (Subsection 3.3.6.2.3, Puyallup River), increases in Chinook salmon production at the Clarks Creek Hatchery and coho salmon production at the Voights Creek Hatchery under Alternative 4 would substantially increase commercial and recreational harvests in the Puyallup River system and adjacent marine areas of Commencement Bay (catch area 11A), compared to Alternative 1 (Table 4.3-11).

In the Nisqually River (Subsection 3.3.6.2.4, Nisqually River), increases in Chinook salmon at the Clear Creek Hatchery would result in minor benefits to the tribal commercial harvest in the Nisqually River (Table 4.3-11). Increased Chinook salmon production at the Chambers Creek Hatchery would be expected to substantially increase the marine area commercial harvest in Chambers Bay (catch area 13C) where fishing would continue to target this hatchery production. Similarly, increased Chinook salmon production at the Tumwater Falls Hatchery would substantially increase commercial harvest in marine waters of nearby Budd Inlet (catch area 13F). Increased coho salmon production at the south Puget Sound net pens (Squaxin Island) would be expected to substantially increase the commercial harvest in the nearby marine areas of Peale Passage and Case Inlet (catch area 13D).

In the Skokomish River (Subsection 3.3.6.2.5, Skokomish River), increased chum salmon production at Hoodsport Hatchery and McKernan Hatchery under Alternative 4 would result in substantial increases in commercial harvest in the Skokomish River (Table 4.3-11) and in commercial fisheries in nearby marine areas in Hood Canal, compared to Alternative 1. Increased production of pink salmon at the Hoodsport Hatchery would benefit the relatively small recreational fishery in the nearby marine catch area 12, but would not be expected to affect the commercial harvest because fisheries directed at pink salmon have not occurred in this area in recent years.

4.3.7.3 Strait of Juan de Fuca Subregion

As described in Subsection 3.3.6.3, Strait of Juan de Fuca Subregion, hatchery production affects commercial and recreational salmon and steelhead fishing in most of the major river systems in the Strait of Juan de Fuca subregion (Table 3.3-7). Hatcheries that enhance fisheries in mid-Hood Canal rivers and/or nearby marine terminal areas include the McKernan Hatchery, Hamma Hamma Hatchery, Lilliwaup Hatchery, Quilcene National Fish Hatchery, Hurd Creek Hatchery, Little Boston Hatchery, and Port Gamble and Quilcene Bay net pens; hatcheries in the Dungeness River system include the

Dungeness Hatchery; and hatcheries in the Elwha River include the Lower Elwha Hatchery, Elwha Channel Hatchery, and Morse Creek Hatchery. In general, the relative contribution of hatchery production in most major rivers in the Strait of Juan de Fuca subregion is highest for coho salmon fisheries and moderate for chum salmon fisheries (Table 3.3-7). The purpose of hatchery production associated with most major rivers in the subregion is conservation, and does not contribute to fisheries. However, hatchery production associated with marine net pens in the subregion contributes to fisheries in adjacent marine areas (Subsection 3.3.6.3, Strait of Juan de Fuca Subregion).

A harvest moratorium to protect Elwha River fishery resources will continue to be in place during dam removal operations (from 2012 through 2017) (Subsection 3.3.6.3.3, Elwha River).

4.3.7.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries in the Strait of Juan de Fuca subregion compared to the affected environment (Subsection 3.3.6.3, Strait of Juan de Fuca Subregion). Under Alternative 1, major river systems in the Strait of Juan de Fuca subregion having in-river or marine terminal area fisheries affected by hatchery production would include mid-Hood Canal rivers, and the Dungeness and Elwha Rivers as described for the affected environment (Table 3.3-1). The relative contribution of hatchery production in most major rivers in the Strait of Juan de Fuca subregion under Alternative 1 would be highest for coho salmon fisheries and moderate for chum salmon fisheries (Table 3.3-7), which would be the same as described for the affected environment. Under Alternative 1, contributions of hatchery production to tribal and non-tribal fisheries in mid-Hood Canal rivers, the Dungeness and Elwha Rivers, marine terminal areas, and to fisheries by species, would be the same as existing conditions. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to the affected environment.

4.3.7.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the relative contribution of hatchery production to fisheries in the Strait of Juan de Fuca subregion compared to Alternative 1 (Subsection 3.3.6.3, Strait of Juan de Fuca Subregion), because the number of fish released would be the same. The contributions to tribal and non-tribal fisheries in major rivers and marine terminal areas, and to fisheries by species, would be the same as under Alternative 1. Under Alternative 2, major river systems in the Strait of Juan de Fuca subregion having in-river or marine terminal area fisheries affected by hatchery production would include mid-Hood Canal rivers, and the Dungeness and Elwha Rivers, as described under Alternative 1. The relative contribution of hatchery production in most major rivers in the Strait of Juan de Fuca subregion under Alternative 2 would be highest for coho salmon fisheries and moderate for chum salmon fisheries (Table 3.3-7), which is the same as described under Alternative 1. Under Alternative 2, contributions of hatchery production to tribal and non-tribal fisheries in mid-Hood Canal rivers, the Dungeness and Elwha Rivers, marine terminal areas, and to fisheries by species, would be the same as Alternative 1. There would be no change to recreational fishing opportunities in terminal areas associated with major rivers, compared to Alternative 1.

4.3.7.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would reduce the total number of juvenile hatchery-origin salmon and steelhead released into the analysis area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be less under Alternative 3 than under Alternative 1. The analysis of effects under Alternative 3 presented below emphasizes major river systems and hatcheries in the Strait of Juan de Fuca subregion where reductions in hatchery production would occur. Where there would be no reductions in hatchery production compared to Alternative 1, hatcheries and major river systems in the Strait of Juan de Fuca subregion are not analyzed further.

Under Alternative 3, hatchery production of coho salmon at the Dungeness Hatchery would be reduced, which would substantially reduce the tribal commercial harvest and recreational harvest in the Dungeness River (Table 4.3-10), and marine area commercial harvest in nearby Dungeness Bay, compared to Alternative 1.

Reductions in production for the small steelhead program at the Dungeness Hatchery would have minor effects on recreational steelhead fishing in the Dungeness River (Table 4.3-10).

4.3.7.3.4 Alternative 4 (Increased Production)

Under Alternative 4, there would be no changes in salmon and steelhead production at hatcheries in rivers in the Strait of Juan de Fuca subregion compared to Alternative 1, and thus no effects on in-river harvests (Table 4.3-11). However, increases in coho salmon production at the Port Gamble and Quilcene net pens would substantially benefit the tribal and non-tribal commercial harvests in nearby marine areas (Port

Gamble, and Quilcene and Dabob Bays) of the north Hood Canal portion of the Strait of Juan de Fuca subregion (catch area 12). In addition, the recreational harvest of coho salmon in Quilcene Bay and Dabob Bay that targets coho salmon returning from the Quilcene net pen releases would substantially increase compared to Alternative 1, but there would be a lesser effect on recreational harvest in nearby marine catch area 12 because many other stocks of coho salmon contribute to this fishery (Subsection 3.3.6.3.1, Mid-Hood Canal Rivers).

4.3.8 Ports and Fishing Communities

The commercial and recreational harvest of salmon and steelhead affects the economies of ports and fishing communities in the socioeconomic analysis area (Subsection 3.3.7, Ports and Fishing Communities). This subsection describes expected economic effects under the alternatives in terms of annual personal income and jobs, and includes ports and fishing communities considered vulnerable to changes in commercial and recreational fishing activity that would be associated with changes in hatchery production levels under the alternatives (Subsection 3.3.7, Ports and Fishing Communities).

As described in Subsection 3.3.7, Ports and Fishing Communities, salmon and steelhead harvested in the socioeconomic analysis area are brought to 17 major ports in the 12 counties within the socioeconomic analysis area (Table 3.3-8). For the purposes of this EIS, personal income and jobs information at the county level are used to assess economic effects on ports and fishing communities within the associated counties.

4.3.8.1 North Puget Sound Subregion

As described in Subsection 3.3.7.1, North Puget Sound Subregion, hatchery production affects personal income and jobs associated with commercial and recreational salmon and steelhead fishing in ports and fishing communities in the north Puget Sound subregion (Table 3.3-9). The amount of personal income and number of jobs that commercial and recreational fishing generate are largest in Whatcom County (ports of Blaine and Bellingham) and Snohomish County (port of Everett). In all but one county (Whatcom County), recreational fishing activities generate more personal income and jobs than commercial fishing activities (Table 3.3-9). Communities in other counties in the north Puget Sound subregion are less dependent on fishing, but would be vulnerable to changes in fishing activities (Subsection 3.3.7.1, North Puget Sound Subregion).

4.3.8.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries and associated economic impacts in the north Puget Sound subregion compared to the affected environment (Subsection 3.3.7.1, North Puget Sound Subregion).

Under Alternative 1, commercial and recreational fishing and hatchery operations would contribute a total of $41,724,837 of personal income (Table 4.3-12) and 975 jobs (Table 4.3-13) to the north Puget Sound subregion, which would be the same as the affected environment.

Under Alternative 1, of the total personal income and jobs from fishing activities, Whatcom County (where the ports of Blaine and Bellingham are located) would generate $14,031,890 in personal income and 361 jobs, representing the largest percentages (34 percent of the total personal income [Table 4.3-12] and 37 percent of the total jobs [Table 4.3-13]) in the north Puget Sound subregion, which would be the same as the affected environment. The next largest percentages of total personal income and jobs in the north Puget Sound subregion would occur in Snohomish County (where the port of Everett is located), where $13,488,613 in personal income (32 percent) (Table 4.3-12) and 271 jobs (28 percent) (Table 4.3-13) would be generated, which would be the same as the affected environment. Under Alternative 1, fishing would also be important to Skagit County, contributing $7,807,961 (19 percent) in personal income and 187 jobs (19 percent) in the north Puget Sound subregion (Table 4.3-12 and Table 4.3-13, respectively), which would be the same as the affected environment.

Overall, under Alternative 1, recreational fishing activities would account for most of the personal income and jobs in the north Puget Sound subregion (in all but Whatcom County), generating a total of $22,249,969 (53 percent) of the personal income and 497 jobs (51 percent) (Table 4.3-12 and Table 4.3-13, respectively), which would be the same as the affected environment.

1 Table 4.3-12. Total (direct and indirect) impacts on personal income (in dollars) in north Puget Sound subregion counties by alternative.

County	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Personal Income ($) [1]	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent
Whatcom County										
Commercial	11,558,897	11,558,897	0	0	11,214,133	-344,764	-3	12,485,460	926,563	8
Recreational	2,472,992	2,472,992	0	0	2,358,525	-114,467	-5	2,618,985	145,992	6
Total	**14,031,890**	**14,031,890**	**0**	**0**	**13,572,658**	**-459,232**	**-3**	**15,104,445**	**1,072,555**	**8**
Skagit County										
Commercial	3,619,539	3,619,539	0	0	3,537,049	-82,489	-2	3,771,749	152,210	4
Recreational	4,188,423	4,188,423	0	0	4,030,354	-158,068	-4	4,542,463	354,040	9
Total	**7,807,961**	**7,807,961**	**0**	**0**	**7,567,404**	**-240,558**	**-3**	**8,314,211**	**506,250**	**7**
Snohomish County										
Commercial	1,435,076	1,435,076	0	0	1,409,830	-25,246	-2	1,500,536	65,460	5
Recreational	12,053,537	12,053,537	0	0	10,879,246	-1,174,291	-10	12,996,966	943,429	8
Total	**13,488,613**	**13,488,613**	**0**	**0**	**12,289,076**	**-1,199,537**	**-9**	**14,497,503**	**1,008,890**	**8**
Island County										
Commercial	39,581	39,581	0	0	38,748	-833	-2	40,827	1,246	3
Recreational	2,948,297	2,948,297	0	0	2,815,408	-132,890	-5	3,219,402	271,105	9
Total	**2,987,878**	**2,987,878**	**0**	**0**	**2,854,156**	**-133,723**	**-5**	**3,260,230**	**272,351**	**9**
San Juan County										
Commercial	62,447	62,447	0	0	59,138	-3,309	-5	68,645	6,198	10
Recreational	586,719	586,719	0	0	568,374	-18,345	-3	620,820	34,101	6
Total	**649,166**	**649,166**	**0**	**0**	**627,512**	**-21,654**	-3	**689,465**	**40,299**	6

Table 4.3-12. Total (direct and indirect) impacts on personal income (in dollars) in north Puget Sound subregion counties by alternative, continued.

		Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
	Alternative 1 (No Action)		Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
County	**Personal Income ($)** [1]	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**
NORTH PUGET SOUND TOTALS										
Commercial	**16,715,540**	**16,715,540**	**0**	**0**	**16,258,897**	**-456,642**	**-3**	**17,867,217**	**1,151,677**	**7**
Recreational	**22,249,969**	**22,249,969**	**0**	**0**	**20,651,908**	**-1,598,061**	**-7**	**23,998,636**	**1,748,667**	**8**
Hatchery Facility Operations [2]	**2,759,328**	**2,759,328**	**0**	**0**	**2,229,178**	**-530,150**	**-19**	**3,962,538**	**1,203,210**	**44**
Total	**41,724,837**	**41,724,837**	**0**	**0**	**39,139,983**	**-2,584,853**	-6	**45,828,391**	**4,103,554**	**10**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. All values are expressed in 2007 dollars.

[2] Effects of hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

Table 4.3-13. Total (direct and indirect) impacts on jobs (in numbers) in north Puget Sound subregion counties by alternative.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
County	**Number of Jobs[1]**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**
Whatcom County										
Commercial	297	297	0	0	288	-9	-3	321	24	8
Recreational	64	64	0	0	61	-3	-5	67	4	6
Total	**361**	**361**	**0**	**0**	**349**	**-12**	**-3**	**388**	**28**	**8**
Skagit County										
Commercial	87	87	0	0	85	-2	-2	90	4	4
Recreational	100	100	0	0	96	-4	-4	109	9	9
Total	**187**	**187**	**0**	**0**	**18**	**-6**	**-3**	**199**	**12**	**7**
Snohomish County										
Commercial	29	29	0	0	28	-1	-2	30	1	5
Recreational	243	243	0	0	219	-24	-10	262	19	8
Total	**271**	**271**	**0**	**0**	**247**	**-24**	**-9**	**292**	**20**	**8**
Island County										
Commercial	1	1	0	0	1	0	0	1	0	3
Recreational	69	69	0	0	66	-3	-5	75	6	9
Total	**70**	**70**	**0**	**0**	**66**	**-3**	**-5**	**76**	**6**	**9**
San Juan County										
Commercial	2	2	0	0	2	0	-5	3	0	10
Recreational	23	23	0	0	22	-1	-3	24	1	6
Total	**25**	**25**	**0**	**0**	**24**	**-1**	**-3**	**27**	**2**	**6**

Table 4.3-13. Total (direct and indirect) impacts on jobs (in numbers) in north Puget Sound subregion counties by alternative, continued.

		Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
	Alternative 1 (No Action)		Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
County	**Number of Jobs[1]**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**
NORTH PUGET SOUND TOTALS										
Commercial	**416**	**416**	**0**	**0**	**404**	**-12**	**-3**	**445**	**29**	**7**
Recreational	**497**	**497**	**0**	**0**	**463**	**-34**	**-7**	**536**	**39**	**8**
Hatchery Facility Operations [2]	**62**	**62**	**0**	**0**	**51**	**-11**	**-18**	**88**	**26**	**42**
Total	**975**	**975**	**0**	**0**	**918**	**-57**	**-6**	**1069**	**94**	**10**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. Includes full and part-time jobs.

[2] Estimates of jobs for hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

Under Alternative 1, other counties within the north Puget Sound subregion that would be less dependent on fishing but economically vulnerable to changes in fishing activity are Island County and San Juan County (Table 4.3-12 and Table 4.3-13), which would be the same as the affected environment. Under Alternative 1, the economic condition of the communities less affected by fishing activities than those associated with ports in counties mentioned above would be the same as described for the affected environment. Such communities would include La Conner, Anacortes, Mount Vernon, Concrete, Rockport, Darrington, Sedro Woolley, Burlington, Monroe, Snohomish, Carnation, and Sultan, as identified in Subsection 3.3.7.1, North Puget Sound Subregion.

4.3.8.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter the relative contribution of hatchery production to fisheries and associated economic impacts to counties, ports, and fishing communities in the north Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-12 and Table 4.3-13), because the number of fish released would be the same.

Under Alternative 2, commercial and recreational fishing and hatchery operations would contribute a total of $41,724,837 of personal income (Table 4.3-12) and 975 jobs (Table 4.3-13) to the North Puget Sound subregion, which would be the same as Alternative 1.

Under Alternative 2, of the total personal income and jobs from fishing activities, Whatcom County (where the ports of Blaine and Bellingham are located) would generate $14,031,890 in personal income and 361 jobs, representing the largest percentages (34 percent of the total personal income [Table 4.3-12], and 37 percent of the total jobs [Table 4.3-13]) in the north Puget Sound subregion, which would be the same as Alternative 1. The next largest percentages of total personal income and jobs in the north Puget Sound subregion would occur in Snohomish County (where the port of Everett is located), where $13,488,613 in personal income (32 percent) (Table 4.3-12) and 271 jobs (28 percent) (Table 4.3-13) would be generated, which would be the same as Alternative 1. Under Alternative 2, fishing would also be important to Skagit County, contributing $7,807,961 (19 percent) in personal income and 187 jobs (19 percent) in the north Puget Sound subregion (Table 4.3-12 and Table 4.3-13, respectively), which would be the same as Alternative 1.

Overall, under Alternative 2, recreational fishing activities would account for most of the personal income and jobs in the north Puget Sound subregion (in all but Whatcom County), generating a total of

$22,249,969 (53 percent) of the personal income and 497 jobs (51 percent) (Table 4.3-12 and Table 4.3-13, respectively), which would be the same as Alternative 1.

Under Alternative 2, other counties within the north Puget Sound subregion that would be less dependent on fishing but economically vulnerable to changes in fishing activity are Island County and San Juan County (Table 4.3-12 and Table 4.3-13), which would be the same as Alternative 1. Under Alternative 2, the economic condition of the communities less affected by fishing activities than those associated with ports in counties mentioned above (i.e., La Conner, Anacortes, Mount Vernon, Concrete, Rockport, Darrington, Sedro Woolley, Burlington, Monroe, Snohomish, Carnation, and Sultan) would be the same as Alternative 1.

4.3.8.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, local economic effects from fishing activities on ports and communities in the north Puget Sound subregion would be $39,139,983 in total personal income and 919 total jobs, representing decreases of $2,584,853 (6 percent) in personal income and 57 jobs (6 percent), compared to Alternative 1 (Table 4.3-12 and Table 4.3-13, respectively).

Under Alternative 3, local economic effects on ports and communities (at the county level) would result in reduced personal income and jobs (Table 4.3-12 and Table 4.3-13, respectively) in all counties compared to Alternative 1. Under Alternative 3, reductions would be largest in Snohomish County (where the port of Everett is located), where fishing-related personal income would decrease $1,199,537 (9 percent) to $12,289,076 (Table 4.3-12) and employment would decrease by 24 jobs (9 percent) to a total of 247 jobs, compared to Alternative 1 (Table 4.3-13). Most of the decrease in personal income and jobs in Snohomish County (e.g., port of Everett) would be due to impacts on recreational fishing activities, which would contribute over 96 percent of the decreases in personal income and jobs (Table 4.3-12 and Table 4.3-13, respectively). Smaller reductions in personal income (Table 4.3-12) and jobs (Table 4.3-13) would also occur under Alternative 3 in ports and communities in Whatcom (e.g., Port of Bellingham), Skagit, Island, and San Juan Counties. In those counties, decreases in personal income and jobs would range from $21,654 and one job in San Juan County to $459,232 and 12 jobs in Whatcom County, and percentage reductions would range from 3 percent in Whatcom, Skagit, and San Juan Counties to 5 percent in Island County for both personal income and jobs, compared to Alternative 1 (Table 4.3-12 and Table 4.3-13, respectively).

The economic condition of the communities less affected by fishing activities in the north Puget Sound subregion than those associated with ports in counties mentioned above would also likely experience income and job decreases to some extent under Alternative 3, compared to Alternative 1. The extent of such impacts under Alternative 3 is not known. As described in Subsection 3.3.7.1, North Puget Sound Subregion, such communities would include La Conner, Anacortes, Mount Vernon, Concrete, Rockport, Darrington, Sedro Woolley, Burlington, Monroe, Snohomish, Carnation, and Sultan, as identified in Subsection 3.3.7.1, North Puget Sound Subregion.

4.3.8.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, local economic effects from fishing activities on ports and communities in the north Puget Sound subregion would be $45,828,391 in total personal income and 1,069 total jobs, representing increases of $4,103,554 (10 percent) in personal income and 94 jobs (10 percent), compared to Alternative 1 (Table 4.3-12 and Table 4.3-13, respectively).

Under Alternative 4, local economic effects on ports and communities (at the county level) would result in increased personal income and jobs in all counties (Table 4.3-12 and Table 4.3-13, respectively). Under Alternative 4, increases would be largest in Whatcom and Snohomish Counties (where the ports of Bellingham and Everett are located), where fishing-related personal income would increase $1,072,555 (8 percent) and $1,008,890 (8 percent), to $15,104,445 and $14,497,503, respectively compared to Alternative 1 (Table 4.3-12). Jobs would increase by 28 jobs (8 percent) to a total of 388 jobs in Whatcom County, and by 20 jobs (8 percent) to a total of 292 jobs in Snohomish County, under Alternative 4 (Table 4.3-13). Increases in Whatcom County would mainly be due to increases from commercial fishing activities (contributing to 86 percent of the increase in both personal income [Table 4.3-12] and jobs

[Table 4.3-13]). In contrast, increases in Snohomish County would mainly be due to increases from recreational fishing activities (contributing to 94 percent of the increase in personal income [Table 4.3-12], and 95 percent of the increase in jobs [Table 4.3-13]). Smaller increases in personal income (Table 4.3-12) and jobs (Table 4.3-13) would also occur under Alternative 4 in ports and communities in Skagit, Island, and San Juan Counties. In those counties increases in personal income (in dollars) and jobs would range from $40,299 and 2 jobs in San Juan County, to $506,250 and 12 jobs in Skagit County, and percentage increases would range from 6 percent in San Juan County, to 9 percent in Island County for both personal income and jobs (Table 4.3-12 and Table 4.3-13, respectively), compared to Alternative 1.

Under Alternative 4, the economic condition of the communities that benefit from fishing activities in the north Puget Sound subregion, other than those associated with ports in counties mentioned above, would also likely experience income and job increases to some extent, compared to Alternative 1. The extent of such impacts under Alternative 4 is not known. As described in Subsection 3.3.7.1, North Puget Sound Subregion, such communities would include La Conner, Anacortes, Mount Vernon, Concrete, Rockport, Darrington, Sedro Woolley, Burlington, Monroe, Snohomish, Carnation, and Sultan.

4.3.8.2 South Puget Sound Subregion

As described in Subsection 3.3.7.2, South Puget Sound Subregion, hatchery production affects personal income and jobs associated with commercial and recreational salmon and steelhead fishing in ports and fishing communities in the south Puget Sound subregion (Table 3.3-9). The amount of personal income and number of jobs that commercial and recreational fishing generate are largest in King County (port of Seattle). In all counties in the south Puget Sound subregion, recreational fishing activities generate more personal income and jobs than commercial fishing activities (Table 3.3-9). Communities in other counties in the south Puget Sound subregion are less dependent on fishing, but would be vulnerable to changes in fishing activities (Subsection 3.3.7.2, South Puget Sound Subregion).

4.3.8.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries and associated economic impacts in the south Puget Sound subregion compared to the affected environment (Subsection 3.3.7.2, South Puget Sound Subregion).

Under Alternative 1, commercial and recreational fishing and hatchery operations would contribute a total of $46,838,604 of personal income (Table 4.3-14) and 912 jobs (Table 4.3-15) to the south Puget Sound subregion, which would be the same as the affected environment.

Under Alternative 1, of the total personal income and jobs from fishing activities, King County (where the Port of Seattle is located) would generate $20,840,553 in personal income and 323 jobs, representing the largest percentages (44 percent of the total personal income [Table 4.3-14], and 35 percent of the total jobs [Table 4.3-15]) in the south Puget Sound subregion, which would be the same as the affected environment. The next largest percentages of total personal income and jobs in the south Puget Sound subregion would occur in Pierce County (where the Port of Tacoma is located), where $8,369,537 (18 percent) in personal income and 172 jobs (9 percent) would be generated (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as the affected environment. Mason County (where the port of Shelton is located) would generate $4,924,113 (10 percent) in personal income and 145 jobs (16 percent) in the subregion (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as the affected environment. Thurston and Kitsap Counties would also generate income and jobs from fishing activities, together contributing $6,497,204 (14 percent) in annual total personal income and 143 jobs (16 percent) (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as the affected environment.

Overall, under Alternative 1, recreational fishing activities would account for most of the personal income and jobs in the south Puget Sound subregion, generating a total of $29,581,949 (63 percent) of the total personal income and 575 (63 percent) of the jobs (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as the affected environment.

Under Alternative 1, the economic condition of the communities in the south Puget Sound subregion less affected by fishing activities than those associated with ports in counties mentioned above would be the same as described for the affected environment. Such communities would include the rural towns in King County, and the cities/towns of Puyallup, Orting, Buckley, Yelm, Tenino, McKenna, Hoodsport, Poulsbo, and Bremerton, as identified in Subsection 3.3.7.2, South Puget Sound Subregion.

1 Table 4.3-14. Total (direct and indirect) impacts on personal income (in dollars) in south Puget Sound subregion counties by alternative.

County	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Personal Income[1] ($)	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent	Personal Income ($)	Personal Income ($)	Percent
King County										
Commercial	7,410,819	7,410,819	0	0	7,237,113	-173,705	-2	8,259,253	848,434	11
Recreational	13,429,734	13,429,734	0	0	12,498,562	-931,173	-7	18,041,103	4,611,369	34
Total	**20,840,553**	**20,840,553**	**0**	**0**	**19,735,675**	**-1,104,878**	**-5**	**26,300,356**	**5,459,803**	**26**
Pierce County										
Commercial	956,496	956,496	0	0	854,320	-102,176	-11	1,017,412	60,916	6
Recreational	7,413,041	7,413,041	0	0	6,759,934	-653,107	-9	8,420,423	1,007,382	14
Total	**8,369,537**	**8,369,537**	**0**	**0**	**7,614,254**	**-755,283**	**-9**	**9,437,835**	**1,068,298**	**13**
Thurston County										
Commercial	632,471	632,471	0	0	378,899	-253,572	-40	643,915	11,445	2
Recreational	2,609,945	2,609,945	0	0	2,457,334	-152,611	-6	2,880,083	270,138	10
Total	**3,242,415**	**3,242,415**	**0**	**0**	**2,836,233**	**-406,182**	**-13**	**3,523,998**	**281,583**	**9**
Mason County										
Commercial	1,977,397	1,977,397	0	0	1,800,019	-177,378	-9	2,261,526	284,129	14
Recreational	2,946,716	2,946,716	0	0	2,787,753	-158,963	-5	3,226,899	280,182	10
Total	**4,924,113**	**4,924,113**	**0**	**0**	**4,587,772**	**-336,341**	**-7**	**5,488,425**	**564,311**	**12**
Kitsap County										
Commercial	72,277	72,277	0	0	60,872	-11,405	-16	80,557	8,281	12
Recreational	3,182,512	3,182,512	0	0	2,954,788	-227,725	-7	3,644,870	462,358	15
Total	**3,254,789**	**3,254,789**	**0**	**0**	**3,015,660**	**-239,129**	**-7**	**3,725,428**	**470,639**	**15**

Table 4.3-14. Total (direct and indirect) impacts on personal income (in dollars) in south Puget Sound subregion counties by alternative, continued.

	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
County	**Personal Income[1] ($)**	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**
SOUTH PUGET SOUND TOTALS										
Commercial	**11,049,458**	**11,049,458**	**0**	**0**	**10,331,223**	**-718,235**	**-7**	**12,262,663**	**1,213,205**	**11**
Recreational	**29,581,949**	**29,581,949**	**0**	**0**	**27,458,371**	**-2,123,578**	**-7**	**36,213,379**	**6,631,430**	**22**
Hatchery Facility Operations[2]	**6,207,197**	**6,207,197**	**0**	**0**	**4,845,837**	**-1,361,360**	**-22**	**7,213,917**	**1,006,720**	**16**
Total	**46,838,604**	**46,838,604**	**0**	**0**	**42,635,431**	**-4,203,173**	**-9**	**55,689,959**	**8,851,355**	**19**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. All values are expressed in 2007 dollars.

[2] Effects of hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

1 Table 4.3-15. Total (direct and indirect) impacts on jobs (in numbers) in south Puget Sound subregion counties by alternative.

County	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Number of Jobs[1]	Number of Jobs	Number of Jobs	Percent	Number of Jobs	Number of Jobs	Percent	Number of Jobs	Number of Jobs	Percent
King County										
Commercial	115	115	0	0	112	-3	-2	128	13	11
Recreational	208	208	0	0	194	-14	-7	280	71	34
Total	**323**	**323**	**0**	**0**	**306**	**-17**	**-5**	**408**	**85**	**26**
Pierce County										
Commercial	20	20	0	0	18	-2	-11	21	1	6
Recreational	153	153	0	0	139	-13	-9	173	21	14
Total	**172**	**172**	**0**	**0**	**157**	**-16**	**-9**	**194**	**22**	**13**
Thurston County										
Commercial	15	15	0	0	9	-6	-40	15	0	2
Recreational	61	61	0	0	57	-4	-6	67	6	10
Total	**75**	**75**	**0**	**0**	**66**	**-9**	**-13**	**82**	**7**	**9**
Mason County										
Commercial	58	58	0	0	53	-5	-9	66	8	14
Recreational	87	87	0	0	82	-5	-5	95	8	10
Total	**145**	**145**	**0**	**0**	**135**	**-10**	**-7**	**161**	**17**	**12**
Kitsap County										
Commercial	2	2	0	0	1	0	-16	2	0	12
Recreational	67	67	0	0	62	-5	-7	76	10	15
Total	**68**	**68**	**0**	**0**	**63**	**-5**	**-7**	**78**	**10**	**15**

Table 4.3-15. Total (direct and indirect) impacts on jobs (in numbers) in south Puget Sound subregion counties by alternative, continued.

		Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
	Alternative 1 (No Action)		Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
County	**Number of Jobs[1]**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**	**Number of Jobs**	**Number of Jobs**	**Percent**
SOUTH PUGET SOUND TOTALS										
Commercial	**209**	**209**	**0**	**0**	**193**	**-16**	**-8**	**232**	**23**	**11**
Recreational	**575**	**575**	**0**	**0**	**534**	**-41**	**-7**	**691**	**116**	**20**
Hatchery Facility Operations[2]	**129**	**129**	**0**	**0**	**106**	**-23**	**-18**	**147**	**18**	**14**
Total	**913**	**913**	**0**	**0**	**833**	**-80**	**-9**	**1070**	**157**	**17**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. Includes full- and part-time jobs.

[2] Job effects of hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

4.3.8.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter the economic impacts to counties, ports, and fishing communities in the south Puget Sound subregion, which would be the same as under Alternative 1 (Table 4.3-14 and Table 4.3-15), because the number of fish released would be the same.

Under Alternative 2, commercial and recreational fishing and hatchery operations would contribute a total of $46,838,604 of personal income (Table 4.3-14) and 912 jobs (Table 4.3-15) to the south Puget Sound subregion.

Under Alternative 2, of the total personal income and jobs from fishing activities, King County (where the Port of Seattle is located) would generate $20,840,553 in personal income and 323 jobs, representing the largest percentages (44 percent of the total personal income [Table 4.3-14]), and 35 percent of the total jobs [Table 4.3-15]) in the south Puget Sound subregion, which would be the same as Alternative 1. The next largest percentages of total personal income and jobs in the south Puget Sound subregion would occur in Pierce County (where the Port of Tacoma is located), where $8,369,537 (18 percent) in personal income (Table 4.3-14) and 172 jobs (19 percent) (Table 4.3-15) would be generated, which would be the same as Alternative 1. Mason County (where the port of Shelton is located) would generate $4,924,113 (10 percent) in personal income and 145 jobs (16 percent) in the subregion (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as Alternative 1. Thurston and Kitsap Counties would also generate income and jobs from fishing activities, together contributing $6,497,204 (14 percent) in total personal income and 143 jobs (16 percent) (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as Alternative 1.

Overall, under Alternative 2, recreational fishing activities would account for most of the personal income and jobs in the south Puget Sound subregion, generating a total of $29,581,949 (63 percent) of the total personal income and 575 (63 percent) of the jobs (Table 4.3-14 and Table 4.3-15, respectively), which would be the same as Alternative 1.

Under Alternative 2, the economic condition of the communities in the south Puget Sound subregion less affected by fishing activities than those associated with ports in counties mentioned above would be the same as Alternative 1 (i.e., rural towns in King County, and the cities/towns of Puyallup, Orting and Buckley, Yelm, Tenino, McKenna, Hoodsport, Poulsbo, and Bremerton).

4.3.8.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, local economic effects from fishing activities on ports and communities in the south Puget Sound subregion would be $42,635,431 in total personal income and 832 total jobs, representing decreases of $4,203,173 (9 percent) in personal income and 80 jobs (9 percent), compared to Alternative 1 (Table 4.3-14 and Table 4.3-15, respectively).

Under Alternative 3, local economic effects on ports and communities (at the county level), would result in reduced personal income and jobs in all counties (Table 4.3-14 and Table 4.3-15, respectively) compared to Alternative 1. Under Alternative 3, reductions would be largest in King County (where the Port of Seattle is located), where fishing-related personal income would decrease $1,104,878 (5 percent) to $19,735,675 under Alternative 1 (Table 4.3-14), and employment would decrease by 17 jobs (5 percent) to a total of 306 jobs under Alternative 1 (Table 4.3-15). Most of the decrease in personal income and jobs in King County would be due to impacts on recreational fishing activities, which would contribute over 82 percent of the decreases in personal income and jobs (Table 4.3-14 and Table 4.3-15, respectively). Smaller reductions in personal income (Table 4.3-14) and jobs (Table 4.3-15) would also occur under Alternative 3 in ports and communities in Pierce (e.g., Port of Tacoma), Thurston (Port of Olympia), Mason (Port of Shelton), and Kitsap (Port of Bremerton) counties. In those counties, decreases in personal income (in dollars) and jobs would range from $239,129 and 5 jobs in Kitsap County to $755,283 and 16 jobs in Pierce County, and percentage reductions would range from 7 percent in Mason and Kitsap Counties to 13 percent in Thurston County for both personal income and jobs, compared to Alternative 1 (Table 4.3-14 and Table 4.3-15, respectively).

Under Alternative 3, the economic condition of the communities less affected by fishing activities in the south Puget Sound subregion than those associated with ports in counties mentioned above would also likely experience income and job decreases to some extent, compared to Alternative 1. The extent of such impacts under Alternative 3 is not known. As described in Subsection 3.3.7.2, South Puget Sound Subregion, such communities would include rural towns in King County, and the cities/towns of Puyallup, Orting, Buckley, Yelm, Tenino, McKenna, Hoodsport, Poulsbo, and Bremerton.

4.3.8.2.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, local economic effects from fishing activities on ports and communities in the south Puget Sound subregion would be $55,689,959 in total personal income and 1,070 total jobs, representing increases of $8,851,355 (19 percent) in personal income and 158 jobs (17 percent), compared to Alternative 1 (Table 4.3-14 and Table 4.3-15, respectively).

Under Alternative 4, local economic effects on ports and communities (at the county level), would result in increased personal income and jobs in all counties (Table 4.3-14 and Table 4.3-15, respectively). Under Alternative 4, increases would be largest in King County (where the Port of Seattle is located), where fishing-related personal income would increase $5,459,803 (26 percent) to $26,300,356, compared to Alternative 1 (Table 4.3-14). Jobs would increase by 85 jobs (26 percent) to a total of 408 jobs under Alternative 1 (Table 4.3-15). With the exception of Mason County, increases in personal income and jobs would be due to increases from recreational fishing activities (Table 4.3-14 and Table 4.3-15). In Mason County, the contribution of recreational fishing activities and commercial fishing activities to increases in person income and jobs would be similar (Table 4.3-14 Table 4.3-15). In contrast to King County, smaller increases in personal income (Table 4.3-14) and jobs (Table 4.3-15) would occur under Alternative 4 in ports and communities in the other counties in the south Puget Sound subregion. In these counties, increases in personal income (in dollars) and jobs would range from $281,583 and 7 jobs in Thurston County, to $1,068,287 and 22 jobs in Pierce County, and percentage increases would range from 9 percent in Thurston County to 15 percent in Kitsap County for both personal income and jobs, compared to Alternative 1 (Table 4.3-14 and Table 4.3-15, respectively).

Under Alternative 4, the economic condition of the communities that benefit from fishing activities in the south Puget Sound subregion, other than those associated with ports in counties mentioned above, would also likely experience income and job increases to some extent, compared to Alternative 1. The extent of such impacts under Alternative 4 is not known. As described in Subsection 3.3.7.2, South Puget Sound Subregion, such communities would include rural towns in King County, and the cities/towns of Puyallup, Orting, Buckley, Yelm, Tenino, McKenna, Hoodsport, Poulsbo, and Bremerton.

4.3.8.3 Strait of Juan de Fuca Subregion

As described in Subsection 3.3.7.3, Strait of Juan de Fuca Subregion, hatchery production affects personal income and jobs associated with commercial and recreational salmon and steelhead fishing in ports and fishing communities in the Strait of Juan de Fuca subregion (Table 3.9-9). The amount of personal income and number of jobs that commercial and recreational fishing generate are largest in Clallam County (Ports of Port Angeles and Neah Bay). In both counties in the Strait of Juan de Fuca subregion, recreational fishing activities generate more personal income and jobs than commercial fishing activities (Table 3.3-9). Communities in other counties in the Strait of Juan de Fuca subregion are less dependent on fishing, but would be vulnerable to changes in fishing activities (Subsection 3.3.7.3, Strait of Juan de Fuca Subregion).

4.3.8.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the relative contribution of hatchery production to fisheries and associated economic impacts in the Strait of Juan de Fuca subregion compared to the affected environment (Subsection 3.3.6.3, Strait of Juan de Fuca Subregion). Under Alternative 1, commercial and recreational fishing and hatchery operations would contribute a total of $5,686,540 of personal income (Table 4.3-16) and 173 jobs (Table 4.3-17) to the Strait of Juan de Fuca subregion.

Under Alternative 1, of the total personal income and jobs in the Strait of Juan de Fuca subregion, fishing activities in Clallam County (where the Ports of Port Angeles and Neah Bay are located) would generate $3,700,082 in personal income and 112 jobs, representing the largest percentages (65 percent of the total personal income and total jobs [Table 4.3-16 and Table 4.3-17, respectively) in the Strait of Juan de Fuca subregion, which would be the same as the affected environment. Jefferson County (where the Port of Port Townsend is located), would generate $1,247,410 (22 percent) in personal income and 43 jobs (25 percent) in the subregion (Table 4.3-16 and Table 4.3-17, respectively), which would be the same as the affected environment.

Overall, under Alternative 1, recreational fishing activities would account for most of the personal income and jobs in the Strait of Juan de Fuca subregion (Table 4.3-16 and Table 4.3-17, respectively), generating a total of $3,923,344 (69 percent) of the total personal income and 123 (71 percent) of the total jobs in the subregion (Table 4.3-16 and Table 4.3-17, respectively), which would be the same as the affected environment.

Table 4.3-16. Total (direct and indirect) impacts on personal income (in dollars) in Strait of Juan de Fuca subregion counties by alternative.

		Alternative 2 (Proposed Action)			**Alternative 3 (Reduced Production)**			**Alternative 4 (Increased Production)**		
	Alternative 1 (No Action)		**Change from Alternative 1**			**Change from Alternative 1**			**Change from Alternative 1**	
County	**Personal Income[1] ($)**	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**	**Personal Income ($)**	**Personal Income ($)**	**Percent**
Clallam County										
Commercial	831,210	831,210	0	0	674,562	-156,648	-19	884,212	53,002	6
Recreational	2,868,872	2,868,872	0	0	2,559,316	-309,556	-11	3,209,917	341,044	12
Total	**3,700,082**	**3,700,082**	**0**	**0**	**3,233,878**	**-466,204**	**-13**	**4,094,129**	**394,047**	**11**
Jefferson County										
Commercial	192,938	192,938	0	0	178,689	-14,250	-7	209,972	17,034	9
Recreational	1,054,472	1,054,472	0	0	996,173	-58,299	-6	1,220,847	166,376	16
Total	**1,247,410**	**1,247,410**	**0**	**0**	**1,174,861**	**-72,549**	**-6**	**1,430,819**	**183,409**	**15**
STRAIT OF JUAN DE FUCA TOTALS										
Commercial	**1,024,148**	**1,024,148**	**0**	**0**	**853,251**	**-170,898**	**-17**	**1,094,184**	**70,036**	**7**
Recreational	**3,923,344**	**3,923,344**	**0**	**0**	**3,555,489**	**-367,855**	**-9**	**4,430,764**	**507,420**	**13**
Hatchery Facility Operations[2]	**739,048**	**739,048**	**0**	**0**	**605,068**	**-133,980**	**-18**	**783,708**	**44,660**	**6**
Total	**5,686,540**	**5,686,540**	**0**	**0**	**5,013,808**	**-672,733**	**-12**	**6,308,656**	**622,116**	**11**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. All values are expressed in 2007 dollars.

[2] Effects of hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

Table 4.3-17. Total (direct and indirect) impacts on jobs (in numbers) in Strait of Juan de Fuca subregion counties by alternative.

County	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Number of Jobs[1]	Number of Jobs	Number of Jobs	Percent	Number of Jobs	Number of Jobs	Percent	Number of Jobs	Number of Jobs	Percent
Clallam County										
Commercial	25	25	0	0	20	-5	-19	27	2	6
Recreational	87	87	0	0	78	-9	-11	97	10	12
Total	**112**	**112**	**0**	**0**	**98**	**-14**	**-13**	**124**	**12**	**11**
Jefferson County										
Commercial	7	7	0	0	6	-1	-7	7	1	9
Recreational	36	36	0	0	34	-2	-6	42	6	16
Total	**43**	**43**	**0**	**0**	**40**	**-3**	**-6**	**49**	**6**	**15**
STRAIT OF JUAN DE FUCA TOTALS										
Commercial	**32**	**32**	**0**	**0**	**27**	**-5**	**-17**	**34**	**2**	**7**
Recreational	**123**	**123**	**0**	**0**	**112**	**-11**	**-9**	**139**	**16**	**13**
Hatchery Facility Operations[2]	**18**	**18**	**0**	**0**	**14**	**-4**	**-22**	**20**	**20**	**11**
Total	**173**	**173**	**0**	**0**	**153**	**-20**	**-12**	**193**	**38**	**12**

Source: Estimates derived by TCW Economics based on harvest and trip estimates provided by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Estimated annual averages from 2002 to 2006. Includes full- and part-time jobs.

[2] Estimates of jobs for hatchery facility operations are not estimated for individual counties, but are estimated for the subregion only.

Under Alternative 1, the economic condition of the communities in the Strait of Juan de Fuca subregion less affected by fishing activities than those associated with ports in counties mentioned above would be the same as described for the affected environment. Such communities would include the mostly rural communities in northern Hood Canal and along the Strait of Juan de Fuca (e.g., Sequim), as described in Subsection 3.3.7.3, Strait of Juan de Fuca Subregion. Under Alternative 1, the moratorium on fishing in the Elwha River that was imposed in 2012 would continue through 2017 to protect salmon and steelhead until after Elwha dam removal operations are completed, which would be the same as the affected environment.

4.3.8.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter the economic impacts to counties, ports, and fishing communities in the Strait of Juan de Fuca subregion, which would be the same as under Alternative 1 (Table 4.3-16 and Table 4.3-17), because the number of fish released would be the same. Under Alternative 2, commercial and recreational fishing and hatchery operations would contribute a total of $5,686,540 of personal income (Table 4.3-16) and 173 jobs (Table 4.3-17) to the Strait of Juan de Fuca subregion.

Under Alternative 2, of the total personal income and jobs in the Strait of Juan de Fuca subregion, fishing activities in Clallam County (where the Ports of Port Angeles and Neah Bay are located) would generate $3,700,082 in personal income and 112 jobs, representing the largest percentages (65 percent of the total personal income and total jobs [Table 4.3-16 and Table 4.3-17, respectively]) in the Strait of Juan de Fuca subregion, which is the same as Alternative 1. Jefferson County (where the Port of Port Townsend is located), would generate $1,247,410 (22 percent) in personal income and 43 jobs (25 percent) in the subregion (Table 4.3-16 and Table 4.3-17, respectively), which would be the same as Alternative 1.

Overall, under Alternative 2, recreational fishing activities would account for most of the personal income and jobs in the Strait of Juan de Fuca subregion (Table 4.3-16 and Table 4.3-17, respectively), generating a total of $3,923,344 (69 percent) of the total personal income and 123 (71 percent) of the total jobs in the subregion (Table 4.3-16 and Table 4.3-17, respectively), which would be the same as Alternative 1.

Under Alternative 2, the economic condition of the communities in the Strait of Juan de Fuca subregion less affected by fishing activities than those associated with ports in counties mentioned above would be the same as Alternative 1. Such communities would include the mostly rural communities in northern

Hood Canal and along the Strait of Juan de Fuca (e.g., Sequim), as described in Subsection 3.3.7.3, Strait of Juan de Fuca Subregion. Under Alternative 2, the moratorium on fishing in the Elwha River that was imposed in 2012 would continue through 2017 to protect salmon and steelhead until after Elwha Dam removal operations are completed, which would be the same as Alternative 1.

4.3.8.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, local economic effects from fishing activities on ports and communities in the Strait of Juan de Fuca subregion would be $5,013,808 in total personal income and 152 total jobs, representing decreases of $672,733 (12 percent) in personal income and 21 jobs (12 percent), compared to Alternative 1 (Table 4.3-16 and Table 4.3-17, respectively).

Under Alternative 3, local economic effects on ports and communities (at the county level) in the Strait of Juan de Fuca subregion would result in reduced personal income and jobs in both counties (Table 4.3-16 and Table 4.3-17, respectively) compared to Alternative 1. Under Alternative 3, reductions would be largest in Clallam County (where the Ports of Port Angeles and Neah Bay are located), where fishing-related personal income would decrease $466,204 (13 percent) to $3,233,878 compared to Alternative 1 (Table 4.3-16), and employment would decrease by 14 jobs (13 percent) to a total of 98 jobs compared to Alternative 1 (Table 4.3-17). Most of the decrease in personal income and jobs in Clallam County would be due to impacts on recreational fishing activities, which would contribute over 64 percent of the decreases in personal income and jobs (Table 4.3-16 and Table 4.3-17, respectively). Smaller reductions in personal income (Table 4.3-16) and jobs (Table 4.3-17) would also occur under Alternative 3 in ports and communities in Jefferson County (Port of Port Townsend). In that county, the decrease in personal income (in dollars) and jobs would be $72,549 and 3 jobs, and the percentage reductions would be 6 percent for both personal income and jobs, compared to Alternative 1 (Table 4.3-16 and Table 4.3-17, respectively).

The economic condition of the communities less affected by fishing activities in the Strait of Juan de Fuca subregion than those associated with ports in counties mentioned above would also likely experience income and job losses to some extent under Alternative 3, compared to Alternative 1. The extent of such impacts is not known. As described in Subsection 3.3.7.3, Strait of Juan de Fuca Subregion, such communities include the mostly rural communities in northern Hood Canal and along the Strait of Juan de Fuca (e.g., Sequim).

4.3.8.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest and contribute to local economic impacts would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, local economic effects from fishing activities on ports and communities in the Strait of Juan de Fuca subregion would be $6,308,656 in total personal income and 193 total jobs, representing increases of $622,116 (11 percent) in personal income and 20 jobs (20 percent), compared to Alternative 1 (Table 4.3-16 and Table 4.3-17, respectively).

Under Alternative 4, local economic effects on ports and communities (at the county level) in the Strait of Juan de Fuca subregion would result in increased personal income and jobs in both counties (Table 4.3-16 and Table 4.3-17, respectively). Under Alternative 4, increases would be largest in Clallam County (where the Ports of Port Angeles and Neah Bay are located), where fishing-related personal income would increase $394,047 (11 percent) to $4,094,129 compared to Alternative 1 (Table 4.3-16). Jobs would increase by 12 jobs (11 percent) to a total of 124 jobs in Clallam County compared to Alternative 1 (Table 4.3-17). In Jefferson County (where the Port of Port Townsend is located), personal income would increase $183,409 (15 percent) and jobs would increase by 6 jobs (15 percent), compared to Alternative 1 (Table 4.3-16 and Table 4.3-17, respectively). Increases in both counties would be due mainly to increases from recreational fishing activities (contributing to at least 80 percent of the increase in both personal income [Table 4.3-16] and jobs [Table 4.3-17]).

Under Alternative 4, the economic condition of the communities that benefit from fishing activities in the Strait of Juan de Fuca subregion, other than those associated with ports in counties mentioned above, would also likely experience income and job increases to some extent, compared to Alternative 1. The extent of such beneficial impacts is not known. As described in Subsection 3.3.7.3, Strait of Juan de Fuca

Subregion, such communities include the mostly rural communities in northern Hood Canal and along the Strait of Juan de Fuca (e.g., Sequim).

4.3.9 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, but is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to natural-origin salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources. For example, a measure intended to reduce risks to fish by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures are summarized for fish in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

Under adaptive management, in addition to applicable updated and new BMPs that may become available, the primary proposed mitigation measures implemented to reduce or eliminate negative impacts to fish resources that would affect socioeconomics would be reducing hatchery program size (number of hatchery-origin fish released) and/or discontinuing hatchery programs. In general, those measures would reduce negative impacts to fish resources by reducing juvenile competitive interactions and genetic risks to natural-origin fish. These changes would affect socioeconomics by decreasing the numbers of hatchery-origin fish available for harvest and reducing associated economic values from commercial and recreational fishing, as well as reducing personal income and jobs from hatchery production. There are no primary proposed mitigation measures to reduce or eliminate negative impacts to fish resources that would have a noticeable benefit to socioeconomics. However, mitigation measures associated with development of more efficient fisheries that target hatchery-origin fish in order to reduce competition and genetic risks to natural-origin fish may provide some socioeconomic benefit to the extent additional hatchery-origin fish are available and harvested.

4.4 Environmental Justice

4.4.1 Introduction

The environmental justice analyses address effects of salmon and steelhead hatchery programs on existing environmental justice conditions in the analysis area described in Subsection 3.4, Environmental Justice, when combined with effects anticipated under each alternative. This assessment of the environmental justice effects of the alternatives evaluates predicted changes in environmental justice indicators, including harvest and income associated with environmental justice groups and communities of concern, specifically minority (including Indian tribes with federally recognized treaty fishing rights) and low-income populations.

This subsection analyzes affected groups and communities of concern within the Puget Sound region and three multi-county subregions (Figure 3.3-1). The three subregions are the north Puget Sound subregion (consisting of Whatcom, Skagit, Snohomish, Island, and San Juan Counties); the south Puget Sound subregion (consisting of King, Pierce, Thurston, Mason, and Kitsap Counties); and the Strait of Juan de Fuca subregion (consisting of Clallam and Jefferson Counties) (Table 3.4-1).

4.4.2 Analysis Area

The environmental justice analysis area includes minority and low-income communities that may be affected by the project alternatives. The analysis area for environmental justice is the same as the analysis area for socioeconomics as described in Subsection 4.3.2, Analysis Area (Socioeconomics). The socioeconomic and environmental justice analysis areas include the Puget Sound project area (Subsection 1.4, Project and Analysis Areas), as well as the area encompassed by the 12 counties that occur within the project area (Figure 3.3-1).

4.4.3 Methods for Analysis

This subsection provides an overview of environmental justice impact methods used to analyze environmental justice effects for this EIS. In general, the analyses address effects on the existing conditions of environmental justice groups and communities described in Subsection 3.4.1, Introduction (Environmental Justice), when combined with effects anticipated under each alternative. The analysis of environmental justice effects is based on the evaluation of environmental justice groups and communities of concern in the context of the applicable environmental justice indicators described below. As described in more detail in Subsection 3.4.1, Introduction (Environmental Justice), separate indicators are used for tribal user groups, non-tribal user groups, and communities of concern.

As described in Subsection 4.3.3.1, Commercial Harvest and Recreational Trips, modeled estimates of harvest are used in conjunction with historical averages to estimate salmon and steelhead harvest under the alternatives. These harvest numbers provide the foundation for determining changes in environmental justice economic indicators under the alternatives. As explained in Appendix I, Socioeconomic Impact Methods, estimates of salmon and steelhead harvested in marine waters are assigned to ports at which the fish are brought. Salmon and steelhead harvested in fresh waters are assigned to counties in which the freshwater systems enter marine waters.

The harvest and economic data in the tables within this subsection are for the purpose of comparing relative differences among alternatives, and should not be considered precise predictions of actual harvests or economic conditions for environmental justice groups and communities of concern in the future. Appendix I, Socioeconomic Impact Methods, contains more detailed information on the methods used to estimate harvest and economic characteristics under the alternatives.

For this analysis of environmental justice effects, socio-demographic data are evaluated at the county level to identify communities of concern. For consistency with the socioeconomic analysis presented in Subsection 3.3, Socioeconomics, and Subsection 4.3, Socioeconomics, information within the environmental justice analysis area is organized according to three subregions: north Puget Sound, south Puget Sound, and Strait of Juan de Fuca.

The alternatives would affect the number of salmon and steelhead released from hatcheries in the project area (Subsection 1.4, Project and Analysis Areas), which in turn would affect the number of returning hatchery-origin adults available for harvest with associated economic impacts in the environmental justice analysis area (Subsection 3.4.1, Introduction [Environmental Justice]). Some counties in the environmental justice analysis area (Clallam, Jefferson, Mason, and Thurston Counties) include areas that extend outside the Puget Sound drainage. Because data describing environmental justice conditions are available only county-wide, the environmental justice analysis area (like the socioeconomic analysis area) is larger than the EIS project area described in Subsection 1.4, Project and Analysis Areas.

For the purposes of quantitative assessment of how changes in hatchery production associated with the alternatives would affect salmon and steelhead fisheries in the environmental justice analysis area, it is assumed that the numbers and distribution of natural-origin fish harvested (as described in Subsection 3.3, Socioeconomics), would remain the same as existing conditions under all alternatives.

4.4.3.1 Tribal Indicators

Selection of indicators to represent potential effects of the alternatives on Puget Sound treaty tribes is based both on economic and cultural criteria. While economic issues of concern to these tribes include the need for jobs and income, the tribes also place importance on spiritual, cultural, and lifestyle values associated with fish and wildlife, as discussed in Subsection 3.4.1.2, Approach to Identifying Native American Tribes of Concern. Indicators used in this EIS to assess potential environmental justice effects on tribes include tribal commercial salmon and steelhead harvests, tribal ceremonial and subsistence uses, and economic values to tribes from harvest and hatchery operations.

4.4.3.1.1 Tribal Commercial Salmon and Steelhead Harvests

Puget Sound treaty tribes with fishing rights are entitled to up to 50 percent of the available harvest at usual and accustomed grounds and stations (pursuant to *United States v. Washington*). This indicator focuses on tribal commercial harvest of salmon and steelhead in marine and freshwater areas. Only Puget Sound treaty tribes commercially harvest salmon and steelhead in freshwater areas (Subsection 3.4.2.1, Tribal Commercial Salmon and Steelhead Harvests).

4.4.3.1.2 Ceremonial and Subsistence Uses

A portion of tribal fish harvests is used to meet ceremonial and subsistence needs, which serve as an indicator of cultural viability. Thus, this indicator focuses qualitatively on salmon and steelhead harvested for ceremonial and subsistence purposes (Subsection 3.4.2.2, Ceremonial and Subsistence Uses).

4.4.3.1.3 Economic Value to Tribes from Harvest and Hatchery Operations

This indicator addresses the economic value to Puget Sound treaty tribes from the sale of commercially caught salmon and steelhead, as well as economic values associated with hatchery operations (Subsection 3.4.2.3, Economic Value to Tribes from Harvest and Hatchery Operations).

4.4.3.2 Non-tribal User Group of Concern Indicators

Hatchery production of salmon and steelhead and associated harvests may affect potential user groups of concern (commercial and recreational fishers). For non-tribal commercial fishers, the net revenues associated with fish landings at ports are used as indicators to assess environmental justice effects. Net revenues earned by non-tribal user groups of concern who are commercial fishers affect income levels and poverty rates, which are environmental justice concerns. As described in Subsection 3.4.3, Income to

Non-tribal User Groups of Concern, recreational fishers are not an environmental justice group of concern and thus are not analyzed in this EIS for environmental justice effects.

4.4.3.3 Communities of Concern Indicators

As described in Subsection 3.4.1.4, Approach to Identifying Communities of Concern, environmental justice communities of concern are the counties in the environmental justice analysis area whose percentage of minority populations exceeds the reference area thresholds for low income or minority criteria (Table 3.4-2). No counties qualify as low-income communities of concern (Subsection 3.4.4, Income to Communities of Concern); however, four counties qualify as communities of concern based on minority criteria (Subsection 3.4.4, Income to Communities of Concern). Per capita income from fish harvest and hatchery operations at the county level is the indicator of environmental justice effects for communities of concern.

4.4.4 Native American Tribes of Concern

4.4.4.1 Tribal Commercial Salmon and Steelhead Harvests

As described in Subsection 3.4.2.1, Tribal Commercial Salmon and Steelhead Harvests, Puget Sound treaty tribes harvest a total of 1,321,156 fish annually. Most of this harvest (790,399, or 60 percent) occurs in the north Puget Sound subregion, 434,935 (33 percent) occurs in the south Puget Sound subregion, and 95,822 (7 percent) occurs in the Strait of Juan de Fuca subregion (Table 3.3-4).

4.4.4.1.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the tribal commercial salmon and steelhead harvest or its distribution in the environmental justice analysis area compared to existing conditions (Subsection 3.4.2.1, Tribal Commercial Salmon and Steelhead Harvests). Under Alternative 1, annual tribal harvest in the environmental justice analysis area would continue to total 1,321,156 fish, with annual harvests in the north Puget Sound, south Puget Sound, and Strait of Juan de Fuca subregions of 790,399 (60 percent), 434,935 (33 percent), and 95,822 (7 percent) fish, respectively (Table 4.4-1), which is the same as existing conditions.

Table 4.4-1. Effects on annual tribal salmon and steelhead harvests in Puget Sound subregions by alternative.

Subregion	Alternative 1 (No Action) Number of Fish	Alternative 2 (Proposed Action) Number of Fish	Alternative 2 Change from Alternative 1 Number of Fish	Alternative 2 Change from Alternative 1 Percent	Alternative 3 (Reduced Production) Number of Fish	Alternative 3 Change from Alternative 1 Number of Fish	Alternative 3 Change from Alternative 1 Percent	Alternative 4 (Increased Production) Number of Fish	Alternative 4 Change from Alternative 1 Number of Fish	Alternative 4 Change from Alternative 1 Percent
North Puget Sound	790,399	790,399	0	0	759,568	-30,831	-4	833,455	43,056	5
South Puget Sound	434,935	434,935	0	0	387,239	-47,696	-11	494,797	59,862	14
Strait of Juan de Fuca	95,822	95,822	0	0	84,724	-11,098	-12	100,264	4,442	5
Puget Sound Total	**1,321,156**	**1,321,156**	**0**	**0**	**1,231,531**	**-89,625**	**-7**	**1,428,516**	**107,360**	**8**

Source: Harvest estimates are from the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Values represent total harvest of salmon and steelhead by tribes in the subregions, not just fish originating from Puget Sound hatcheries. Catch does not include harvest for ceremonial and subsistence purposes.

4.4.4.1.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change tribal commercial salmon and steelhead harvests or their distribution in the environmental justice analysis area, which would be the same as under Alternative 1 (Table 4.4-1) because the number of fish released would be the same. Under Alternative 2, annual tribal harvest in the environmental justice analysis area would total 1,321,156 fish, with annual harvests in the north Puget Sound, south Puget Sound, and Strait of Juan de Fuca subregions of 790,399 (60 percent), 434,935 (33 percent), and 95,822 (7 percent) fish, respectively, which is the same as Alternative 1 (Table 4.4-1).

4.4.4.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the total annual tribal commercial harvest of salmon and steelhead in the environmental justice analysis area would be 1,231,531 fish, a decrease of 89,625 fish (7 percent) compared to 1,321,156 under Alternative 1 (Table 4.4-1). Decreases in tribal harvest would occur in all three subregions under Alternative 3. The most substantial decrease in tribal harvest would occur in the south Puget Sound subregion, where harvest would decline by 47,696 fish (11 percent) to 387,239 fish compared to 434,935 under Alternative 1 (Table 4.4-1). The largest percentage decrease however, would occur in the Strait of Juan de Fuca subregion, where commercial harvest would decline by 12 percent (11,098 fish) to 84,724 fish compared to 95,822 under Alternative 1 (Table 4.4-1). Under Alternative 3, the distribution of harvest among the three subregions would be 62 percent, 31 percent, and 7 percent in the north Puget Sound subregion, south Puget Sound subregion, and Strait of Juan de Fuca subregion, respectively, compared to Alternative 1, which is 60 percent, 33 percent, and 7 percent, respectively (Table 4.4-1).

4.4.4.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about

170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total annual tribal commercial harvest of salmon and steelhead in the environmental justice analysis area would be 1,428,516 fish, an increase of 107,360 fish (8 percent) compared to 1,321,156 under Alternative 1 (Table 4.4-1). Increases in tribal harvest would occur in all three subregions under Alternative 4. The most substantial increase in tribal harvest would occur in the south Puget Sound subregion, where harvest would increase by 59,862 fish (14 percent) to 494,797 fish compared to 434,935 under Alternative 1 (Table 4.4-1). Under Alternative 4, the distribution of harvest among the three subregions would be 58 percent, 35 percent, and 7 percent in the north Puget Sound subregion, south Puget Sound subregion, and Strait of Juan de Fuca subregion, respectively, compared to Alternative 1 (which is 60 percent, 33 percent and 7 percent, respectively) (Table 4.4-1).

4.4.4.2 Ceremonial and Subsistence Uses

As described in Subsection 3.4.2.2, Ceremonial and Subsistence Uses, salmon and steelhead used for ceremonial and subsistence uses are harvested non-commercially by members of Puget Sound treaty tribes. Ceremonial and subsistence uses are important to maintaining tribal cultural viability, as well as the provision of a culturally valuable source of food. Many tribes believe that the salmon available for tribal subsistence needs are inadequate based on the current abundances of natural-origin and hatchery-origin fish (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, April 6, 2010).

4.4.4.2.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the non-commercial harvest of salmon and steelhead for tribal ceremonial and subsistence uses of fish in the environmental justice analysis area compared to existing conditions (Subsection 3.4.2.2, Ceremonial and Subsistence Uses). Tribal fishers may fish specifically to catch fish for ceremonies or other community uses when there is no concurrent commercial fishery, as well as continue to use a portion of their harvest for ceremonial and subsistence purposes. For those tribes who believe that their subsistence needs are inadequate under existing conditions (Subsection 3.4.2.2, Ceremonial and Subsistence Uses), subsistence needs for salmon and steelhead would continue to be inadequate under Alternative 1.

4.4.4.2.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change tribal harvest for ceremonial and subsistence uses of salmon and steelhead in the environmental justice analysis area, and would be the same as Alternative 1 because the number of fish released would be the same. Under Alternative 2, tribal fishers may catch fish for ceremonies or other community uses when there is no concurrent commercial fishery, as well as continue to take a portion of their harvest for ceremonial and subsistence uses, which is the same as Alternative 1. For those tribes who believe that their subsistence needs are inadequate under Alternative 1, subsistence needs for salmon and steelhead would continue to be inadequate under Alternative 2.

4.4.4.2.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest for ceremonial and subsistence uses would be less under Alternative 3 than under Alternative 1. However, under Alternative 3, effects on tribal ceremonial and subsistence uses would not be expected to change compared to Alternative 1. This is because tribal harvest of salmon and steelhead for ceremonial and subsistence uses customarily takes priority over harvesting for commercial uses (Subsection 3.4.2.2, Ceremonial and Subsistence Uses). However, for those tribes who believe that the abundances of salmon and steelhead are inadequate to meet subsistence needs under Alternative 1, their subsistence needs for salmon and steelhead would continue to be inadequate under Alternative 3 because the abundances of salmon and steelhead would be less than under Alternative 1.

4.4.4.2.2 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, increases in hatchery production would not be expected to change harvests for tribal ceremonial and subsistence uses compared to Alternative 1 because tribal members customarily meet their ceremonial and subsistence needs as a priority over commercial sales (Subsection 3.4.2.2, Ceremonial and Subsistence Uses). However, for those tribes who believe that abundances of fish under Alternative 1 are inadequate to meet subsistence needs, increases in numbers of salmon and steelhead available for harvest under Alternative 4 would increase the amount available for subsistence harvest.

4.4.4.3 Economic Value to Tribes from Harvest and Hatchery Operations

As described in Subsection 3.4.2.3, Economic Value to Tribes from Harvest and Hatchery Operations, Puget Sound treaty tribes generate an average annual total of $9,148,467 in gross economic (ex-vessel) value from commercial harvest of salmon and steelhead. Most of this value is derived from harvest in the north Puget Sound subregion ($4,455,730), followed by the south Puget Sound subregion ($3,890,770), and the Strait of Juan de Fuca subregion ($801,967) (Table 3.3-4). In addition, operation of tribal hatcheries generates $3,413,457 in tribal personal income and 74 tribal jobs (Table 3.3-6). Most of the income and jobs are in the south Puget Sound subregion ($2,104,988 and 44 jobs), followed by the north Puget Sound subregion ($1,051,468 and 24 jobs) and Strait of Juan de Fuca subregion ($257,001 and 6 jobs). Hatchery operations cost values for tribes (funds received by tribes for routine operation of hatcheries, such as fish food and other supplies, administration, and required services such as mass-marking) total $4,458,287 annually, and are highest in the south Puget Sound subregion ($2,574,548), followed by the north Puget Sound subregion ($1,471,992) and Strait of Juan de Fuca subregion ($411,747) (Table 3.3-6).

4.4.4.3.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the gross economic value to tribes from commercial salmon and steelhead harvests, tribal income and tribal jobs related to hatchery operations, or hatchery operations cost values or their distributions in the environmental justice analysis area compared to existing conditions (Subsection 3.4.2.3, Economic Value to Tribes from Harvest and Hatchery Operations). Under Alternative 1, the commercial harvest of salmon and steelhead by Puget Sound treaty tribes would generate $9,148,467 in average annual gross economic value (Table 4.4-2), which is the same as existing conditions. These economic values would be greatest in the north Puget Sound subregion ($4,455,730), followed by the south Puget Sound subregion ($3,890,770), and the Strait of Juan de Fuca subregion ($801,967) (Table 4.4-2).

Table 4.4-2. Effects on tribal gross economic (ex-vessel) values (in dollars) from harvest in Puget Sound subregions by alternative.

Subregion	Alternative 1 (No Action)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
			Change from Alternative 1			Change from Alternative 1			Change from Alternative 1	
	Gross Economic Value ($)	Gross Economic Value ($)	Gross Economic Value ($)	Percent	Gross Economic Value ($)	Gross Economic Value ($)	Percent	Gross Economic Value ($)	Gross Economic Value ($)	Percent
North Puget Sound	4,455,730	4,455,730	0	0	4,142,350	-313,380	-7	4,847,448	391,718	9
South Puget Sound	3,890,770	3,890,770	0	0	3,337,719	-553,051	-14	4,467,302	576,532	15
Strait of Juan de Fuca	801,967	801,967	0	0	621,282	-180,685	-23	864,794	62,827	8
Puget Sound Total	**9,148,467**	**9,148,467**	**0**	**0**	**8,101,351**	**-1,047,116**	**11**	**10,179,544**	**1,031,077**	**11**

Source: Estimates of gross economic (ex-vessel) values are from the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

Under Alternative 1, personal income and jobs supporting tribal hatcheries would continue to be $3,413,457 and 74 jobs, respectively, as described under existing conditions (Table 3.3-6). Under Alternative 1, personal income and jobs supporting tribal hatcheries would continue to be greatest in the south Puget Sound subregion ($2,104,988 and 44 jobs, respectively), followed by the north Puget Sound subregion ($1,051,468 and 24 jobs), and Strait of Juan de Fuca subregion ($257,001 and 6 jobs).

Annual tribal hatchery operations cost values would continue to be $4,458,285 under Alternative 1 and would be highest in the south Puget Sound subregion ($2,574,548), followed by the north Puget Sound subregion ($1,471,992), and Strait of Juan de Fuca subregion ($411,747) (Table 4.4-8), which would be the same as existing conditions.

4.4.4.3.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change gross economic values to Puget Sound treaty tribes from commercial harvest of salmon and steelhead (Table 4.4-2), personal income or jobs from operation of tribal hatcheries, or hatchery operations cost values or their distributions in the environmental justice analysis area, which would be the same as under Alternative 1 because the number of fish released would be the same.

Under Alternative 2, the commercial harvest of salmon and steelhead by Puget Sound treaty tribes would generate $9,148,467 in average annual gross economic value, which would be the same as Alternative 1 (Table 4.4-2). These economic values would be greatest in the north Puget Sound subregion ($4,455,730), followed by the south Puget Sound subregion ($3,890,770), and the Strait of Juan de Fuca subregion ($801,967) (Table 4.4-2).

Under Alternative 2, personal income and jobs supporting tribal hatcheries would continue to be $3,413,457 and 74 jobs, respectively, which is the same as Alternative 1 (Table 3.3-6). Personal income and jobs supporting tribal hatcheries would continue to be greatest in the south Puget Sound subregion ($2,104,988 and 44 jobs, respectively), followed by the north Puget Sound subregion ($1,051,468 and 24 jobs), and Strait of Juan de Fuca subregion ($257,001 and 6 jobs).

Annual tribal hatchery operations cost values would continue to be $4,458,287 under Alternative 2, and would be highest in the south Puget Sound subregion ($2,574,548), followed by the north Puget Sound subregion ($1,471,992), and Strait of Juan de Fuca subregion ($411,747) (Table 4.3-8), which would be the same as Alternative 1.

4.4.4.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the total annual tribal gross economic value from commercial harvest of salmon and steelhead would be $8,101,351, a decrease of $1,047,116 (11 percent) from $9,148,467 under Alternative 1 (Table 4.4-2). Decreases in tribal gross economic value would occur in all three subregions under Alternative 3. The most substantial decrease would be in the south Puget Sound subregion where annual gross economic values would decrease $553,051 (14 percent) to $3,337,719 compared to $3,890,770 under Alternative 1 (Table 4.4-2). The largest percentage decrease however, would occur in the Strait of Juan de Fuca subregion, where tribal gross economic value would decline 23 percent ($180,685) to $621,282 compared to $801,967 under Alternative 1 (Table 4.4-2). Tribal gross economic value in the north Puget Sound subregion would decrease $313,380 (7 percent) to $4,142,350 compared to $4,455,730 under Alternative 1 (Table 4.4-2).

Under Alternative 3, tribal personal income and jobs at tribal hatcheries would not be affected, and would continue to support a total of $3,413,457 in personal income and 74 jobs in the environmental justice analysis area, as under Alternative 1. Alternative 3 would affect tribal hatchery operation cost values, which would be $3,527,594, a $930,691 (21 percent) decrease, compared to $4,458,287 under Alternative 1 (Table 4.3-8).

4.4.4.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, the total annual tribal gross economic value from commercial harvest of salmon and steelhead would be $10,179,544, an increase of $1,031,077 (11 percent), compared to $9,148,467 under Alternative 1 (Table 4.4-2). Increases in tribal gross economic value would occur in all three subregions under Alternative 4. The most substantial increase would be in the south Puget Sound subregion where annual gross economic values would increase by $576,532 (15 percent) to $4,467,302 compared to $3,890,770 under Alternative 1 (Table 4.4-2). Tribal gross economic value in the north Puget Sound subregion would increase by $391,718 (9 percent) to $4,847,448 compared to $4,455,730 under Alternative 1, and in the Strait of Juan de Fuca subregion would increase by $62,827 (8 percent) to $864,794 compared to $801,967 under Alternative 1 (Table 4.4-2).

Under Alternative 4, tribal personal income and jobs at tribal hatcheries would not be affected, and would continue to support a total of $3,413,457 in personal income and 74 jobs, as under Alternative 1. Alternative 4 would affect tribal hatchery operation cost values, which would be $6,283,837, a $1,825,552 (41 percent) increase, compared to $4,458,287 under Alternative 1 (Table 4.3-8).

4.4.5 Income to Non-tribal User Groups of Concern

As described in Subsection 3.4.3, Income to Non-tribal User Groups of Concern, application of socio-demographic data and minority and low income criteria identified commercial fishers based at seven ports in the environmental justice analysis area subregions as a non-tribal environmental justice group of concern. The seven ports are Bellingham Bay and Everett in the north Puget Sound subregion; Seattle, Shelton, and Tacoma in the south Puget Sound subregion; and Neah Bay and Port Angeles in the Strait of Juan de Fuca subregion. Net revenues (profits minus losses) for the commercial fishers based at the seven ports total $3,335,926, and are highest in the north Puget Sound subregion ($1,850,497), followed by the south Puget Sound subregion ($1,473,806), and Strait of Juan de Fuca subregion ($11,623) (Table 3.4-6).

4.4.5.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the average annual total net revenue or its distribution for commercial fishers in the environmental justice analysis area compared to existing conditions (Subsection 3.4.3, Income to Non-tribal User Groups of Concern). Under Alternative 1, annual total net revenues associated with salmon harvest by non-tribal commercial fishers based at the seven ports and who are deemed a user group of concern would continue to total $3,335,926, with the highest net revenue in the north Puget Sound subregion ($1,850,497), followed by the south Puget Sound subregion ($1,473,806), and the Strait of Juan de Fuca subregion ($11,623) (Table 4.4-3), which would be the same as existing conditions.

4.4.5.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change net revenues for commercial fishers or its distribution in the environmental justice analysis area, which would be the same as under Alternative 1 (Table 4.4-3) because the number of fish released would be the same. Under Alternative 2, annual total net revenues associated with salmon landings by non-tribal commercial fishers based at the seven ports and identified as a user group of concern would continue to total $3,335,926, with the highest net revenue in the north Puget Sound subregion ($1,850,497), followed by the south Puget Sound subregion ($1,473,806), and Strait of Juan de Fuca subregion ($11,623), which would be the same as under Alternative 1 (Table 4.4-3).

4.4.5.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest would be less under Alternative 3 than under Alternative 1.

Under Alternative 3, the annual total net revenue to commercial fishers that are a user group of concern would be $3,295,437, a decrease of $40,489 (1 percent) compared to $3,335,926 under Alternative 1 (Table 4.4-3). Decreases in net revenue from commercial fishers that are a user group of concern would occur in all three subregions under Alternative 3. Under Alternative 3, the largest decrease in annual net revenue would occur in the north Puget Sound subregion where net revenue would be $1,816,231, a decrease of $34,266 (2 percent) compared to $1,850,497 under Alternative 1 (Table 4.4-3). Under Alternative 3, net revenue to commercial fishers that are a user group of concern in the south Puget Sound subregion would be $1,467,687, a decrease of $6,119 (less than 1 percent) compared to $1,473,806 under Alternative 1, and in the Strait of Juan de Fuca subregion, net revenue would be $11,519, a decrease of $104 (1 percent) compared to $11,623 under Alternative 1 (Table 4.4-3). Alternative 3 would result in decreases of net revenues associated with the non-tribal user group of concern that comprise the commercial fishers based at the seven ports in the Puget Sound subregions compared to Alternative 1 (Table 4.4-3).

Table 4.4-3. Effects on net revenues (in dollars) to commercial fishers (non-tribal user group of concern) from commercial salmon brought to ports in Puget Sound subregions by alternative.

Subregion and Commercial Fishing Port	Alternative 1 (No Action) Net Revenue ($)	Alternative 2 (Proposed Action)			Alternative 3 (Reduced Production)			Alternative 4 (Increased Production)		
		Net Revenue ($)	Change from Alternative 1: Net Revenue ($)	Change from Alternative 1: Percent	Net Revenue ($)	Change from Alternative 1: Net Revenue ($)	Change from Alternative 1: Percent	Net Revenue ($)	Change from Alternative 1: Net Revenue ($)	Change from Alternative 1: Percent
North Puget Sound										
Bellingham Bay	1,581,951	1,581,951	0	0	1,548,318	-33,633	-2	1,716,177	134,226	8
Everett	268,546	268,546	0	0	267,913	-633	less than -1	280,530	11,984	4
Total	**1,850,497**	**1,850,497**	**0**	**0**	**1,816,231**	**-34,266**	**-2**	**1,996,707**	**146,210**	**8**
South Puget Sound										
Seattle	1,166,822	1,166,822	0	0	1,165,453	-1,369	less than -1	1,254,061	87,239	7
Shelton	222,005	222,005	0	0	217,383	-4,622	-2	254,958	32,953	15
Tacoma	84,979	84,979	0	0	84,851	-128	less than -1	86,778	1,799	2
Total	**1,473,806**	**1,473,806**	**0**	**0**	**1,467,687**	**-6,119**	**less than -1**	**1,595,797**	**121,991**	**8**
Strait of Juan de Fuca										
Neah Bay	1,621	1,621	0	0	1,556	-65	-4	1,698	77	5
Port Angeles	10,002	10,002	0	0	9,963	-39	less than -1	10,040	38	less than 1
Total	**11,623**	**11,623**	**0**	**0**	**11,519**	**-104**	**-1**	**11,738**	**115**	**1**
Total Puget Sound	**3,335,926**	**3,335,926**	**0**	**0**	**3,295,437**	**-40,489**	**-1**	**3,604,242**	**268,316**	**8**

Source: Estimates of net revenues from non-tribal commercial salmon harvest were derived by the Puget Sound Hatchery EIS Technical Work Group. Refer to Appendix I, Socioeconomic Impact Methods, for additional details.

[1] Environmental justice user groups of concern are identified in Table 3.4-5.

4.4.5.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, annual total net revenue to commercial fishers that are a user group of concern would be $3,604,242, an increase of $268,316 (8 percent) compared to $3,335,926 under Alternative 1 (Table 4.4-3). Increases in net revenue to commercial fishers that are a user group of concern would occur in all three subregions under Alternative 4. Under Alternative 4, the largest increase in annual net revenue would occur in the north Puget Sound subregion where net revenue would be $1,996,707, an increase of $146,210 (8 percent) compared to $1,850,497 under Alternative 1 (Table 4.4-3). Under Alternative 4, net revenue to commercial fishers that are a user group of concern in the south Puget Sound subregion would be $1,595,797, an increase of $121,991 (8 percent) compared to $1,473,806 under Alternative 1, and in the Strait of Juan de Fuca subregion net revenue would be $11,738, an increase of $115 (1 percent) compared to $11,623 under Alternative 1 (Table 4.4-3). The increases in net revenues under Alternative 4 would result in benefits to the commercial fisher non-tribal user group of concern based in the environmental justice analysis area.

4.4.6 Income to Communities of Concern

As described in Subsection 3.4.4, Income to Communities of Concern, hatchery production of salmon and steelhead and associated commercial and recreational harvests indirectly affect persons and businesses that do business with commercial and recreational fishers. Included in community-level effects are direct income effects on fish harvesters and hatchery employees, and indirect effects on fish processors, recreational support businesses, and businesses that provide materials and services to the hatchery operations. For this analysis, changes in per capita income are calculated for counties that are identified in Subsection 3.4.4, Income to Communities of Concern, as environmental justice communities of concern (Table 3.4-7). Four counties are identified that represent communities of concern in the south Puget Sound subregion and Strait of Juan de Fuca subregion. No counties represent communities of concern in the north Puget Sound subregion (Subsection 3.4.4, Income to Communities of Concern). The per capita income in the four counties representing communities of concern based on minority criteria is $29,521, $18,056, and $20,948 for King, Mason, and Pierce Counties, respectively, in the south Puget Sound subregion, and $19,517 for Clallam County in the Strait of Juan de Fuca subregion (Table 3.4-8).

4.4.6.1 Alternative 1 (No Action)

Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the per capita income for environmental justice communities of concern compared to existing conditions (Subsection 3.4.4, Income to Communities of Concern). Under Alternative 1, per capita income for environmental justice communities of concern would be $29,521, $18,056, $20,948, and $19,517 for King, Mason, Pierce, and Clallam Counties, respectively (Table 4.4-4), which would be the same as existing conditions.

4.4.6.2 Alternative 2 (Proposed Action)

Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change per capita income in environmental justice communities of concern in the environmental justice analysis area, which would be the same as under Alternative 1 (Table 4.4-4) because the number of fish released would be the same. Under Alternative 2, per capita income for environmental justice communities of concern would be $29,521, $18,056, $20,948, and $19,517 for King, Mason, Pierce, and Clallam Counties, respectively (Table 4.4-4), which would be the same as Alternative 1.

4.4.6.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would reduce the total number of juvenile hatchery-origin salmon and steelhead released in the project area by about 12 million fish (8 percent), from about 147 million fish to about 135 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases that would be available for harvest would be less under Alternative 3 than under Alternative 1.

Table 4.4-4. Effects on per capita income for counties representing communities of concern in Puget Sound subregions by alternative.

Subregion and County[1]	**Alternative 1 (No Action)**	**Alternative 2 (Proposed Action)**			**Alternative 3 (Reduced Production)**			**Alternative 4 (Increased Production)**		
			Change from Alternative 1			**Change from Alternative 1**			**Change from Alternative 1**	
	Per Capita Income ($)	**Per Capita Income ($)**	**Per Capita Income ($)**	**Percent**	**Per Capita Income ($)**	**Per Capita Income ($)**	**Percent**	**Per Capita Income ($)**	**Per Capita Income ($)**	**Percent**
South Puget Sound										
King	29,521	29,521	0	0	29,520	-1	less than -1	29,524	3	less than 1
Mason	18,056	18,056	0	0	18,046	-10	less than -1	18,069	13	less than 1
Pierce	20,948	20,948	0	0	20,946	-2	less than -1	20,950	2	less than 1
Strait of Juan de Fuca										
Clallam	19,517	19,517	0	0	19,509	-8	less than -1	19,522	5	less than 1

Sources: Estimates are from the Puget Sound Hatchery EIS Technical Work Group, based on population estimates from the U.S. Census Bureau (2000).

[1] Counties that represent environmental justice communities of concern are identified in Table 3.4-7. The north Puget Sound subregion is not shown in this table because there are no counties representing environmental justice communities of concern in that subregion.

Under Alternative 3, per capita income in the four counties representing environmental justice communities of concern would decrease compared to Alternative 1 because commercial and recreational salmon and steelhead harvests and hatchery operations would be reduced. Under Alternative 3, the largest decrease in per capita income would occur in Mason County in the south Puget Sound subregion, where per capita income would be $18,046, a decrease of $10, compared to $18,056 under Alternative 1 (Table 4.4-4). Under Alternative 3, the per capita income in King, Pierce, and Clallam Counties would be $29,520, $20,946, and $19,509, respectively, with corresponding decreases of $1, $2, and $8 compared to $29,521, $20,948, and $19,517, respectively, under Alternative 1 (Table 4.4-4). When these changes are viewed as percentages, all of these decreases in per capita income under Alternative 3 would be less than 1 percent for each county, compared to Alternative 1 (Table 4.4-4). Although quantifiable reductions in per capita income under Alternative 3 would occur for all communities of concern, changes of less than 1 percent would be considered negligible.

4.4.6.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would increase the total number of juvenile hatchery-origin salmon and steelhead released in the project area by 16 percent, from about 147 million fish to about 170 million fish (Table 2.4-1). The number of adult hatchery-origin salmon and steelhead returning from these releases and available for harvest would be greater under Alternative 4 than under Alternative 1.

Under Alternative 4, per capita income in the four counties representing environmental justice communities of concern would increase compared to Alternative 1 because of increased commercial and recreational salmon and steelhead harvests. Under Alternative 4, the largest increase in per capita income would occur in Mason County in the south Puget Sound subregion, where per capita income would be $18,069, an increase of $13, compared to $18,056 under Alternative 1 (Table 4.4-4). Under Alternative 3, the per capita income in King, Pierce, and Clallam Counties would be $29,524, $20,950, and $19,522, with corresponding increases of $3, $2, and $5 compared to $29,521, $20,948, and $19,517, respectively, under Alternative 1 (Table 4.4-4). When these changes are viewed as percentages, increases in per capita income would be less than 1 percent for each community of concern compared to Alternative 1 (Table 4.4-4). Although quantifiable increases in per capita income under Alternative 4 would occur for all communities of concern, changes of less than 1 percent would be considered negligible.

4.4.7 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations, and measures that would be applied over the long term under adaptive management (including updated and new BMPs). An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, but is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect other resources, such as environmental justice. Proposed potential mitigation measures for fish are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

Under adaptive management, in addition to applicable updated and new BMPs that may become available, the primary proposed potential mitigation measures to reduce or eliminate negative impacts to fish that would affect environmental justice would be reducing hatchery program size (number of hatchery-origin fish released) and/or discontinuing hatchery programs. These changes would affect environmental justice by decreasing the numbers of fish available for harvest and thus reducing associated tribal commercial harvest and economic values, reducing numbers of fish available for ceremonial and subsistence uses, and reducing income to non-tribal user groups and communities of concern. There are no primary proposed mitigation measures to reduce or eliminate negative impacts to fish resources that would have a noticeable benefit to environmental justice. However, mitigation measures associated with development of more efficient fisheries targeting hatchery-origin fish to reduce competition and genetic risks to natural-origin fish may provide some environmental justice benefit to the extent additional hatchery-origin fish are available and harvested.

4.5 Wildlife

4.5.1 Introduction

The wildlife analyses address effects of salmon and steelhead hatchery programs on existing wildlife conditions in the analysis area described in Subsection 3.5, Wildlife, when combined with effects anticipated under each alternative. As described in Subsection 3.5, Wildlife, existing hatchery operations and fish production in the project area have the potential to affect wildlife species directly and indirectly through facility presence, hatchery discharges to receiving waters, and predator-prey relationships associated with fish production.

Discussed in this subsection are effects associated with existing hatchery programs in the project area. These effects include the operation of hatchery facilities (which could affect wildlife through transfer of toxic contaminants or pathogens from hatchery-origin fish to wildlife), operation of hatchery weirs (which could block or entrap wildlife), hatchery predator control programs (which may harass or kill wildlife preying on juvenile salmon at hatchery facilities), distribution of hatchery salmon carcasses into the environment (which provide food and nutrients), or other aquatic habitat changes that occur from hatchery operations (Subsection 3.5.2, Hatchery Operations and Wildlife). Changes in hatchery production under the alternatives that may impact the abundance and distribution of salmon and steelhead species in the project area (Subsection 4.2, Fish) may affect wildlife predator and prey interactions.

This subsection also describes the effects of implementing the alternatives on predator-prey relationships for key wildlife groups associated with salmon and steelhead, specifically 1) ESA-listed freshwater, marine, and terrestrial wildlife species; 2) non-listed fish-eating birds; 3) non-listed marine mammals; and 4) other non-listed freshwater, marine, and terrestrial wildlife species, including invertebrates (Subsection 3.5.3, Predator-prey Relationships Between Wildlife and Salmon and Steelhead). Information is organized by species, and some species are grouped when appropriate. For information on hatchery-origin and natural-origin fish species, and their ecological interactions, see Subsection 3.2, Fish.

The analysis area for wildlife is the same as the project area as described in Subsection 1.4, Project and Analysis Areas. Some wildlife species are found throughout the analysis area, while others are only found in part of the analysis area.

4.5.2 Methods for Analysis

The analysis begins with an overview of effects from existing hatchery programs in the project area. These effects are then analyzed when combined with each alternative. The analysis in this subsection uses inferences from the best available information to evaluate effects on wildlife from hatchery facilities and their operation, and describes how the alternatives would likely affect predator-prey relationships between wildlife and the fish that would be released from hatcheries under the alternatives. As described in Subsection 3.5.3, Predator-prey Relationships between Wildlife and Salmon and Steelhead, these relationships are based on a literature review conducted by Cederholm et al. (2000) and other studies representing best available science. Cederholm et al. (2000) explain that a strong relationship between wildlife and salmon and steelhead is one where salmon and steelhead provide an important role in the distribution, abundance, viability, and/or population status of the wildlife species, especially at particular life stages or specific seasons. A recurrent relationship between wildlife and salmon and steelhead is a relationship that may affect some populations of a given wildlife species, but in general does not affect the distribution, abundance, viability, or population status of the species as a whole. Whether a relationship is strong or recurrent would not change under the alternatives. Wildlife species that do not have a relationship with salmon and steelhead as described by Cederholm et al. (2000) are not analyzed in this EIS.

Although it has not been demonstrated that wildlife differentiate between hatchery-origin and natural-origin salmon and steelhead, changes in production of hatchery-origin fish under the alternatives may affect wildlife in general (and species or species groups) because the total available salmon and steelhead in the analysis area (including both hatchery-origin and natural-origin fish) may change. Thus, analyses of the alternative effects on wildlife considers changes in total releases and returns from salmon and steelhead production (hatchery-origin plus natural-origin salmon and steelhead) under the assumption that wildlife predators do not distinguish between hatchery-origin and natural-origin fish.

Alternative effects include the number of adult salmon and steelhead available to wildlife predators. As shown in Table 2.4-1, hatchery production would not change under Alternative 2 compared to Alternative 1, whereas under Alternative 3, hatchery production of Chinook salmon, coho salmon, chum salmon, and steelhead would decrease, and under Alternative 4, hatchery production of Chinook salmon, coho salmon, chum salmon, pink salmon, and steelhead would increase.

For specific wildlife species, the analysis of alternative effects includes the number of Chinook salmon available to wildlife predators as shown in Table 4.5-1. Compared to Alternative 1, Alternative 2 would not have changes in hatchery production. Under Alternative 3, the number of juvenile Chinook salmon released would decrease 18 percent, and overall returns of adult hatchery-origin and natural-origin Chinook salmon would decrease 13 percent compared to Alternative 1. Under Alternative 4, the number of juvenile Chinook salmon released would increase 13 percent, and overall adult returns would increase 10 percent. Similarly, overall adult returns of the other salmon and steelhead species would be expected to decrease under Alternative 3 and increase under Alternative 4, in response to the changes in hatchery production levels (Table 2.4-1).

Table 4.5-1. Salmon and steelhead releases and estimated adult Chinook salmon in Puget Sound relative to Alternative 1 by action alternative.

Group	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
	Number (thousands)	**Percent Change from Alt. 1**	**Number (thousands)**	**Percent Decrease from Alt. 1**	**Number (thousands)**	**Percent Increase from Alt. 1**
Total hatchery-origin juveniles released (all species)	146,997	0	135,082	-8	169,967	+16
Total hatchery-origin juveniles released (Chinook salmon)	45,317	0	37,182	-18	51,307	+13
Adult Chinook salmon returns						
Hatchery-origin[1]	221	0	181	-18	254	+15
Natural-origin[2]	85	0	85	0	85	0
Total	**306**	**0**	**266**	**-13**	**339**	**+11**

Sources: Hatchery releases, Table 2.4-1; S. Leider, pers. comm., NMFS, Fish Biologist, July 30, 2012.

[1] Numbers of hatchery-origin Chinook salmon are estimated returns to Puget Sound fisheries and escapement based on release levels and juvenile average survival rates for Puget Sound hatchery programs (Fuss and Ashbrook 1995). Numbers do not include fish originating from outside the analysis area.

[2] Note natural-origin adult Chinook salmon return numbers are different from those in Table 3.2-1 because a different data set was used to align hatchery-origin and natural-origin information for this comparative analysis. Numbers do not include fish originating from outside the analysis area.

By themselves, the percent changes in the number of hatchery-origin fish released would not reflect the total number of adult fish that would be available to wildlife predators, because the total number of fish available to wildlife predators would also include natural-origin fish. For the purpose of comparison, numbers of natural-origin fish are the same for the action alternatives (Table 4.5-1). However, changes in the numbers of hatchery-origin fish released would generally decrease risks to natural-origin fish under Alternative 3, and increase risks to natural-origin fish under Alternative 4 (Subsection 4.2, Fish), which may affect total salmon and steelhead in the analysis area.

An adaptive management process would occur under Alternative 2, Alternative 3, and Alternative 4 that could result in decreased or increased production of hatchery-origin fish at certain locations over time.

The EIS identifies potential mitigation measures that could be implemented over time at specific hatcheries under the adaptive management process to reduce risks (e.g., Subsection 4.2, Fish). However, because mitigation measures that would be implemented over time depend on the outcome of the adaptive management process and are uncertain at this time, changes in hatchery production as a result of applying potential mitigation measures are not analyzed in the EIS.

4.5.3 Hatchery Operations and Wildlife

This subsection focuses on effects to wildlife from existing hatchery operations including potential contaminants, predator control programs, operation of hatchery structures or weirs, salmon carcasses, and other hatchery operations.

4.5.3.1 Transfer of Toxic Contaminants and Pathogens

As discussed in Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens, and Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish (Human Health), limited information is available on the relative levels of toxic contaminants in hatchery-origin fish compared to natural-origin fish. However, because hatchery-origin fish spend most of their lives in the natural environment, hatchery-origin fish would generally not be expected to have a higher level of toxic contaminants than natural-origin fish. Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens, describes the effects of contaminant loading in wildlife from consumption of contaminated prey, including fish. Although studies have shown that wildlife are exposed to toxic contaminants and pathogens from consumption of fish, hatcheries are not known to be the cause of contaminant or pathogen loadings (Subsection 3.7, Human Health).

Hatchery-origin fish that tend to rear in Puget Sound marine waters rather than migrating to the ocean (e.g., resident Chinook salmon), likely accumulate more toxic contaminants than their ocean-going counterparts (O'Neill and West 2009) (Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens). However, these fish are relatively scarce, smaller in relative size (compared to ocean-going Chinook salmon adults), and survival of yearling hatchery-origin fall-run Chinook salmon has declined (Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon). Thus, for this analysis it is generally assumed that hatchery-origin fish would not contain higher contaminant loads than natural-origin fish because both types of fish rear in and migrate through the same potentially impaired waters.

As described in Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens, heavy contaminant loads in Puget Sound Chinook salmon likely contributed to contaminant loads in Southern Resident killer whales, in part because Southern Resident killer whales prefer to capture larger, and thus older, Chinook salmon prey, which typically have higher contaminant loads than younger salmon. Pathogen transfer from hatchery-origin fish to other wildlife, such as amphibians, is possible as described in Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens; however, this phenomenon has not been recorded as occurring in Puget Sound.

4.5.3.1.1 Alternative 1 (No Action)

Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the extent of contaminant exposure to wildlife predators from consumption of salmon and steelhead compared to existing conditions. This would include exposure to contaminants from consumption of adult Chinook salmon by the Southern Resident killer whale. Chemical and drug use at hatcheries would also not be altered under Alternative 1 compared to existing conditions. The potential for pathogen transfer from hatchery-origin fish to wildlife would also be the same as existing conditions.

4.5.3.1.2 Alternative 2 (Proposed Action)

Hatchery operations and production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter the extent of contaminant exposure to wildlife predators from consumption of salmon and steelhead compared to Alternative 1. This would include exposure to contaminants from consumption of adult Chinook salmon by the Southern Resident killer whale. Chemical and drug use at hatcheries would also not be altered under Alternative 2 compared to Alternative 1. The potential for pathogen transfer from hatchery-origin fish to wildlife would also be the same as Alternative 1.

4.5.3.1.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would result in an 18 percent decrease of Chinook salmon hatchery production, which would reduce the total number of natural-origin and hatchery-origin adult Chinook salmon returning to Puget Sound by 13 percent, or 40,000 fish (Table 4.5-1). In addition, under Alternative 3, the total number of juvenile hatchery-origin salmon and steelhead released would be reduced overall by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1) compared to Alternative 1. Thus, the number of adult hatchery-origin salmon and steelhead would be less under Alternative 3 compared to Alternative 1, thereby reducing the number of salmon and steelhead available as prey to wildlife and, consequently, the amount of exposure to potential toxic contaminants from salmon and steelhead consumption or the transfer of pathogens from fish to wildlife.

The magnitude of reductions in salmon and steelhead in any given year would depend on many factors including the origins and numbers of other available salmon species and survival of hatchery-origin releases to adulthood. It is possible that chemical and drug use at hatcheries may decrease under Alternative 3 compared to Alternative 1 because of a decrease in hatchery production.

As described under Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens, salmon and steelhead exposure to contaminants in the analysis area likely occurs when the salmon and steelhead reside in Puget Sound. Hatchery-origin fish are not expected to have more exposure to contaminants than natural-origin fish. The decrease in salmon and steelhead in the analysis area under Alternative 3 compared to Alternative 1 may result in a decrease in consumption of these fish if an alternative fish supply is available. Thus, compared to Alternative 1, Alternative 3 would not be expected to result in a different exposure rate to contaminants through the consumption of salmon and steelhead, which would include exposure of the Southern Resident killer whale to contaminants from consuming Chinook salmon. It is possible that pathogen transfer from hatchery-origin fish to wildlife, such as amphibians, would decrease under Alternative 3, compared to Alternative 1, because of a decrease in hatchery production. Similarly, it is possible that pollutant discharges from hatcheries, if any, would decrease under Alternative 3 compared to Alternative 1.

4.5.3.1.4 Alternative 4 (Increased Production)

Compared to Alternative 1, Alternative 4 would not result in changes to hatchery operations but would result in a 13 percent increase in hatchery production, which would increase the total number of natural-origin and hatchery-origin adult Chinook salmon returning to Puget Sound by 11 percent, or 33,000 fish (Table 4.5-1). In addition, under Alternative 4, the total number of juvenile hatchery-origin salmon and steelhead released would increase overall by 16 percent. It is possible that chemical and drug use at hatcheries may increase under Alternative 4 compared to Alternative 1 because of an increase in hatchery production. Similarly, it is possible that the potential for an increase in pathogen transfer from hatchery-origin fish to wildlife, such as amphibians, may increase under Alternative 4 compared to Alternative 1.

As described under Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens, salmon and steelhead exposure to contaminants in the analysis area likely occurs when the salmon and steelhead reside in Puget Sound. The increase in salmon and steelhead production in Puget Sound under

Alternative 4 compared to Alternative 1 may result in an increase in consumption of hatchery-origin fish and thus increase the total amount of toxic contaminants consumed. However, these fish are not known to have an increased amount of toxic contaminants compared to natural-origin fish (Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens). Thus, Alternative 4 is not expected to result in a different exposure rate to contaminants compared to Alternative 1 because of consumption of salmon and steelhead, but may increase the total amount of contaminants consumed, which would include exposure of the Southern Resident killer whale to contaminants from consuming Chinook salmon. It is possible that wildlife, such as amphibians, would be exposed to more pathogens under Alternative 4 compared to Alternative 1 because of an increase in hatchery production. Similarly, it is possible that pollutant discharges, if any, would increase under Alternative 4 compared to Alternative 1.

4.5.3.2 Hatchery Predator Control Programs and Weirs

Existing hatchery predator control programs and devices as described in Subsection 3.5.2.2, Hatchery Predator Control Programs and Weirs, would continue to be used and maintained under all alternatives. These programs would continue to restrict the opportunities for wildlife to consume fish at hatchery facilities. No changes in predator control programs would occur under any of the alternatives. Existing weirs would continue to be operated and maintained under all alternatives, and no new weirs would be installed.

Compared to Alternative 1, hatchery production changes under Alternative 2, Alternative 3, and Alternative 4 would not affect existing hatchery predator control programs or weirs. As described in Subsection 3.5.2.2, Hatchery Predator Control Programs and Weirs, weirs can alter stream flow and streambed and riparian habitat; affect habitat availability for non-target fish, amphibians, and aquatic invertebrates; and act as barriers to aquatic wildlife movements; however, the overall impacts to wildlife would be minor. These impacts would continue unchanged under all alternatives.

4.5.3.3 Nutrients from Salmon and Steelhead Carcasses

As described in Subsection 3.5.2.3, Nutrients from Salmon and Steelhead Carcasses, freshwater and terrestrial food webs and ecosystem function are affected by salmon and steelhead carcass availability and associated marine-derived nutrients in spawning streams. Birds (such as wintering bald eagles), mammals, and aquatic invertebrates feed directly on salmon and steelhead carcasses, and the decomposer communities (i.e., organisms including bacteria, fungi, and invertebrates that decompose organic material) that develop on carcasses are, in turn, consumed by other aquatic invertebrate species. Carcasses in streams result from natural-origin and hatchery-origin spawners and from hatchery-origin fish that return to hatchery facilities to spawn and then are placed out into streams by hatchery operators.

4.5.3.3.1 Alternative 1 (No Action)

Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the number of carcasses distributed to streams from either hatchery-origin fish returning to spawn or from placement of carcasses in streams by hatchery operators. Carcass distribution and availability in the analysis area would be the same as existing conditions.

4.5.3.3.2 Alternative 2 (Proposed Action)

Hatchery operations and production of salmon and steelhead under Alternative 2 would be the same as Alternative 1. As a result, Alternative 2 would not alter the number of carcasses distributed to streams from either hatchery-origin fish returning to spawn or from placement of carcasses in streams by hatchery operators. Carcass distribution and availability in the analysis area would be the same as Alternative 1.

4.5.3.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, reductions in hatchery production under Alternative 3 would reduce the number of hatchery-origin adults that spawn naturally and may reduce the number of carcasses that would be available for placement in streams below the current annual average of 28,850 carcasses distributed in Puget Sound rivers and streams by WDFW hatcheries (Appendix B, Hatchery Effects and Evaluation Methods for Fish). However, as discussed in Appendix B, Hatchery Effects and Evaluation Methods for Fish, most of the salmon and steelhead biomass deposited in streams consists of natural-origin chum salmon and pink salmon (80 percent), and compared to the overall number and biomass of natural-origin salmon and steelhead in the analysis area, hatchery-origin carcasses would be expected to contribute a relatively small proportion of total carcasses. Compared to Alternative 1, the effects of changes that would occur under Alternative 3 would be localized in areas where natural spawning by hatchery-origin salmon and steelhead occurs and where hatchery operators place carcasses, and would not have an overall effect on nutrient availability from salmon and steelhead carcasses in the analysis area. Under Alternative 3, there would be no changes in hatchery operations compared to Alternative 1.

4.5.3.3.4 Alternative 4 (Increased Production)

Relative increases in production under Alternative 4 would increase the number of naturally spawning hatchery-origin salmon and steelhead and may increase the 28,850 carcasses available for placement in streams. However, as discussed in Appendix B, Hatchery Effects and Evaluation Methods for Fish, most of the salmon and steelhead biomass deposited in streams consists of natural-origin chum salmon and pink salmon (80 percent), and compared to the overall number and biomass of natural-origin salmon and steelhead in the analysis area, hatchery-origin carcasses would be expected to contribute a relatively small proportion of total carcasses. Compared to Alternative 1, the effects of changes that would occur under Alternative 4 would be localized in areas where natural spawning by hatchery-origin salmon and steelhead occurs and where hatchery operators place carcasses, and would not have an overall effect on nutrient availability from salmon and steelhead carcasses in the analysis area. Under Alternative 4, there would be no changes in hatchery operations compared to Alternative 1.

4.5.3.4 Other Hatchery Operations

The operation of existing hatchery facilities can affect water quality and quantity as well as water volume and flow in stream reaches, particularly in the bypass areas, as described in Subsection 3.5.2.4, Other Hatchery Operations. Depending on the timing and degree of alterations, habitat availability for stream-breeding amphibians, crustaceans, and aquatic insects would be affected. The amount of water used may vary among the action alternatives. Hatchery facilities often contain ponds with walls lined with asphalt or other hard surfaces that do not provide amphibian habitat. As described in Subsection 3.5.2.4, Other Hatchery Operations, such ponds, present a minimal risk of mortality to amphibians. Other potential, but minor, sources of amphibian mortality at the hatchery facilities under any alternative could include entrapment in fish screens and other exclusionary devices.

4.5.3.4.1 Alternative 1 (No Action)

Hatchery operations and production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not affect water quality and quantity (water use) for hatchery operations. Thus, water quality and quantity for hatchery operations would be the same as existing conditions. Alternative 1 would also not affect the minimal potential for mortality or lost breeding opportunities by amphibians from pond activity or entrapment in fish screens and other exclusionary devices as described under existing conditions (Subsection 3.5.2.2, Hatchery Predator Control Programs and Weirs).

4.5.3.4.2 Alternative 2 (Proposed Action)

Hatchery operations and production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not affect water quality and quantity (water use) for hatchery operations. Thus, water quality and quantity for hatchery operations would be the same as Alternative 1. Similar to Alternative 1, hatchery operations under Alternative 2 would not affect the minimal potential for mortality or lost breeding opportunities by amphibians from pond activity or entrapment in fish screens and other exclusionary devices.

4.5.3.4.3 Alternative 3 (Reduced Production)

Reduced hatchery production under Alternative 3 may result in more water in bypass areas associated with hatchery facilities compared to water in bypass areas under Alternative 1. In general, more water would increase available habitat for stream-breeding amphibians, crustaceans, and aquatic insects, which would result in a benefit to wildlife, although likely minimal. Similar to Alternative 1, hatchery operations under Alternative 3 would not affect the minimal potential for mortality or lost breeding opportunities by amphibians from pond activity or entrapment in fish screens and other exclusionary devices.

4.5.3.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, increased hatchery production under Alternative 4 may result in less water in the bypass areas. In general, less water would reduce available habitat for stream-breeding amphibians, crustaceans, and aquatic insects, which is a disadvantage to wildlife, although the habitat change is likely minimal. Similar to Alternative 1, hatchery operations under Alternative 4 would not affect the minimal potential for mortality or lost breeding opportunities by amphibians from pond activity or entrapment in fish screens and other exclusionary devices.

4.5.4 Predator-prey Relationships between Wildlife and Salmon and Steelhead

This subsection focuses on predator-prey relationships between salmon and steelhead and individual wildlife species or groups of wildlife species, and is based on changes in the number of hatchery-origin salmon and steelhead released from hatcheries under the alternatives. As described in Subsection 4.5.1, Introduction, the analysis area for wildlife is the same as the project area as described in Subsection 1.4, Project and Analysis Areas. The analysis conducted in this subsection does not differentiate between hatchery-origin and natural-origin salmon and steelhead because it has not been demonstrated that wildlife differentiate between hatchery-origin and natural-origin salmon and steelhead (Subsection 4.5.2, Methods for Analysis). However, changes in production of hatchery-origin fish under the alternatives may affect wildlife in general (and species or species groups) because the total number of salmon and steelhead available as food sources in the analysis area (including both hatchery-origin and natural-origin fish) may change. Potential changes in overall available salmon and steelhead, based on changes in hatchery production, are analyzed in this subsection.

4.5.4.1 ESA-listed Species

As described in Subsection 3.5.3.1, ESA-listed Species, the ESA-listed species that may be affected by the action alternatives include killer whale and marbled murrelet. Four other ESA-listed species occur in the analysis area, but would not be affected by any of the alternatives (Subsection 3.5.3.1, ESA-listed Species).

4.5.4.1.1 Killer Whale

As described in Subsection 3.5.3.1.1, Killer Whale, the three pods of Southern Resident killer whales occur in the analysis area (Puget Sound), and are most frequently observed from May through December. From January to April, the Southern Resident killer whale is observed outside the analysis area along the coasts of Washington, Oregon, California, and Vancouver Island, as well as within the Straits of Juan de Fuca and Georgia. During their time in the analysis area from May to October, Southern Resident killer whales feed on adult Chinook salmon to a greater extent than on other salmon species (52 to 83 percent of prey remains) (Table 3.5-2) (Hanson et al. 2010). However, in November and December, the species also appears to consume a large proportion of chum salmon (47 percent of prey remains) (Table 3.5-2). The whales are thought to also feed on other salmon species during the remaining months (January through April), although fewer data are available for the period January through early May. Cederholm et al. (2000) state that Southern Resident killer whales have a strong relationship with salmon and steelhead.

As discussed in Subsection 3.5.3.1.1, Killer Whale, Chinook salmon adults originating from the Fraser River that move through the analysis area appear to be eaten in much greater numbers (80 to 90 percent) than Puget Sound-origin Chinook salmon (6 to 14 percent) during summer months in the Strait of Juan de Fuca and the San Juan Islands. However, identification of salmon populations consumed at other times of the year, especially on the outer coast, has not been well defined. Thus, although Puget Sound-origin salmon and steelhead populations are part of the diet of Southern Resident killer whales, their relative importance to the overall diet of Southern Resident killer whales is unknown.

Adult salmon returning from hatchery releases have partially compensated for declines in natural-origin salmon populations and may have benefitted Southern Resident killer whales (Myers 2011). However, there is no evidence that Southern Resident killer whales distinguish between hatchery-origin and natural-origin salmon (NMFS 2008a; Hanson et al. 2010) and the species is believed to exploit a locally available prey base.

As described in Subsection 3.5.3.1.1, Killer Whale, limiting factors affecting Southern Resident killer whales include quantity and quality of prey, disturbance from sound and vessels, exposure to toxic chemicals and oil spills, and loss of critical habitat (which occurs within the analysis area). Threats to the species include deterioration of existing habitat, changes in food availability, exposure to pollutants, and human disturbance. These threats and limiting factors have historically been shown to limit their recovery and affect their health (NMFS 2008a). Changes to exposure of toxic contaminants by the Southern Resident killer whales as a result of implementing the alternatives is described in Subsection 4.5.3.1, Transfer of Toxic Contaminants and Pathogens. Changes in hatchery production, as would occur under the action alternatives, would affect the Southern Resident killer whales' food supply but would not affect other limiting factors and threats specific to the Southern Resident killer whale as described in Subsection 3.5.3.1.1, Killer Whale, which include disturbance from sound and vessels, presence of toxic chemicals in the analysis area, habitat deterioration, human disturbance, and the potential for oil spills. As a result, these limiting factors are not discussed in the alternative comparison below. Critical habitat features that would not be affected by the alternatives include water quality and passage conditions.

Alternative 1 (No Action). The effects of Alternative 1 would be the same as those occurring under existing conditions. Alternative 1 would not alter or affect the quantity or quality of Southern Resident killer whale prey, or result in loss of critical habitat compared to existing conditions. Alternative 1 would not affect the Southern Residents' existing habitat or change the availability of food for the species compared to existing conditions. Under Alternative 1, the three pods of Southern Resident killer whale would be expected to continue to inhabit the analysis area from May through December as described under existing conditions (Subsection 3.5.3.1.1, Killer Whale). The species would be expected to continue to feed primarily on Chinook salmon (such as the locally abundant Fraser River Chinook salmon) from May to September, and to a lesser degree, chum salmon, as described in Subsection 3.5.3.1.1, Killer Whale. Alternative 1 would not affect critical habitat of the Southern Resident killer whale in the analysis area.

Alternative 2 (Proposed Action). Operation of hatchery facilities and their production of Chinook salmon, other salmon, and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, effects to Southern Resident killer whales under Alternative 2 would be the same as under Alternative 1. Alternative 2 would not affect the Southern Resident killer whales' existing habitat or change the availability of food for the species compared to Alternative 1. Under Alternative 2, the three pods of Southern Resident killer whale would be expected to continue to inhabit the analysis area from May through December as described under Alternative 1. Under Alternative 2, the species would be expected to continue to feed primarily on Chinook salmon (such as the locally-abundant Fraser River Chinook salmon) from May to September, and to a lesser degree, chum salmon as described in Subsection 3.5.3.1.1, Killer Whale. As under Alternative 1, Alternative 2 would not affect critical habitat of the Southern Resident killer whale in the analysis area.

Alternative 3 (Reduced Production). Compared to Alternative 1, Alternative 3 would not result in changes to hatchery operations but would result in an 18 percent decrease of Chinook salmon hatchery production, which would reduce the total number of natural-origin and hatchery-origin adult Chinook salmon returning to Puget Sound by 13 percent, or 40,000 fish (Table 4.5-1). In addition, under Alternative 3, the total number of juvenile hatchery-origin salmon and steelhead released would be reduced overall by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the number of adult hatchery-origin salmon and steelhead would be fewer under Alternative 3 compared to Alternative 1, thereby reducing the number of salmon available as prey to Southern Resident killer whales. The magnitude of reductions in available prey in any given year would depend on many factors, including the origins and numbers of other available salmon species and survival of hatchery-origin releases to adulthood. Large numbers of Fraser River-origin adult Chinook salmon would continue to pass through Puget Sound from May to October and be consumed by the three pods of Southern Resident killer whale as described in Subsection 3.5.3.1.1, Killer Whale.

Under Alternative 3, reduced availability of hatchery-origin prey would pose an increased risk to Southern Resident killer whales, compared to Alternative 1, by reducing its prey base, which is considered a limiting factor for the species and is also a biological feature of its critical habitat (71 Fed. Reg. 69054, November 29, 2006). However, the extent of this risk in the context of other limiting factors and threats as described in Subsection 3.5.3.1.1, Killer Whale (i.e., disturbance from sound and vessels, exposure to toxic chemicals, oil spills, human disturbance, and habitat deterioration), and the assumed continued availability of Fraser River Chinook salmon as food (which are a primary prey item during 6 months of the year) (Table 3.5-2), is unknown.

It is expected that the overall reduction in total Chinook salmon prey available to Southern Resident killer whales under Alternative 3, compared to Alternative 1, would likely be smaller than that reflected by the 13 percent reduction in adult Chinook salmon returns shown in Table 4.5-1, based on the continued supply of Fraser River salmon, as well as salmon from other areas outside of Puget Sound. Thus, Alternative 3 may not produce a noticeable change in distribution of the three pods and abundance of killer whales in the context of existing threats and their inherently variable prey base in Puget Sound compared to Alternative 1, which reflects the availability of salmon and steelhead from many different populations originating within and outside the analysis area. Because the Southern Resident killer whales' critical habitat is defined to include prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development (Subsection 3.5.3.1.1, Killer Whale), Alternative 3 may affect the Southern Resident killer whales' critical habitat because fewer fish would be available as food, although the extent of this effect in comparison to other limiting factors, threats, and critical habitat features is unknown.

In summary, the importance of and impact to the whales' overall diet of prey composed of adult salmon from reduced hatchery production under Alternative 3 is difficult to assess without more detailed information on the proportion of salmon and steelhead prey originating from within the analysis area relative to the proportion originating from outside the analysis area, and the proportions of prey of natural-origin and hatchery-origin salmon and steelhead (available information is described in Subsection 3.5.3.1.1, Killer Whale). Finally, under Alternative 3, Southern Resident killer whales would likely feed on a higher proportion of natural-origin Chinook salmon adults than under Alternative 1 because the availability of hatchery-origin Chinook salmon would be reduced.

Alternative 4 (Increased Production). Compared to Alternative 1, hatchery production would increase by 13 percent under Alternative 4, which would increase the total number of natural-origin and hatchery-origin adult Chinook salmon returning to Puget Sound by 11 percent, or 33,000 fish (Table 4.5-1). In addition, under Alternative 4, the total number of juvenile hatchery-origin salmon and steelhead released would increase overall by 16 percent. Thus, the number of hatchery-origin salmon and steelhead would be greater under Alternative 4 compared to Alternative 1. The increases in hatchery production may translate into more prey for Southern Resident killer whales, in particular from increases in adult Chinook salmon, which would benefit the species because a limiting factor for the Southern Resident killer whale is the quantity of its prey (NMFS 2008a). However, the magnitude of increases in available prey in any given year would depend on many factors, including the origin and numbers of salmon species available and survival of hatchery-origin releases to adulthood.

As described above, large numbers of adult Chinook salmon entering Puget Sound that originate in the Fraser River or other areas outside of Puget Sound would temper the beneficial impacts to killer whale diets from increases in Puget Sound hatchery-origin fish (Table 3.5-2). Thus, as under Alternative 3, the importance to the whales' overall diet of adult prey returning from increased hatchery production under Alternative 4 is difficult to assess without more detailed information on the proportion of salmon and steelhead originating from within the analysis area relative to the proportion originating from outside the analysis area.

Under Alternative 4, increased availability of hatchery-origin prey would likely benefit Southern Resident killer whales compared to Alternative 1, by increasing its food base. However, the extent of this benefit in the context of other limiting factors and existing threats as described in Subsection 3.5.3.1.1, Killer Whale (i.e., disturbance from sound and vessels, exposure to toxic chemicals, oil spills, human disturbance, and habitat deterioration), and the assumed continued availability of Fraser River Chinook salmon (which are a primary prey item during 6 months of the year) (Table 3.5-2), is unknown.

It is expected that the overall increase in total Chinook salmon prey available to Southern Resident killer whales under Alternative 4, compared to Alternative 1, would likely be smaller than that reflected by the 11 percent increase in adult Chinook salmon returns attributable to Alternative 4 as shown in Table 4.5-1, based on the continued supply of Fraser River salmon, as well as salmon from other areas outside of Puget Sound. Thus, Alternative 4 may not produce a noticeable change in the health, distribution of the three pods, and abundance of killer whales in the context of existing threats and their inherently variable prey base in Puget Sound compared to Alternative 1, which reflects the availability of salmon and steelhead from many different populations originating within and outside the analysis area.

Compared to Alternative 1, yearling fall-run Chinook salmon hatchery production (delayed release) under Alternative 4 would increase 114 percent, from about 2.5 million to about 5.4 million (Table 4.2-5). These releases may result in increased numbers of hatchery-origin Chinook salmon that remain in Puget Sound and may rear to sexual maturity rather than migrating into the ocean (i.e., resident Chinook salmon) (Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon). Because of their longer exposure to the degraded marine waters of Puget Sound, these fish would be expected to accumulate more toxic contaminants in their bodies than hatchery-origin and natural-origin fish that rear in the ocean (Subsection 3.5.2.1, Transfer of Toxic Contaminants and Pathogens). Although survival after release is generally low and the fish are smaller in size than their ocean-going counterparts (Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon), to the extent these fish survive and are eaten by

Southern Resident killer whales, Alternative 4 may pose a greater risk of toxic contaminant transfer to killer whales than Alternative 1.

In summary, the importance of and impact to the whales' overall diet of prey composed of adult salmon from increased hatchery production under Alternative 4 is difficult to assess without more detailed information on the proportion of salmon and steelhead prey originating from within the analysis area relative to the proportion originating from outside the analysis area (such as Fraser River salmon), and the proportions of natural-origin and hatchery-origin salmon prey (data limitations are described in Subsection 3.5.3.1.1, Killer Whale). Under Alternative 4, Southern Resident killer whales would likely feed on a smaller proportion of natural-origin Chinook salmon adults than under Alternative 1, because of increased availability of hatchery-origin Chinook salmon. Because Alternative 4 may increase the food supply for the Southern Resident killer whale, Alternative 4 may benefit the species' critical habitat. Its critical habitat is defined to include prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development (Subsection 3.5.3.1.1, Killer Whale).

4.5.4.1.2 Marbled Murrelet

As described in Subsection 3.5.3.1.2, Marbled Murrelet, this seabird species occurs year-round in the analysis area, and its breeding distribution is likely limited because of distance to suitable nesting habitat. Critical habitat for the marbled murrelet occurs on forested land that surrounds Puget Sound (the analysis area), but does not include marine or fresh water (61 Fed. Reg. 26256, May 24, 1996[2]). The marbled murrelet is an opportunistic feeder that consumes a diverse prey base in marine habitats. The species has been found to feed on juvenile salmon only in freshwater lakes primarily in British Columbia and Alaska, and salmon were not a primary prey component (Carter and Sealy 1986). Although Cederholm et al. (2000) state that marbled murrelets have a recurrent relationship with salmon and steelhead, there is no evidence that suggests a relationship with salmon or steelhead in the analysis area. As a result, and as summarized in Subsection 3.5.3.1.2, Marbled Murrelet, these birds do not likely benefit from hatchery-origin salmon and steelhead releases in the analysis area, and are not analyzed further.

[2] The critical habitat designation for marbled murrelet was subsequently revised (76 Fed. Reg. 61599, October 5, 2011), reducing the area of critical habitat designated in southern Oregon and California, but made no changes to critical habitat in Washington.

4.5.4.2 Non-listed Species - Birds

Many of the avian predators on fish described in Subsection 3.5.3.2, Non-listed Species - Birds, have relationships with salmon and steelhead that are considered either strong or recurrent, as defined by Cederholm et al. (2000) and shown in Table 3.5-3. Bald eagles, osprey, common merganser, and Caspian terns have strong relationships with salmon and steelhead. Other species described under Subsection 3.5.3.2, Non-listed Species - Birds, have a recurrent relationship with salmon and steelhead. The species described in Subsection 3.5.3.2, Non-listed Species - Birds, are analyzed below to illustrate expected impacts associated with each alternative.

4.5.4.2.1 Bald Eagle

As described in Subsection 3.5.3.2.1, Bald Eagle, this species is resident year-round in the analysis area, and numbers increase in winter months as non-breeding individuals from the north arrive to feed on adult salmon and steelhead in Puget Sound rivers. Bald eagles target salmon carcasses during the winter months and, during this time period, have a strong relationship with salmon and steelhead (Cederholm et al. 2000). Spawning chum salmon are the preferred prey resource of overwintering resident and migrant bald eagles in the analysis area because of its timing and concentration of carcasses. Other salmon carcasses (coho salmon and steelhead) may be eaten in late winter or spring. Overwintering bald eagles in the analysis area move among river systems in response to returns of adult salmon and steelhead to spawning areas. Bald eagle distribution and abundance are variable within a winter season and from year to year. As described in Subsection 3.5.3.2.1, Bald Eagle, bald eagles in the analysis area do not appear to target salmon and steelhead when the birds are nesting.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of salmon and steelhead prey for bald eagles or alter its wintering distribution compared to existing conditions. Bald eagles would continue to move among rivers in the analysis area to exploit locally available salmon and steelhead carcasses, particularly chum salmon because of its timing and concentration of carcasses during winter months (and to a lesser degree coho salmon and steelhead in late winter and spring). Similar to existing conditions, Alternative 1 would have no effect on nesting bald eagles because they do not target salmon and steelhead during the nesting season. Alternative 1 would not affect bald eagle distribution at any time of the year or its abundance as compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of salmon and steelhead prey for bald eagles or alter its wintering distribution compared to existing conditions. Under Alternative 2, bald eagles would continue to move among rivers in the analysis area to exploit locally available salmon and steelhead carcasses, particularly chum salmon because of its timing and concentration of carcasses during winter months (and to a lesser degree coho salmon and steelhead in late winter and spring). Similar to Alternative 1, Alternative 2 would have no effect on nesting bald eagles because they do not target salmon and steelhead during the nesting season. Alternative 2 would not affect bald eagle distribution at any time of the year or its abundance.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of adult hatchery-origin salmon and steelhead as prey for bald eagles would be expected to decrease in the analysis area. The magnitude of the effect of reductions in hatchery production on the adult salmon and steelhead prey base for bald eagles would depend on many factors, including the survival of hatchery-origin releases to adulthood, availability of salmon and steelhead carcasses at hatcheries, and hatchery policies and procedures regarding the distribution of carcasses from hatcheries into streams.

Reductions in the number of hatchery-origin adult salmon and steelhead returns to Puget Sound could affect the number of spawning salmon and steelhead, as well as the number of salmon and steelhead carcasses placed in streams by hatchery operators, as described in Subsection 3.5.2.3, Nutrients from Salmon and Steelhead Carcasses, which could affect the food base for wintering bald eagles. Reductions in the numbers of salmon and steelhead carcasses may result in bald eagles moving elsewhere in search of alternate or more abundant prey, thereby affecting bald eagle distribution during winter months.

Overall, however, abundance and movements of wintering bald eagles in the analysis area may depend on the availability of the carcasses of its primary prey species, chum salmon, as described by Stinson et al. (2007), because of its timing and concentration of carcasses, and to a lesser extent coho salmon and steelhead. Hatchery production of chum salmon is only expected to decrease by 1 percent under Alternative 3 compared to Alternative 1 (Table 2.4-1). The decrease in hatchery production would not affect chum salmon timing of spawning, and would have a negligible effect on the concentration of chum salmon carcasses. Thus, compared to Alternative 1, the availability of salmon and steelhead prey in winter would change under Alternative 3, but changes would likely be too small to affect overall bald eagle distribution and abundance in the analysis area compared to Alternative 1, given the inherent variability in bald eagle winter abundance and distribution. Similar to Alternative 1, Alternative 3 would have no effect on nesting bald eagles because they do not target salmon and steelhead when nesting.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of adult hatchery-origin salmon and steelhead as prey for bald eagles would be expected to increase in the analysis area. The magnitude of the effect of increases in hatchery production on the adult salmon and steelhead prey base for bald eagles would depend on many factors, including the survival of hatchery-origin releases to adulthood, availability of salmon and steelhead carcasses at hatcheries, and hatchery policies and procedures regarding the distribution of carcasses from hatcheries into streams.

Increases in the number of hatchery-origin adult salmon and steelhead returns to Puget Sound could affect the number of spawning salmon and steelhead and their carcasses placed in streams by hatchery operators as described in Subsection 3.5.2.3, Nutrients from Salmon and Steelhead Carcasses, and thereby affect the food supply of wintering bald eagles. Under Alternative 4, there would be a 28 percent increase in hatchery production of chum salmon compared to Alternative 1 (Table 2.4-1). Chum salmon are the salmon species primarily consumed by bald eagles because of their timing and concentration of carcasses (Stinson et al. 2007), and represent the largest biomass of carcasses in Puget Sound (49 percent) (Table 3.2-2).

The Alternative 4 increases in hatchery production with resulting increases in the number of carcasses distributed to Puget Sound streams may attract larger numbers of bald eagles to local salmon and steelhead streams, thereby affecting their local distribution and abundance during winter months as compared to Alternative 1. Thus, under Alternative 4, the likely increased availability of salmon and steelhead prey during winter months would benefit the food supply of bald eagles compared to Alternative 1, and may affect local winter presence in some streams, given the inherent variability in bald eagle winter abundance and distribution. Similar to Alternative 1, Alternative 4 would have no effect on nesting bald eagles because they do not target salmon and steelhead when nesting.

4.5.4.2.2 Osprey

As described in Subsection 3.5.3.2.2, Osprey, this species occurs in the analysis area during the breeding season where they nest near freshwater and marine habitats with suitable foraging areas. Osprey is a state monitor species in the analysis area (Subsection 3.5.3.2.2, Osprey). Osprey consume almost exclusively live surface-schooling or benthic fish that occur in shallows within a few feet of the surface (Poole et al. 2002). Prey is opportunistically selected based on abundance or availability (Vana-Miller 1987), and thus osprey would be expected to target easily-obtained prey in the vicinity of their nests. Osprey may feed on a variety of fish species, but, in some locations, can feed primarily on salmon (Lind 1976; Hughes 1983; Steeger et al. 1992). Two or three common fish species may dominate the diet of local ospreys in a given area (Poole 1989; Poole et al. 2002). Cederholm et al. (2000) consider osprey as having a strong relationship with juvenile and adult salmon and steelhead.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of juvenile and adult salmon and steelhead prey for nesting osprey, affect its distribution or selection of nesting areas, or alter its abundance compared to existing conditions. Osprey would continue to nest near freshwater and marine habitats with suitable foraging areas.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of juvenile and adult salmon and steelhead prey for nesting osprey, affect its distribution or selection of nesting areas, or alter its abundance compared to existing conditions. Under Alternative 2, osprey would continue to nest near freshwater and marine habitats with suitable foraging areas as described under Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead as prey for osprey would be expected to decrease in the analysis area. The magnitude of the effect of reductions of hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As described in Subsection 3.5.3.2.2, Osprey, fish are the primary prey of osprey and are selected based on their abundance or availability (Vana-Miller 1987). Osprey occur in the analysis area during the breeding season. Under Alternative 3, osprey would target easily obtained prey in the vicinity of their nests and would continue to feed on a variety of fish species, but in some locations, may feed primarily on salmon (Lind 1976; Hughes 1983; Steeger et al. 1992) as described under Subsection 3.5.3.2.2, Osprey. Although osprey are generally opportunistic and have been documented to feed on more than 80 different fish species, two or three common species can dominate the diet of ospreys in a given area (Poole 1989; Poole et al. 2002). Thus, compared to Alternative 1, it is possible that a decrease in hatchery production under Alternative 3 may affect the diet of nesting ospreys at specific locations where the species feeds primarily on salmon and steelhead. Under Alternative 3, these birds would be expected to continue to feed on salmon and steelhead, but the proportion of other fish species in their diet may increase to compensate for any decrease in salmon and steelhead compared to Alternative 1.

In summary, under Alternative 3, osprey would not be expected to alter their distribution or abundance in the analysis area compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult salmon and steelhead as prey for osprey would be expected to increase in the analysis area. The magnitude of the effect of increases in hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As described in Subsection 3.5.3.2.2, Osprey, fish are the primary prey of osprey and are selected based on abundance or availability (Vana-Miller 1987). Osprey occur in the analysis area during the breeding season. Under Alternative 4, osprey would target easily obtained prey in the vicinity of their nests and would continue to feed on a variety of fish species, but in some locations, may feed primarily on salmon (Lind 1976; Hughes 1983; Steeger et al. 1992) as described under Alternative 1. Although osprey are generally opportunistic and have been documented to feed on more than 80 different fish species, two or three common species can dominate the diet of ospreys in a given area (Poole 1989; Poole et al. 2002). An increase in hatchery production, as would occur under Alternative 4, may affect the diet of nesting ospreys at specific locations compared to Alternative 1. Under Alternative 4, these birds would be expected to continue to feed on salmon and steelhead, and may additionally decrease the proportion of other fish species in their diet because of the increased abundance of salmon and steelhead when compared to Alternative 1.

In summary, under Alternative 4, osprey in the analysis area would not be expected to alter their distribution or abundance in the analysis area compared to Alternative 1.

4.5.4.2.3 Harlequin Duck

As described in Subsection 3.5.3.2.3, Harlequin Duck, the harlequin duck is an uncommon migratory species that breeds in fast-flowing mountain streams. Its prey primarily consists of aquatic insects, although alevins and salmon and steelhead eggs are also eaten (Robertson and Goudie 1999; Lewis and Kraege 2004). Their winter range includes inland marine waters and rocky coastal areas where their prey is primarily benthic invertebrates (Vermeer 1983; Gaines and Fitzner 1987). In late summer and early fall, once salmon spawn, harlequins commonly feed at creek mouths where their diet includes alevins and salmon eggs (Rosenberg and Rothe 2007). Cederholm et al. (2000) consider harlequin ducks as having a strong relationship with salmon and steelhead based on their consumption of salmon eggs and juvenile salmon at specific times of the year.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. Hatchery releases do not include salmon alevins or eggs. As a result, Alternative 1 would not change the availability of salmon and steelhead alevins or eggs for consumption by the harlequin duck, affect its distribution or wintering locations when it feeds on alevins and eggs, or alter its overall abundance compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under existing conditions. Hatchery releases do not include salmon alevins or eggs. As a result, Alternative 2 would not change the availability of salmon and steelhead alevins or eggs for consumption by the harlequin duck, affect its distribution or wintering locations when it feeds on alevins and eggs, or alter its overall abundance compared to existing conditions.

Alternative 3 (Reduced Production). Although hatchery production of salmon and steelhead under Alternative 3 would be reduced, hatchery releases do not include salmon alevins or eggs. As a result, Alternative 3 would not change the availability of salmon and steelhead alevins or eggs for consumption by the harlequin duck, affect its distribution or wintering locations when it feeds on alevins and eggs, or alter its overall abundance compared to existing conditions.

Alternative 4 (Increased Production). Although hatchery production of salmon and steelhead under Alternative 4 would be increased, hatchery releases do not include salmon alevins or eggs. As a result, Alternative 4 would not change the availability of salmon and steelhead alevins or eggs for consumption by the harlequin duck, affect its distribution or wintering locations when it feeds on alevins and eggs, or alter its overall abundance compared to existing conditions.

4.5.4.2.4 Common Merganser

As described in Subsection 3.5.3.2.4, Common Merganser, this species is a common year-round resident, and has a strong relationship with salmon and steelhead. Common mergansers prey on salmon and steelhead eggs and juveniles (Cederholm et al. 2000) in both marine and freshwater aquatic habitats, and some studies have demonstrated the importance of salmon and steelhead as prey to young common mergansers.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. Hatchery releases do not include salmon or steelhead eggs. As a result, Alternative 1 would not change the availability of juvenile salmon and steelhead prey or salmon and steelhead eggs for the common merganser, affect its distribution or nesting locations, or alter its local abundance compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. Hatchery releases do not include salmon or steelhead eggs. As a result, Alternative 2 would not change the availability of juvenile salmon and steelhead prey or salmon and steelhead eggs for the common merganser, affect its distribution or nesting locations, or alter its prey base compared to Alternative 1.

Alternative 3 (Reduced Production). Under Alternative 3, overall hatchery production of salmon and steelhead would decrease by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of out-migrating juvenile hatchery-origin salmon and steelhead as prey for common mergansers would be expected to decrease in the analysis area. Similarly, decreased hatchery production would result in decreased numbers of returning hatchery-origin adults spawning naturally. The magnitude of the effect of reductions of juvenile hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases. Hatchery releases do not include salmon and steelhead eggs.

Under Alternative 3, the reduction in hatchery production would affect the juvenile salmon and steelhead prey base of common mergansers, which may affect some individuals raising young. However, hatchery production under Alternative 3 would not affect the number of salmon and steelhead eggs available to common mergansers as described under Alternative 1, except for reduced numbers of juveniles and eggs that would result from reduced numbers of hatchery-origin adults that would spawn naturally.

To compensate for the reduced number of juvenile salmon and steelhead prey, these individuals would be expected to feed more on fish other than salmon and steelhead. However, reduced hatchery production under Alternative 3 would not be expected to alter common mergansers' overall distribution, nesting locations, or abundance as compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile salmon and steelhead as prey for common mergansers would be expected to increase in the analysis area. Similarly, increased hatchery production would result in increased numbers of returning hatchery-origin adults that may spawn naturally. The magnitude of the effect of increases in hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases. Hatchery releases do not include salmon and steelhead eggs.

Under Alternative 4, the increase in hatchery production would affect the juvenile salmon and steelhead prey base of common mergansers, which may benefit some individuals raising young. However, hatchery production would not affect the number of salmon and steelhead eggs as described under Alternative 1, except for increased numbers of juveniles and eggs that would result from increased numbers of returning hatchery-origin adults that would spawn naturally.

The increased number of juvenile salmon and steelhead prey may result in common mergansers increasing the amount of salmon and steelhead consumed and decreasing their effort expended in searching for an adequate food supply, particularly to feed their young. However, the hatchery production increases under Alternative 4 would not be expected to alter common mergansers' overall distribution, nesting locations, or abundance compared to Alternative 1.

4.5.4.2.5 Caspian Tern

As described in Subsection 3.5.3.2.5, Caspian Tern, the occurrence of Caspian terns is uncommon and variable in the analysis area, but the species historically has had nesting colonies in this area. The species feeds almost exclusively on fish, and is opportunistic in its response to prey abundance and availability. The diet of terns that nested in two historical colonies in the analysis area included juvenile Chinook salmon, coho salmon, and other marine fish.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of juvenile salmon and steelhead prey for Caspian terns or affect their distribution or abundance in the analysis area compared to existing conditions. Alternative 1 would not affect selection or use of nesting colonies in the analysis area compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of juvenile salmon and steelhead prey for Caspian terns or affect their distribution or abundance in the analysis area compared to Alternative 1. Alternative 2 would not affect selection or use of nesting colonies in the analysis area compared to Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of out-migrating hatchery-origin salmon and steelhead as prey for Caspian terns would be expected to decrease in the analysis area.

As described in Subsection 3.5.3.2.5, Caspian Tern, the occurrence of Caspian terns is uncommon in the analysis area, but when present they have been recorded as preying on juvenile salmon and steelhead, including hatchery-origin fish, as well as other marine fish. It is possible that a decrease in hatchery production under Alternative 3 may affect the diet of nesting Caspian terns at specific breeding colonies compared to Alternative 1. Under Alternative 3, these birds would be expected to continue to feed on salmon and steelhead, but additionally increase the proportion of other fish species in their diet to compensate for any decrease in salmon and steelhead as compared to Alternative 1.

In summary, under Alternative 3, Caspian terns in the analysis area would not be expected to alter their distribution or their selection and use of nesting colonies in the analysis area as compared to Alternative 1. Alternative 3 would not be expected to affect their overall abundance compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile salmon and steelhead as prey for Caspian terns would be expected to increase in the analysis area. The magnitude of the effect of increases in hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases.

An increase in hatchery production under Alternative 4 may affect the diet of nesting Caspian terns at specific locations compared to Alternative 1. Under Alternative 4, these birds would be expected to continue to feed on juvenile salmon and steelhead, and may additionally decrease the proportion of other fish species in their diet because of the increased abundance of salmon and steelhead as compared to Alternative 1.

In summary, under Alternative 4, Caspian terns in the analysis area would not be expected to alter their distribution or selection and use of nesting colonies in the analysis area as compared to Alternative 1. Alternative 4 would not be expected to affect their overall abundance as compared to Alternative 1.

4.5.4.2.6 Other Birds

This subsection describes the effects of the alternatives for those other bird species that have a recurrent relationship (as described in Subsection 3.5.1, Introduction [Wildlife]) with salmon and steelhead. These species generally prey on salmon and steelhead (including eggs and all juvenile life stages) and their carcasses when and where locally available within the analysis area, but are not dependent on salmon and steelhead as their primary source of food. Most of these species and groups of species, described in Subsection 3.5.3.2.6, Other Birds, are common in the analysis area, although some species are state monitor, candidate, or sensitive species (Table 3.5-3). These species are grouped together in this analysis because effects from changes in hatchery operations and production would be expected to be the same for all birds with a recurrent relationship with salmon and steelhead.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability and distribution of juvenile salmon and steelhead prey for avian predators and salmon and steelhead carcasses compared to existing conditions. The amount of salmon and steelhead eggs available for consumption by other birds would remain unchanged under Alternative 1 because hatcheries do not release salmon and steelhead eggs, and the number of eggs from returning hatchery-origin adults spawning naturally would be the same as existing conditions. Alternative 1 would not affect the distribution or abundance of these birds, including the locations of their breeding and wintering areas as compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability and distribution of juvenile salmon and steelhead prey for avian predators and salmon and steelhead carcasses compared to Alternative 1. Under Alternative 2, the amount of salmon and steelhead eggs available for consumption by other birds would be the same as Alternative 1 because hatcheries do not release salmon and steelhead eggs, and the number of eggs from returning hatchery-origin adults spawning naturally would be the same as under Alternative 1. Alternative 2 would not affect the distribution or abundance of these birds, including their breeding and wintering areas as compared to Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile hatchery-origin salmon and steelhead and their carcasses as food for other birds would be expected to decrease in the analysis area under Alternative 3. Similarly, decreased hatchery production under Alternative 3 would result in decreased numbers of returning hatchery-origin adults spawning naturally compared to Alternative 1. The magnitude of the effect of reductions of juvenile hatchery-origin fish on the overall salmon and steelhead prey base for avian predators in any given year would depend on many factors, including the survival of hatchery-origin releases as they out-migrate through freshwater and estuarine systems and move into the nearshore marine environment. Hatchery releases do not include salmon and steelhead eggs.

Most of the other birds that are avian predators (described in Table 3.5-3) prey on juvenile salmon and steelhead and their carcasses when the prey are seasonally concentrated and easily accessible, as described in Subsection 3.5.3.2.6, Other Birds. These avian predators have a wide prey base, and would not be substantially affected by a reduction in hatchery production under Alternative 3 compared to Alternative 1. Based on available information on the diets of these avian predators, as described in Subsection 3.5.3.2.6, Other Birds, these species would likely increase their consumption of other prey species under Alternative 3 as compared to Alternative 1. Hatchery production under Alternative 3 would not affect the number of salmon and steelhead eggs available to other birds as described under Alternative 1, except that under Alternative 3, reduced numbers of juveniles and eggs would result from reduced numbers of returning hatchery-origin adults that would spawn naturally, compared to Alternative 1.

If salmon and steelhead are more than a minor component of the diet of other birds, their foraging range would be expected to reflect local and seasonal availability of salmon and steelhead. Because it has not been shown that the distribution or abundance of these birds is limited by, or dependent on, salmon and steelhead availability, the reduction in hatchery production under Alternative 3 would not be expected to affect the overall distribution or abundance of other bird species in the analysis area compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of adult and juvenile hatchery-origin salmon and steelhead and their carcasses as food for other birds would be expected to increase in the analysis area under Alternative 4. Similarly, increased hatchery production under Alternative 4 would result in increased numbers of returning hatchery-origin adults spawning naturally compared to Alternative 1. The magnitude of the effect of increases in juvenile hatchery-origin fish on the overall salmon and steelhead prey base for avian predators in any given year would depend on many factors, including the survival of hatchery-origin releases as they out-migrate through freshwater and estuarine systems and move into the nearshore marine environment. Hatchery releases do not include salmon and steelhead eggs.

Avian predators described in Table 3.5-3 prey on salmon and steelhead eggs and juveniles, as well as salmon and steelhead carcasses, when prey are seasonally concentrated and easily accessible, as described in Subsection 3.5.3.2.6, Other Birds. Based on available information on the diets of other birds as described in Subsection 3.5.3.2.6, Other Birds, an increased food supply of salmon and steelhead under Alternative 4 would likely increase their consumption of juvenile salmon and steelhead and their adult carcasses, and decrease their consumption of other prey as compared to Alternative 1. However, the overall increase in salmon and steelhead hatchery production under Alternative 4 would not be expected to affect the distribution or abundance of avian predators in the analysis area, compared to Alternative 1.

4.5.4.3 Non-listed Species - Marine Mammals

Steller sea lion, California sea lion, and harbor seal are common in the analysis area, as described in Subsection 3.5.3.3, Non-listed Species - Marine Mammals. Steller sea lions, California sea lions, and harbor seals prey on salmon and steelhead in the analysis area, but most diet studies have demonstrated a wide range of prey species without a strong preference for salmon and steelhead. Cederholm et al. (2000) consider all three species as having a recurrent relationship with salmon and steelhead. All three species are attracted to salmon and steelhead in local areas at specific times of the year when the fish are present, such as Lake Washington steelhead at the Ballard Locks in Seattle, but otherwise forage in a variety of habitats in the analysis area.

4.5.4.3.1 Steller Sea Lion

As described in Subsection 3.5.3.3.1, Steller Sea Lion, the eastern stock of Steller sea lions is resident year-round in the analysis area and is most abundant in the fall and winter months. The eastern stock of Steller sea lion is no longer listed under the ESA as threatened, and critical habitat for the Steller sea lion does not occur in Puget Sound; thus, critical habitat for Stellar sea lions is not considered further in this EIS. Threats to the Steller sea lion (NMFS 2014) (Subsection 3.5.3.3.1, Steller Sea Lion) are not associated with hatcheries or hatchery releases.

Steller sea lions are opportunistic foragers with a very broad prey base, and have not been strongly associated with salmon and steelhead, with the exception of their recent increasing predation on salmon and steelhead in the tailrace of Bonneville Dam in the Columbia River (Stansell et al. 2012). The diet of Steller sea lions in the analysis area is not well documented, but studies have shown that they are opportunistic in prey selection and consume Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, all species of salmon and steelhead, octopus, and lamprey (COSEWIC 2003; NMFS 2008b; Jeffries 2011). Feeding on salmon and steelhead appears to be greatest in the fall months, as shown in one study near the analysis area (Jeffries 2011; Pearson and Jeffries 2012). There is no evidence that Steller sea lions' distribution in Puget Sound is limited by or dependent on a specific prey population or a specific location. The species is believed to include salmon as part of its diet depending on availability, detectability, and ease of capture, and Steller sea lions appear to feed more on adult salmon and steelhead. Cederholm et al. (2000) state that the Steller sea lion has a recurrent relationship with salmon and steelhead.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of salmon and steelhead prey for Steller sea lions compared to existing conditions. Steller sea lions would continue to opportunistically feed on a wide variety of fish species (Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, all species of salmon and steelhead, octopus, and lamprey). Steller sea lions would continue to feed on all species of salmon and steelhead (mostly adults) based on availability, detectability, and ease of capture, particularly during the fall months when they may prey more on salmon and steelhead than during other months of the year (Jeffries 2011; Pearson and Jeffries 2012). The species would be expected to have a similar distribution, abundance, and opportunistic feeding behavior as described under existing conditions (Subsection 3.5.3.3.1, Steller Sea Lion). Steller sea lions would be expected to use the same haulouts as currently occur in the analysis area.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of salmon and steelhead prey for Steller sea lions compared to Alternative 1. Under Alternative 2, Steller sea lions would continue to feed on a wide variety of fish species (Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, all species of salmon and steelhead, octopus, and lamprey) as described under Alternative 1. Under Alternative 2, Steller sea lions would continue to feed on all species of salmon and steelhead (mostly adults) based on availability, detectability, and ease of capture, as described under Alternative 1, including during the fall months when they may prey more on salmon and steelhead than during other months of the year (Jeffries 2011; Pearson and Jeffries 2012). Under Alternative 2, the species would be expected to have a similar distribution, abundance, and opportunistic feeding behavior as described under Alternative 1. Under Alternative 2, Steller sea lions would be expected to use the same haulouts as described under Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead as prey for Steller sea lions would be expected to decrease in the analysis area. The magnitude of the effect of reductions of hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As opportunistic feeders, Steller sea lions prey on a variety of fish species, including Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, salmon, steelhead, octopus, and lamprey (COSEWIC 2003; NMFS 2008b; Jeffries 2011). Under Alternative 3, Steller sea lions would continue to feed on all species of salmon and steelhead (mostly adults) based on availability, detectability, and ease of capture as described under Alternative 1.

Although the decrease in hatchery production under Alternative 3 may decrease the amount of salmon and steelhead prey available to Steller sea lions compared to Alternative 1, the species would not be expected to alter its behavior of opportunistically feeding on a wide variety of fish species, but may decrease the total amount of salmon and steelhead in its diet in the analysis area, even during the fall months when it may prey more on salmon and steelhead than other months of the year (Jeffries 2011; Pearson and Jeffries 2012). Under Alternative 3, the species would be expected to have similar distribution and abundance as described under Alternative 1. Steller sea lions would be expected to use the same haulouts as described under Alternative 1.

In summary, Steller sea lions consume a variety of prey species, and prey limitation has not been identified as a current threat to Steller sea lions. Thus, under Alternative 3, Steller sea lions may respond to a reduction in overall availability of adult salmon and steelhead by increasing their consumption of other prey species, but their distribution and abundance in the analysis area is not expected to change compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult salmon and steelhead as prey for Steller sea lions would be expected to increase in the analysis area. The magnitude of the effect of increases in hatchery-origin fish on the overall salmon and steelhead prey base in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As opportunistic feeders, Steller sea lions prey on a variety of fish species, including Pacific whiting, rockfish, eulachon, Pacific hake, anchovy, Pacific herring, staghorn sculpin, salmon, steelhead, octopus, and lamprey (COSEWIC 2003; NMFS 2008b; Jeffries 2011). Under Alternative 4, Steller sea lions would continue to feed on all species of salmon and steelhead (mostly adults), based on availability, detectability, and ease of capture, as described under Alternative 1. Although the increase in hatchery production under Alternative 4 may increase the amount of salmon and steelhead available to Steller sea lions, the species would not be expected to alter its behavior of opportunistically feeding on a wide variety of fish species, but may increase the total amount of salmon and steelhead in its diet in the analysis area, particularly during the fall months when it may prey more on salmon and steelhead than during other months of the year (Jeffries 2011; Pearson and Jeffries 2012). Under Alternative 4, the species would be expected to have similar distribution and abundance as described under Alternative 1. Steller sea lions would be expected to use the same haulouts as described under Alternative 1.

In summary, Steller sea lions consume a variety of prey species, and prey limitation has not been identified as a current threat to Steller sea lions. Thus, under Alternative 4, Steller sea lions may respond to an increase in overall availability of adult salmon and steelhead by increasing their consumption of salmon and steelhead, but their distribution and abundance in the analysis area is not expected to change compared to Alternative 1.

4.5.4.3.2 California Sea Lion

California sea lions are present in the analysis area from early September to late May. As described in Subsection 3.5.3.3.2, California Sea Lion, they are wide-ranging opportunistic foragers, and their distribution has been found to be based on seasonal and local availability of a variety of fish species (such as Pacific whiting, Pacific herring, salmon, and steelhead). A diversity of salmon and steelhead species compose a portion of California sea lion diets in the analysis area depending on location and seasonal availability of various species, but non-salmon and steelhead may compose a larger portion of their diet overall.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not be expected to affect the distribution of the California sea lion in the analysis area, alter its feeding habits, or affect its abundance, foraging areas, or selection and use of haulouts as compared to existing conditions. Under Alternative 1, the California sea lion would continue to consume salmon and steelhead as part of its generalized diet that consists of a wide variety of fish and squid species, because the availability of salmon and steelhead prey would be the same as existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not be expected to affect the presence and distribution of the California sea lion in the analysis area, alter its feeding habits, or affect its abundance, foraging areas, or selection and use of haulouts as compared to Alternative 1. Under Alternative 2, the California sea lion would continue to consume salmon and steelhead as part of its generalized diet of a wide variety of fish and squid species because the availability of salmon and steelhead prey would be the same as Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead to the diet of California sea lions would be expected to decrease in the analysis area. The magnitude of the effect of reductions of hatchery-origin fish on the overall salmon and steelhead prey base for California sea lions in any given year would depend on many factors, including survival of hatchery-origin releases to adulthood.

As described in Subsection 3.5.3.3.2, California Sea Lion, some California sea lions in the analysis area may target salmon and steelhead at specific locations, although these associations occur only when the fish are present. With reduced hatchery production of salmon and steelhead under Alternative 3 compared to Alternative 1, they may shift prey consumption to other more easily available prey species and may also change foraging locations in stream and river mouths affected by hatchery production to areas where local salmon and steelhead availability is not affected. Thus, the diet and distribution of California sea lions in the analysis area may change to some extent under Alternative 3, but changes may be too small to be noticeable given the wide prey base and mobility of this predator.

In summary, because of their opportunistic feeding behavior, negligible effects would be expected to California sea lion distribution, selection, and use of haulouts, or their abundance as a result of reduced numbers of hatchery-origin salmon and steelhead prey in the analysis area under Alternative 3 compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead to the diet of California sea lions would be expected to increase in the analysis area. The magnitude of the effect of increases in the prey base in any given year would depend on many factors, including the survival of hatchery-origin fish releases to adulthood.

As described in Subsection 3.5.3.3.2, California Sea Lion, California sea lions in the analysis area may target salmon and steelhead at specific locations, although these associations would occur only when the fish are present. With an increase in hatchery production of salmon and steelhead under Alternative 4 compared to Alternative 1, the California sea lion diet may temporarily shift toward preying on more salmon and steelhead species, and foraging locations at stream and river mouths may temporarily shift to areas with increased hatchery production. Additionally, foraging by California sea lions on prey species other than salmon and steelhead may be reduced when and where hatchery-origin fish are more abundant. Thus, the diet and distribution of the California sea lion in the analysis area may change to some extent under Alternative 4, but changes may be too small to be noticeable given the wide prey base and mobility of this predator.

In summary, because of its opportunistic feeding behavior, negligible effects would be expected to California sea lion distribution, selection, and use of haulouts, or their abundance as a result of increased numbers of hatchery-origin salmon and steelhead in the analysis area under Alternative 4, compared to Alternative 1.

4.5.4.3.3 Harbor Seal

Harbor seals are year-round residents throughout the analysis area, responding to seasonal availability of many prey fish species, including juvenile and adult salmon and steelhead, as described in Subsection 3.5.3.3.3, Harbor Seal. They are the most abundant, widely distributed marine mammal in the analysis area. Harbor seals frequent areas of local salmon and steelhead abundance when seasonally available, and consume Chinook salmon, coho salmon, chum salmon, pink salmon, and sockeye salmon. Available information does not indicate that they are dependent upon salmon and steelhead, but rather either adult or juvenile salmon and steelhead are targeted in specific areas and specific seasons when available.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability and diversity of salmon and steelhead prey (juveniles and adults) for harbor seals compared to existing conditions. Harbor seals would continue to feed on a wide variety of fish species in the analysis area when seasonally available, and their wide distribution and abundance in the analysis area would not change as a result of Alternative 1. Under Alternative 1, harbor seals would be expected to continue to use haulouts and produce pups at the same sites in the analysis area as described under existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the seasonal availability and diversity of salmon and steelhead prey (juveniles and adults) for harbor seals compared to Alternative 1. Harbor seals would continue to feed on a wide variety of fish species in the analysis area, and their wide distribution and abundance would not change under Alternative 2 as compared to Alternative 1. Harbor seals would be expected to continue to use haulouts and produce pups at the same sites in the analysis area under Alternative 2 as described under Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead to the diet of harbor seals would be expected to decrease in the analysis area. The magnitude of the effect of this reduction of hatchery-origin fish on the overall salmon and steelhead prey base for harbor seals in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As described in Subsection 3.5.3.3.3, Harbor Seal, harbor seals in the analysis area may target salmon and steelhead at specific locations and specific times of the year when juvenile or adult salmon and steelhead are present. With reduced hatchery production of salmon and steelhead under Alternative 3 compared to Alternative 1, foraging locations in stream and river mouths affected by hatchery production may shift to areas where other fish are more readily available for consumption. Thus, the distribution of harbor seals in the analysis area may change slightly under Alternative 3 compared to Alternative 1, but changes may be too small to be noticeable given the wide prey base and mobility of this predator.

In summary, because of their opportunistic feeding behavior, negligible effects would be expected to harbor seal abundance and wide distribution in the analysis area as a result of reduced numbers of hatchery-origin salmon and steelhead in the analysis area compared to Alternative 1, and harbor seals would continue to feed on a wide variety of fish species. Under Alternative 3, harbor seals would be expected to continue to use haulouts and produce pups at the same sites in the analysis area as described under Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and hatchery-origin adult salmon and steelhead to the diet of harbor seals would be expected to increase in the analysis area. The magnitude of the effect of increases in the prey base in any given year would depend on many factors, including the survival of hatchery-origin releases to adulthood.

As described in Subsection 3.5.3.3.3, Harbor Seal, harbor seals in the analysis area may target juvenile or adult salmon and steelhead at specific locations, although these associations would occur only when juvenile or adult salmon and steelhead are present. With an increase in hatchery production of salmon and steelhead under Alternative 4 compared to Alternative 1, harbor seal foraging locations and abundance at stream and river mouths may temporarily shift toward areas with increased hatchery production. Thus, the distribution of harbor seals within the analysis area may shift slightly under Alternative 4 compared to Alternative 1. However, these changes in foraging locations may be too small to be noticeable given the wide prey base and mobility of this predator. Under Alternative 4, the harbor seal would be expected to be abundant and widely distributed as described under Alternative 1.

In summary, because the harbor seal consumes a more generalized prey base and is not dependent on salmon and steelhead, the increased hatchery production under Alternative 4 is not expected to increase the overall abundance of harbor seals in the analysis area compared to Alternative 1. Under Alternative 4, harbor seals would be expected to continue to use haulouts and produce pups at the same sites in the analysis area as described under Alternative 1.

4.5.4.4 Other Non-listed Aquatic and Terrestrial Wildlife

4.5.4.4.1 River Otter and Mink

River otter and mink are abundant, widely distributed predators on fish in freshwater and intertidal habitats in the analysis area year-round. As described in Subsection 3.5.3.4.1, River Otter and Mink, river otters have a strong relationship with, and prey on, juvenile salmon, spawning salmon, and salmon carcasses, whereas mink are more generalist predators that have a recurrent relationship with salmon and steelhead by feeding on juvenile and spawning salmon and steelhead and their carcasses (Table 3.5-5). Trapping of river otters and mink occurs during the winter and fall months in western Washington. The effect of hatchery predator control programs on river otter and mink is described in Subsection 4.5.3.2, Hatchery Predator Control Programs and Weirs.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of juvenile and spawning salmon and steelhead as prey and the availability of their associated carcasses that provide food for river otter and mink compared to existing conditions. Both species would continue to be abundant and widely distributed in the analysis area, and trapping of these species would be expected to occur as described under existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of juvenile and spawning salmon and steelhead prey and the availability of their associated carcasses that provide food for river otter and mink compared to Alternative 1. Both species would continue to be abundant and widely distributed in the analysis area under Alternative 2, and trapping of these species would be expected to occur under Alternative 2 as described under Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and spawning salmon and steelhead and their associated carcasses to the diet of river otter and mink would be expected to decrease in the analysis area compared to Alternative 1. This would result in a decreased prey base for river otter and mink, including a potential reduction in availability of salmon and steelhead carcasses under Alternative 3 as compared to Alternative 1.

Compared to river otter, mink are considered generalist predators and are less closely associated with salmon and steelhead than are river otters. Thus, mink are not expected to experience effects (loss of a food resource) from decreased hatchery production under Alternative 3 compared to Alternative 1. Both species would continue to be abundant and widely distributed in the analysis area, and trapping of these species would be expected to occur as described under Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Thus, the contribution of juvenile and adult hatchery-origin salmon and steelhead to the diet of river otter and mink would be expected to increase in the analysis area compared to Alternative 1. This would increase the juvenile and adult salmon and steelhead prey base for river otter and mink under Alternative 4, as well as the number of carcasses distributed in the analysis area compared to Alternative 1. The magnitude of the effect of the increase in the prey base for river otter and mink would depend on many factors, including the survival of hatchery releases as they out-migrate to the marine environment, their survival after entering the sea, and hatchery policies and protocols regarding placement of hatchery-origin carcasses into streams.

As described in Subsection 3.5.3.4.1, River Otter and Mink, available information on the diets and foraging behavior of river otter in freshwater and marine habitats suggests that under Alternative 4, the effect on this species would occur in streams where both hatchery-origin salmon and steelhead and river otter occur and there is increased hatchery production. Compared to Alternative 1, river otters may have an increased salmon and steelhead food supply under Alternative 4.

Compared to river otter, mink are generalist predators and tend to consume a broader prey base, and thus are less closely associated with salmon and steelhead. Mink may benefit from increased salmon and steelhead availability to some extent. Both species would continue to be abundant and widely distributed in the analysis area. Trapping of these species would be expected to occur under Alternative 4 as described under Alternative 1.

4.5.4.4.2 Amphibians and Reptiles

Two species of amphibians (Pacific giant salamander and Cope's giant salamander) occur in freshwater streams within the analysis area and have a recurrent relationship with salmon and steelhead (Cederholm et al. 2000). Pacific giant salamanders occur in headwater and mid-sized streams primarily west of the Cascade Mountains, while Cope's giant salamanders occur in small streams within the Olympic Peninsula and southwestern Washington (Subsection 3.5.3.4.2, Amphibians and Reptiles). Although the abundance of both species is unknown, their status is considered widespread, abundant, and secure.

As described in Subsection 3.5.3.4.2, Amphibians and Reptiles, Pacific giant salamander and Cope's giant salamander may be predators of salmon and steelhead. However, the importance of salmon and steelhead in the diets of Pacific and Cope's giant salamander larvae is not well known, nor is the extent of competition for similar prey species, the potential for predation on amphibians by salmon and steelhead, and geographic overlap of hatchery-origin juvenile salmon and steelhead with giant salamanders. Changes to exposure of pathogens by amphibians as a result of implementing the alternatives are described in Subsection 4.5.3.1, Transfer of Toxic Contaminants and Pathogens.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not change the availability of salmon and steelhead as potential prey, or the competitors with or predators of Pacific giant salamanders and Cope's giant salamanders compared to existing conditions, based on available information on the recurrent relationship between salmon and steelhead and amphibians (Cederholm et al. 2000). Alternative 1 would not affect the abundance and distribution of Pacific giant salamanders and Cope's giant salamanders compared to existing conditions.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not change the availability of salmon and steelhead as potential prey, or the competitors with or predators of Pacific giant salamanders and Cope's giant salamanders compared to Alternative 1, based on available information on the recurrent relationship between salmon and steelhead and amphibians (Cederholm et al. 2000). Alternative 2 would not affect the abundance and distribution of Pacific giant salamanders and Cope's giant salamanders compared to Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). To the extent hatchery-origin fish are released in stream segments occupied by salamanders, decreases in hatchery production under Alternative 3 may affect the availability of salmon and steelhead as potential prey, or competitors with or predators of Pacific giant salamanders and Cope's giant salamanders, based on available information on the recurrent relationship between salmon and steelhead and amphibians (Cederholm et al. 2000). Alternative 3 would not affect the abundance and distribution of Pacific giant salamanders and Cope's giant salamanders compared to Alternative 1.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). To the extent hatchery-origin fish are released in stream segments occupied by salamanders, increases in hatchery production under Alternative 4 may affect the availability of salmon and steelhead as potential prey, or competitors with or predators of Pacific giant salamanders and Cope's giant salamanders, based on available information on the recurrent relationship between salmon and steelhead and amphibians (Cederholm et al. 2000). Alternative 4 would not affect the abundance and distribution of Pacific giant salamanders and Cope's giant salamanders compared to Alternative 1.

4.5.4.4.3 Freshwater, Estuarine, and Marine Invertebrates

As described in Subsection 3.5.3.5, Freshwater, Marine, and Estuarine Invertebrates, invertebrates provide an important role in energy pathways of aquatic ecosystems where salmon and steelhead occur. Aquatic invertebrates, such as insects, are food sources for salmon and steelhead juveniles (as well as other fish) in freshwater and estuarine systems. In addition, habitat for benthic invertebrates is created when salmon and steelhead disturb bottom substrates during spawning. Salmon and steelhead carcasses provide direct and indirect benefits to aquatic invertebrates as sources of food and nutrients to streams. Estuarine habitat provides an important role in the feeding and growth of juvenile salmon and steelhead. The abundance and distribution of freshwater, estuarine, and marine invertebrates is substantial and widespread throughout the analysis area.

Alternative 1 (No Action). Hatchery production of salmon and steelhead under Alternative 1 would be the same as under existing conditions. As a result, Alternative 1 would not alter the extent of salmon and steelhead juveniles (and other fish) preying on invertebrate food sources, the increased habitat available to invertebrates from disturbance of bottom substrate by salmon and steelhead during spawning, or the direct and indirect benefits of salmon and steelhead carcasses as sources of food and nutrients to streams compared to existing conditions. Under Alternative 1, no effects would occur to estuarine habitat, which is important for juvenile salmon and steelhead feeding and growth by supporting invertebrate prey. Compared to existing conditions, no effects would occur to the abundance and distribution of freshwater, estuarine, and marine invertebrates throughout the analysis area under Alternative 1.

Alternative 2 (Proposed Action). Hatchery production of salmon and steelhead under Alternative 2 would be the same as under Alternative 1. As a result, Alternative 2 would not alter the extent of salmon and steelhead (and other fish) preying on invertebrate food sources, the increased habitat available to invertebrates from disturbance of bottom substrate by salmon and steelhead during spawning, or the direct and indirect benefits of salmon and steelhead carcasses as sources of food and nutrients to streams compared to Alternative 1. Under Alternative 2, no effects would occur to estuarine habitat, which is important for juvenile salmon and steelhead feeding and growth by supporting invertebrate prey compared to Alternative 1. Similarly, no effects would occur to the abundance and distribution of freshwater, estuarine, and marine invertebrates throughout the analysis area under Alternative 2 compared to Alternative 1.

Alternative 3 (Reduced Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (from 146,997,000 fish to 135,082,000 fish) (Table 4.5-1). Under Alternative 3, decreases in hatchery production would result in reduced predation on aquatic insects from salmon and steelhead juveniles (and other fish) compared to Alternative 1. Compared to Alternative 1, decreases in hatchery production under Alternative 3 would also reduce invertebrate benefits from salmon and steelhead spawners that disturb bottom substrate and create habitat for benthic invertebrates, and would reduce the sources of direct and indirect benefits of stream food and nutrients to invertebrates from salmon and steelhead carcasses, because fewer carcasses would be available to provide food and sources of nutrients to streams. Under Alternative 3, and as described under Alternative 1, no effects would occur to estuarine habitat, which is important for juvenile salmon and steelhead feeding and growth by supporting invertebrate prey. Compared to Alternative 1, no effects would occur to the abundance and distribution of freshwater, estuarine, and marine invertebrates throughout the analysis area under Alternative 3.

Alternative 4 (Increased Production). Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (from 146,997,000 fish to 169,967,000 fish) (Table 4.5-1). Under Alternative 4, increases in hatchery production would result in increased predation on aquatic insect and invertebrates by salmon and steelhead juveniles (and other fish) in freshwater and marine/estuarine areas. Increases in hatchery production under Alternative 4 would increase benefits from salmon and steelhead spawners that disturb bottom substrate and create habitat for benthic invertebrates, and would increase the direct and indirect benefits from sources of food and stream nutrients to invertebrates from salmon and steelhead carcasses because more carcasses would be available to provide food and sources of nutrients to streams, compared to Alternative 1. Under Alternative 4, as described under Alternative 1, no effects would occur to estuarine habitat, which is important for juvenile salmon and steelhead feeding and growth by supporting invertebrate prey. Compared to Alternative 1, no effects would occur to the abundance and distribution of freshwater, estuarine, and marine invertebrates throughout the analysis area under Alternative 4.

4.5.5 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the action alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks to other resources. For example, a measure intended to reduce risks to fish by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed mitigation measures are summarized for fish in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

Under adaptive management, in addition to applicable updated and new BMPs that may become available, the primary proposed mitigation measures implemented to reduce or eliminate negative impacts to fish resources that would affect wildlife would be reducing hatchery program size (number of hatchery-origin fish released) and/or discontinuing hatchery programs. In general, those measures would reduce negative impacts to fish resources by reducing juvenile competitive interactions and genetic risks to natural-origin fish. These changes would affect wildlife by decreasing the numbers of hatchery-origin fish available for wildlife that have strong relationships to salmon and steelhead as sources of food.

4.6 Water Quality and Quantity

The water quality and quantity analyses address effects of salmon and steelhead hatchery programs on the existing conditions of water resources described in Subsection 3.6, Water Quality and Quantity, when combined with effects anticipated under each alternative. Successful operation of hatchery facilities (including hatcheries, rearing ponds, and acclimation ponds) depends on an adequate supply of high-quality surface, spring, and/or groundwater that, after use in the hatchery facility, is discharged to adjacent receiving environments. Net pens rely on a constant inflow of high-quality water, while solids are deposited through the nets to the water body bottom. The number of fish produced by a hatchery program determines the quantity of water needed for facility operations, the amount of chemicals and solids in the effluent discharged, and the number of returning hatchery-origin fish that are available to contribute nutrients to streams as carcasses from natural spawning or from carcass distribution efforts.

4.6.1 Analysis Area

The analysis area for water quality and quantity is the same as the project area (Subsection 1.4, Project and Analysis Areas).

4.6.2 Methods for Analysis

The analysis begins with an overview of effects from existing hatchery programs in the analysis area. These effects are then analyzed when combined with each alternative. The action alternatives would affect the number of salmon and steelhead released from hatcheries in the analysis area (Subsection 4.6.1, Analysis Area). Hatchery facility operations would not change under the alternatives, but differences in juvenile production levels would occur. Thus, differences in juvenile production under the alternatives and their effects on hatchery facility operations are used to qualitatively evaluate effects on water quality and quantity. These effects include levels of water use and quality of effluent discharges. The qualitative analysis conducted for water quality and quantity in this subsection is based on use of literature representing best available science, consistency with regulatory requirements, and use of information and studies from similar or related projects within and near the analysis area, as cited in Subsection 3.6, Water Quality and Quantity, and in this subsection.

4.6.3 Water Quality

Water quality can be altered by effluent from hatchery facility operations and affect parameters that include temperature, ammonia, organic nitrogen, total phosphorus, BOD, pH, and solids levels

(Subsection 3.6.1.1, Water Quality Parameters; Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities). Chemicals within hatchery effluents that are used to support hatchery production and could be released in hatchery facility effluent include antibiotics, fungicides, and disinfectants; other chemicals and organisms that could potentially be released in effluent include PCBs, DDT and its metabolites, pathogens, steroid hormones, anesthetics, pesticides, herbicides, and feed additives (Subsection 3.6.1.1, Water Quality Parameters; Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities).

Water quality may also be affected by decomposition of carcasses from unused hatchery-origin salmon and steelhead at hatchery facility sites (hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin fish that spawn naturally, as well as carcasses deliberately placed in streams. In general, salmon carcasses improve stream productivity and some water quality parameters (nitrogen and phosphorus) (Subsection 3.6.1.1, Water Quality Parameters) (Cederholm et al. 2000), as long as they do not exacerbate poor water quality conditions in streams or stream reaches or contribute toxins and pathogens to the aquatic system.

As described in Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance, hatchery facility effluent discharges are regulated primarily through compliance with NPDES permits administered by the EPA and Ecology. Under all alternatives, it is expected that EPA, Ecology, and Puget Sound treaty tribes would maintain their roles in NPDES permit administration, development, and promulgation of water quality standards and Clean Water Act section 401 water quality certification, and Ecology would continue to assess water quality in streams, rivers, and lakes and establish TMDLs. The sources of discharge from hatchery facilities (rearing portions of facilities and off-line settling basins), primary pollutants of concern (waste food and feces, as well as carcasses from net pens), and the parameters used to characterize pollutant loading (TSS and settleable solids) would continue to be addressed by the permits.

Hatchery facilities within the analysis area would also continue to operate under their existing NPDES permits and renew these permits as required, including:

- Facilities covered by Ecology’s Upland Fin-fish Hatching and Rearing NPDES General Permit

- Facilities covered by the EPA’s general NPDES permit covering Federal and tribal aquaculture facilities

- The South Sound Net Pens, which is the only net pen facility in the analysis area that meets the minimum thresholds for an NPDES permit but is not operating under a current individual NPDES permit
- The Puyallup Hatchery, which is the only hatchery facility in the analysis area that is currently covered under an individual NPDES permit to implement approved TMDLs

As described in Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies, no hatchery facilities in the analysis area operate under individual NPDES permits for groundwater discharge, and this is expected to continue under all alternatives.

Compliance with NPDES permits would include meeting TMDLs for those hatchery facilities that would discharge to streams with TMDLs that would be developed or revised in the future (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance). Thus, as TMDLs are revised or as new TMDLs are developed for other streams by Ecology, it is anticipated that hatchery facilities would then meet new TMDL requirements when applicable, which would help improve water quality conditions over time under all alternatives. Although hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens), in general, have not been identified as a source of impairment to streams based on hatchery facility effluent releases, and all state, Federal, and tribal hatchery facilities are in compliance with their NPDES permits (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance), the effluent released from these hatchery facilities does contribute to the total pollutant load of receiving and downstream waters. Periodic effluent permit limit exceedances of TSS and settleable solids also result in higher contributions to total pollutant loads, with the most common exceedances occurring for TSS that are typically one-time occurrences caused by high water flow events that flush influent sediments through the hatchery facility system (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance).

When combined with pollutant loads from other point and non-point discharge sources, and given current water quality conditions, impairment can occur even if the hatchery facilities are in compliance with their NPDES permits. As discussed in Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance, two NPDES-permitted hatchery facilities, with permit limit exceedances between January 2011 and November 2012, discharge effluent upstream of water body segments with dissolved oxygen impairments (Issaquah Hatchery and Tulalip Creek Ponds). These periodic exceedances would continue to occur under all alternatives; however, the amount and extent of periodic effluent permit limit exceedances, as well as non-reporting and non-sampling violations, may vary based on changes in hatchery operations. As noted above, if TMDLs are established for these or other impaired streams by Ecology, affected hatchery facilities would then be required to comply with these TMDLs.

For hatchery facilities below the minimum operating thresholds for requiring an NPDES permit (as discussed in Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities), the potential for these facilities to contribute to receiving water impairment by exceeding water quality criteria is unknown under all alternatives. However, effects would continue to be considered minimal because the effluent discharges are below NPDES thresholds, and the facilities would continue to be required to comply with state water quality standards and groundwater standards.

Under all alternatives, the type and quantity of salmon and steelhead carcasses that would be placed in the environment to increase marine-derived nutrients (nitrogen and phosphorus) would continue to be under the control of WDFW (Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies). WDFW would continue to establish guidelines for carcass distribution independent of hatchery program funding and management to minimize the potential for violating water quality standards for nutrients as a result of carcass distribution (including avoiding streams or stream reaches impaired by excess nutrients, not depositing carcasses during poor water quality conditions, not placing carcasses in terrestrial riparian zones, and monitoring). Hatchery facilities providing salmon and steelhead carcasses for distribution would also continue to follow the *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWIFC and WDFW 2006) and *Stream Habitat Restoration Guidelines* (Cramer 2012), which guide carcass placement to protect the health of organisms in waters where carcasses are placed or that may feed on salmon carcasses (Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies). Hatcheries managed by the 16 Puget Sound treaty tribes would continue to be required to meet applicable water quality standards under all alternatives (Subsection 3.6.1.2.2, Tribal Water Quality Standards).

4.6.3.1 Alternative 1 (No Action)

Hatchery production under Alternative 1 would be the same as under existing conditions (Table 2.4-1). The type and amount of chemicals and organisms (antibiotics, fungicides, disinfectants, PCBs, DDT and its metabolites, pathogens, steroid hormones, anesthetics, pesticides, herbicides, and feed additives) that would be used in hatchery facility operations and/or found in hatchery effluents (Subsection 3.6.1.1, Water Quality Parameters) would be the same as existing conditions. As a result, under Alternative 1, there would be no changes to water quality compared to existing conditions.

Although hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens) are generally in compliance with their NPDES permits (either Ecology's Upland Fin-fish Hatching and Rearing NPDES General Permit, EPA's general NPDES permit covering Federal and tribal hatcheries, or an individual permit), periodic effluent permit limit exceedances, as well as instances of hatchery facilities not sampling or not reporting required water quality parameter sampling results, may occur under Alternative 1. The likelihood of these exceedances and instances of non-reporting or non-sampling would be expected to be similar to those described for the affected environment. Most exceedances would be expected to typically be TSS exceedances resulting from extreme high water events (Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies).

Under Alternative 1, the decomposition of hatchery-origin salmon and steelhead carcasses from spawned-out salmon at hatchery facility sites (from hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin adults that spawn naturally in streams, and from hatchery-origin carcasses that are deliberately placed in streams, with resulting release of nutrients (nitrogen and phosphorus) into streams along with potential introduction of toxins and pathogens from salmon carcasses, would be the same as existing conditions.

4.6.3.2 Alternative 2 (Proposed Action)

Hatchery production under Alternative 2 would be the same as under Alternative 1 (Table 2.4-1). The type and amount of chemicals and organisms (antibiotics, fungicides, disinfectants, PCBs, DDT and its metabolites, pathogens, steroid hormones, anesthetics, pesticides, herbicides, and feed additives) that would be used in hatchery facility operations and/or found in hatchery effluents would be the same as Alternative 1. As a result, under Alternative 2, there would be no changes to water quality compared to Alternative 1.

Although hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens) are generally in compliance with their NPDES permits (either Ecology's Upland Fin-fish Hatching and Rearing NPDES General Permit, EPA's general NPDES permit covering Federal and tribal aquaculture facilities, or an individual permit), periodic effluent permit limit exceedances, as well as instances of hatchery facilities not sampling or not reporting required water quality parameter sampling results, may occur under Alternative 2. The likelihood of these exceedances and instances of non-reporting or non-sampling would be expected to be similar to those described under Alternative 1. Most exceedances would be expected to typically be TSS exceedances resulting from extreme high water events (Subsection 3.6.1.2.1, Federal and State Regulations and Implementing Agencies).

Under Alternative 2, the decomposition of hatchery-origin salmon and steelhead carcasses from spawned-out salmon at hatchery facility sites (from hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin adults that spawn naturally in streams, and from hatchery-origin carcasses that are deliberately placed in streams, with resulting nutrient releases (nitrogen and phosphorus) along with potential introduction of toxins and pathogens, would be the same as Alternative 1.

4.6.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (Table 2.4-1). Under Alternative 3, there would likely be a reduction in impacts to water quality relative to Alternative 1 because reduced hatchery production may reduce the amount of chemicals and organisms released from hatchery facility operations (antibiotics, fungicides, disinfectants, PCBs, DDT and its metabolites, pathogens, steroid hormones, anesthetics, pesticides, herbicides, and feed additives) that are discharged to receiving waters (Subsection 3.6.1.1, Water Quality Parameters). These reductions would decrease the contribution of hatchery facilities to the total pollutant load of receiving waters and the potential for water quality impairment relative to Alternative 1. The likelihood of effluent permit limit exceedances may also decrease with reduced hatchery production levels compared to Alternative 1. Hatchery facilities would continue to comply with their existing NPDES permits (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance). Incidences of hatcheries not sampling or not reporting required water quality parameter sampling results would not be expected to change.

Under Alternative 3, the reduction in hatchery production could translate into reduced availability of hatchery-origin salmon and steelhead carcasses from spawned-out salmon at hatchery facility sites (from hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin adults that spawn naturally in streams, and from hatchery-origin carcasses that are deliberately placed in streams, and potential reduction in carcass-related nutrients (nitrogen and phosphorus) into streams, along with a decreased potential for introduction of toxins and pathogens from salmon and steelhead carcasses, compared to Alternative 1.

4.6.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (Table 2.4-1). Under Alternative 4, there may be an increase in impacts to water quality relative to Alternative 1, because increased hatchery production may increase the amount of chemicals and organisms released from hatchery facility operations (antibiotics, fungicides, disinfectants, PCBs, DDT and its metabolites, pathogens, steroid hormones, anesthetics, pesticides, herbicides, and feed additives) discharged to receiving waters (Subsection 3.6.1.1,Water Quality Parameters). These increases would increase the contribution of hatchery facilities to the total pollutant load of receiving waters and the potential for water quality impairment relative to Alternative 1, although as stated above, all hatchery facilities would continue to comply with their NPDES permits.

Increases in hatchery production under Alternative 4 that would increase pollutants or discharges would be reported to the permitting authority by the hatchery operator, and new or modified permits may be required to maintain water quality; if new or modified permits are not required, hatchery facilities would have to continue to comply with their existing NPDES permits (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance). Compared to Alternative 1, the likelihood of periodic exceedances of effluent permits for TSS or settleable solids would likely be greater under Alternative 4 because of the increased hatchery production. Incidences of hatcheries not sampling or not reporting required water quality parameter sampling results would not be expected to change.

Overall, under Alternative 4, increases in hatchery facility contributions to pollutant loads of receiving waters would increase the potential for water quality impairment relative to Alternative 1. However, if a stream is designated by Ecology as impaired, a TMDL would be developed and the hatchery facility discharging to that stream would have to meet the revised effluent discharge limits specified by the TMDL.

Under Alternative 4, the increase in hatchery production would increase the availability of hatchery-origin salmon and steelhead carcasses from spawned-out salmon at hatchery facility sites (from hatchery-origin adults that return to a hatchery facility or net pen but are not collected and used), from hatchery-origin adults that spawn naturally in streams, and from hatchery-origin carcasses that are deliberately placed in streams, and increase the potential for carcass-related nutrients (nitrogen and phosphorus) into streams, along with an increased potential for introduction of toxins and pathogens, compared to Alternative 1. If the number of hatchery-origin adults that return to a hatchery facility or net pen and are not collected or the number of hatchery-origin adults that spawn naturally in streams increase, nutrient releases would increase, and these increases may occur in nutrient-impaired streams or during low water quality conditions. Any additional salmon and steelhead carcasses available for distribution into streams would still be subject to WDFW's placement program guidelines to minimize the potential for violating water quality standards for nutrients as a result of carcass distribution (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance), and would be the same as Alternative 1. Thus, carcass-related nutrient benefits may increase compared to Alternative 1.

4.6.4 Water Quantity

Hatchery facility use of surface water and groundwater is both consumptive and non-consumptive as described in Subsection 3.6.2, Water Quantity. Loss of water from existing sources may include water diversions from an adjacent stream to allow water flow through the hatchery facility or pond system and evaporation or infiltration from hatchery facilities and ponds. Surface water used in hatchery facilities is then returned to its source at some location downstream of its diversion point; however, some portion of the water source (the stream bypass reach) is dewatered (has less water between the point of diversion and discharge return to the river). Effects to existing sources include alteration of stream flow and changes in water quantity (Subsection 3.6.2, Water Quantity).

The Dungeness Hatchery, Quilcene National Fish Hatchery, and White River Hatchery are located along stream segments that Ecology has identified as being impaired for instream flow, and the Quilcene National Fish Hatchery is also located along a segment of the Big Quilcene River that is impaired for temperature (Subsection 3.6.2, Water Quantity). Eight other hatchery facilities in the analysis area are located along stream segments that Ecology identified as being temperature-impaired; however, it is not known whether temperature in these segments is affected by reduced stream flows because of surface or groundwater withdrawals from the hatchery facilities or other water uses within or upstream of the segments. Within the analysis area, 17 of 18 water resource inventory areas (all except the Skokomish-Dosewallips) have established instream flows. Of these, Ecology identified the Nooksack, Snohomish, Cedar-Sammamish, Duwamish-Green, Puyallup-White, Chambers-Clover, Quilcene-Snow, and Elwha-Dungeness water resource inventory areas as fish-critical because low stream flows in those areas present limiting factors for salmon and steelhead. In the past 2 years, Ecology has not recorded water use violations by hatchery facilities in the analysis area, nor have complaints or other issues been received by Ecology's regional compliance staff regarding water use or instream flow violations by hatcheries (Subsection 3.6.2, Water Quantity).

Under all alternatives and for all water resource inventory areas associated with the analysis area, no water use violations or complaints would be expected because of hatchery operations as currently occurs under existing conditions.

4.6.4.1 Alternative 1 (No Action)

Hatchery production under Alternative 1 would be the same as under existing conditions (Table 2.4-1). Hatchery facility use of surface water and groundwater would be the same as existing conditions. As described in Subsection 3.6.2, Water Quantity, water would continue to be removed from surface water (adjacent streams) and groundwater for hatchery uses and returned, as under existing conditions. As a result, under Alternative 1, there would be no hatchery-related changes to water use for consumptive and non-consumptive purposes, compared to existing conditions.

Under Alternative 1, water would continue to be used at the Dungeness Hatchery and White River Hatchery, which operate along stream segments identified as being impaired for instream flow, and the Quilcene National Fish Hatchery, which operates along a segment of the Big Quilcene River that is impaired for instream flow and temperature (Subsection 3.6.2, Water Quantity), as under existing conditions. Although eight other hatchery facilities in the analysis area are located along temperature-impaired stream segments, it is not known whether temperature in these segments would be affected by hatchery-related surface water or groundwater withdrawals or other water uses in or upstream of the segments, as under existing conditions.

4.6.4.2 Alternative 2 (Proposed Action)

Hatchery production under Alternative 2 would be the same as under Alternative 1 (Table 2.4-1). Hatchery facility use of surface water and groundwater would be the same as Alternative 1. Under Alternative 2, water would continue to be removed from surface water (from adjacent streams) and groundwater for hatchery uses and returned, as under Alternative 1. As a result, under Alternative 2, there would be no hatchery-related changes to water use, compared to Alternative 1.

Under Alternative 2, water would continue to be used at the Dungeness Hatchery and White River Hatchery, which operate along stream segments identified as being impaired for instream flow, and the Quilcene National Fish Hatchery, which operates along a segment of the Big Quilcene River that is impaired for instream flow and temperature (Subsection 3.6.2, Water Quantity), as in Alternative 1. Although eight other hatchery facilities in the analysis area are located along temperature-impaired stream segments, it is not known whether temperature in these segments would be affected by hatchery-related surface water or groundwater withdrawals or other water uses in or upstream of the segments, as in Alternative 1.

4.6.4.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (Table 2.4-1). Under Alternative 3, water would continue to be removed from surface water (from adjacent streams) and groundwater for hatchery uses and returned as under Alternative 1. This use of water by hatcheries may include alteration of stream flows and changes in water quantity as under Alternative 1. However, decreased hatchery production under Alternative 3 may result in decreases in consumptive water use by hatchery facilities compared to Alternative 1. Reductions in consumptive water use by hatchery facilities under Alternative 3 would likely result in increased water for stream flows (Subsection 3.6.2, Water Quantity) compared to Alternative 1. The potential reduction in water use by hatcheries would be most beneficial to instream flows associated with the Dungeness Hatchery and White River Hatchery because these hatcheries operate along stream segments identified as impaired for instream flow, and the Quilcene National Fish Hatchery because this hatchery operates along a segment of the Big Quilcene River that is impaired for instream flow and temperature (Subsection 3.6.2, Water Quantity). Although eight other hatchery facilities in the analysis area are located along temperature-impaired stream segments, it is not known whether temperature in these segments would be affected by increased stream flows because of potential reduced surface water or groundwater withdrawals from the hatchery facilities or other water uses in or upstream of the segments under Alternative 3.

4.6.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (Table 2.4-1). Under Alternative 4, water would continue to be removed from surface water (from adjacent streams) and groundwater for hatchery uses and returned as under Alternative 1. This use of water by hatcheries may include alteration of stream flow and changes in water quantity as under Alternative 1. However, increased hatchery production under Alternative 4 may result in increases in consumptive use by hatchery facilities compared to Alternative 1, but only if the increase is covered by the facilities' existing water rights. As described in Subsection 2.4.1, Actions Common to All Alternatives, increased production under Alternative 4 would be based on capacity of existing hatchery facilities, including water rights. Increases in consumptive water use by hatchery facilities under Alternative 4 would likely result in decreased water for stream flows (Subsection 3.6.2, Water Quantity), compared to Alternative 1. The potential increase in water use by hatcheries may have the greatest impact on instream flows associated with the Dungeness Hatchery and White River Hatchery because these hatcheries operate along stream segments identified as impaired for instream flow, and the Quilcene National Fish Hatchery because this hatchery operates along a segment of the Big Quilcene River that is impaired for instream flow and temperature (Subsection 3.6.2, Water Quantity). Although eight other hatchery facilities in the analysis area are located along temperature-impaired stream segments, it is not known whether temperature in these segments would be affected by reduced stream flows because of potential increases in surface water or groundwater uses by the hatchery facilities or other water uses in or upstream of the segments under Alternative 4.

4.6.5 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations, and measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, but is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time to individual hatchery programs to reduce risks to salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species' subsections in Subsection 4.2, Fish) and would likely also affect other resources, such as socioeconomics. Proposed potential mitigation measures are summarized for fish in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

Under adaptive management, in addition to applicable updated and new BMPs that may become available, the primary proposed potential mitigation measures to reduce or eliminate negative impacts to fish resources that would affect water quality and water quantity would be reducing hatchery program size (number of hatchery-origin fish released) and/or discontinuing hatchery programs. These changes would affect water quality and water quantity by reducing chemical releases and improving water quality, decreasing the potential for NPDES permit exceedances, decreasing the nutrient benefit from placement of hatchery-origin carcasses, and decreasing the amount of water used by hatchery facilities.

4.7 Human Health

The human health analysis addresses effects of salmon and steelhead hatchery programs on existing human health conditions in the analysis area described in Subsection 3.7, Human Health, when combined with effects anticipated under each alternative. Changes in hatchery facility operations associated with changes in fish production levels under the alternatives may affect risks to human health from common chemicals used in hatchery operations and safe handling of those chemicals, potentially toxic contaminants in hatchery-origin fish, and potential disease vectors and contaminants transmitted from handling hatchery-origin fish.

4.7.1 Analysis Area

The analysis area for human health is the same as the project area (Subsection 1.4, Project and Analysis Areas).

4.7.2 Methods for Analysis

The analysis begins with an overview of effects from existing hatchery programs in the project area. These effects are then analyzed when combined with each alternative. The alternatives would affect the number of salmon and steelhead released from hatcheries in the analysis area (Subsection 4.7.1, Analysis Area). Hatchery facility operations would not change under the alternatives but changes in juvenile production levels would occur. Thus, changes in juvenile production under the alternatives are used to qualitatively evaluate effects on risks to human health. This qualitative analysis relies on inferences from literature and other studies representing best available science on effects from similar or related projects within and near the analysis area. No modeling was conducted.

4.7.3 Hatchery Chemical Use and Handling

A variety of chemicals are routinely used in hatchery operations to maintain a clean environment for the production of disease-free fish, including disinfectants, therapeutics, pesticides and herbicides, feed additives, and miscellaneous chemicals (Subsection 3.7.1, Hatchery Chemical Use and Handling; Appendix K, Chemicals Used in Hatchery Operations). These chemicals are not considered hazardous to human health when safety precautions and regulations are followed. Subsection 3.7.1.1, Safe Handling of Hatchery Chemicals, describes the Occupational Safety and Health Administration regulations that employees would follow under all alternatives to avoid exposure to chemicals used at hatchery facilities. An issue of concern with use of these chemicals is the potential for accidental spills or environmental releases greater than allowed under current Federal and state programs and rules. An additional issue is the release of hatchery chemicals (e.g., therapeutics) into the aquatic environment that do not have established water quality criteria. Therapeutics are applied infrequently, at low doses, and in compliance with manufacturers' directions to avoid impacts to receiving waters; thus, risks from therapeutics are likely negligible (Subsection 3.7.1.1, Safe Handling of Hatchery Chemicals; Appendix K, Chemicals Used in Hatchery Operations) and are not evaluated further in this EIS.

4.7.3.1 Alternative 1 (No Action)

Hatchery production under Alternative 1 would be the same as under current conditions (Table 2.4-1). As a result, Alternative 1 would not change the amount and types of chemicals used in hatchery facilities, including disinfectants, therapeutics, anesthetics, pesticides and herbicides, feed additives, and miscellaneous chemicals (Subsection 3.7.1, Hatchery Chemical Use and Handling), relative to current conditions. All safety precautions and Federal and state programs and rules would continue to be followed so that these chemicals would not be considered hazardous to human health (Subsection 3.7.1.1, Safe Handling of Hatchery Chemicals). There also would be no change in the amount of chemicals being discharged to surface waters near hatchery facilities (Subsection 3.7.1, Hatchery Chemical Use and Handling) compared to current conditions. As a result, under Alternative 1 there would be no changes in the potential for increased spills or environmental releases, or the risk of releases into the aquatic environment for those chemicals that do not have established water quality criteria, compared to current conditions.

4.7.3.2 Alternative 2 (Proposed Action)

Hatchery production under Alternative 2 would be the same as under Alternative 1 (Table 2.4-1). The amount and types of chemicals used in hatchery facilities, including disinfectants, therapeutics, anesthetics, pesticides and herbicides, feed additives, and miscellaneous chemicals would be the same as under Alternative 1. As a result, under Alternative 2 there would be no changes in risk to human health from accidental spills, environmental releases, and no changes in risk from releases of chemicals into receiving waters for those chemicals that have no established water quality criteria, compared to Alternative 1.

4.7.3.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (Table 2.4-1). Under Alternative 3, there would likely be a reduction in risk to human health relative to Alternative 1 because reduced hatchery production levels may reduce the amount of chemicals that would be used in the hatchery facilities, including disinfectants, therapeutics, anesthetics, pesticides and herbicides, feed additives, and miscellaneous chemicals (Subsection 3.7.1, Hatchery Chemical Use and Handling). Because there would be no other changes in hatchery operations under this alternative, the types of chemicals used (Subsection 3.7.1, Hatchery Chemical Use and Handling) would not change relative to Alternative 1. All safety precautions associated with Federal and state programs and rules would continue to be followed so that these chemicals would not be considered hazardous to human health (Subsection 3.7.1.1, Safe Handling of Hatchery Chemicals). Reduced risks to human health would occur if smaller amounts of chemicals were used under this alternative because there would be a reduced potential for accidental spills or environmental releases compared Alternative 1. Similarly, there would be a reduced risk to human health from releases of chemicals into receiving waters for those chemicals that do not have established water quality criteria, compared to Alternative 1.

4.7.3.4 Alternative 4 (Increased Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (Table 2.4-1). Under Alternative 4, there would likely be an increased risk to human health relative to Alternative 1, because increased hatchery production may increase the amount chemicals used within the hatchery facilities, including disinfectants, therapeutics, anesthetics, pesticides and herbicides, feed additives, and miscellaneous chemicals (Subsection 3.7.1, Hatchery Chemical Use and Handling) (Table 2.4-1). Because there would be no other changes in hatchery operations under this alternative, the types of chemicals used (Subsection 3.7.1, Hatchery Chemical Use and Handling) would not change relative to Alternative 1. All safety precautions associated with Federal and state programs and rules would continue to be followed so that these chemicals would not be considered hazardous to human health (Subsection 3.7.1.1, Safe Handling of Hatchery Chemicals). However, because the amount of chemicals used would likely increase under Alternative 4, there is an increased risk for accidental spills or environmental releases compared Alternative 1. Similarly, there would be an increased risk to human health from releases of chemicals into receiving waters for those chemicals that do not have established water quality criteria.

4.7.4 Toxic Contaminants in Hatchery-origin Fish

As described in Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, juvenile hatchery-origin fish may accumulate toxic chemicals as they feed and rear in hatcheries (e.g., chemicals or therapeutics, contaminated nutritional supplements or feeds), and from the natural environment after the fish are released. Similarly, natural-origin fish may accumulate toxic chemicals from their natural environment. Thus, hatchery-origin and natural-origin fish may pose risks to human health when consumed by people. As discussed in Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, the contribution of contaminants from individual hatchery-origin fish would be expected to be similar to the contribution from individual natural-origin fish. To the extent that some groups of people (consumers) eat more fish than others, they are more likely to be exposed to contaminants accumulated in the fish. Hatchery-origin salmon and steelhead do not present a greater threat of contamination than do natural-origin salmon and steelhead.

Toxic contaminants accumulated by individual hatchery-origin fish before and after release would be the same under all alternatives because the accumulation of toxic contaminants would not be dependent on changes in hatchery production levels. Similarly, consumption among groups of people (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish), would be the same under all alternatives. Therefore, the following analyses address risks of toxic contaminant effects to humans that would be associated with differences in hatchery production levels under the alternatives.

4.7.4.1 Alternative 1 (No Action)

Hatchery production under Alternative 1 would be the same as under current conditions (Table 2.4-1). As a result, Alternative 1 would not change the amount and type of toxic contaminants associated with hatchery operations (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish) and in the natural environment compared to current conditions. There would be no changes in the amount of contaminated salmon and steelhead and the consumption of hatchery-origin salmon and steelhead by humans compared to current conditions.

4.7.4.2 Alternative 2 (Proposed Action)

Hatchery production under Alternative 2 would be same as under Alternative 1 (Table 2.4-1). The amount and types of toxic contaminants associated with hatchery operations (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish) and in the natural environment would be the same as

Alternative 1. As a result, under Alternative 2 there would be no changes in risk to human health from toxic contaminants relative to Alternative 1. There would be no changes in the amount of contaminated salmon and steelhead and the consumption of hatchery-origin salmon and steelhead by humans compared to Alternative 1.

4.7.4.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (Table 2.4-1). Under Alternative 3, the level of toxic contaminants in individual hatchery-origin fish (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish) and in the natural environment would be the same as Alternative 1 because there would be no change in the exposure of individual fish to chemicals, feeds, or contamination in the environment where they are reared and released. However, reduced production under Alternative 3 would likely decrease the number of hatchery-origin salmon and steelhead that would be eaten by humans relative to Alternative 1, thus reducing the overall transfer of contaminants to humans from salmon and steelhead (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish).

4.7.4.4 Alternative 4 (Increased Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (Table 2.4-1). Under Alternative 4, the level of toxic contaminants in individual hatchery-origin fish (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish) and in the natural environment would be the same as Alternative 1 because there would be no change in the exposure of individual fish to chemicals, feeds, or contamination in the environment where they are reared and released. However, increased production under Alternative 4 would likely increase the number of hatchery-origin salmon and steelhead that would be eaten by humans relative to Alternative 1, thus increasing the overall transfer of contaminants to humans (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish). Any increase in toxic contaminant transfer would likely be small because consumption of the fish resulting from increased production would be spread among various groups of people.

4.7.5 Relevant Disease Vectors and Transmission

As described in Section 3.7.3, Relevant Disease Vectors and Transmission, a number of parasites, viruses, and bacteria may be transmitted from fish species through seafood consumption (i.e., improperly cooked or under-cooked fish) or handling of infected fish or fish carcasses that are potentially harmful to human health. Although safe procedures have been developed to protect humans from transmission of disease vectors (e.g., fully cooking fish, compliance with safety programs, use of personal protective equipment), accidents in hatchery operations may occur through skin contact with infected fish and accidental needle-stick injuries. Under all alternatives, safety measures to control the transmission of fish-borne pathogens to humans would continue to be controlled by applying measures described under Subsection 3.7.3, Relevant Disease Vectors and Transmission. Consequently, the transmission of fish-borne pathogens to humans would continue to be rare under all alternatives.

4.7.5.1 Alternative 1 (No Action)

Hatchery production under Alternative 1 would be the same as under current conditions (Table 2.4-1). As a result, Alternative 1 would not change the amount and type of disease vectors and transmission associated with hatchery operations (Subsection 3.7.3, Relevant Disease Vectors and Transmission) relative to current conditions. Hatchery programs would continue to implement proper safety measures to minimize the potential for the occurrence of pathogens and their transfer to humans (Subsection 3.7.3, Relevant Disease Vectors and Transmission). Thus, the potential for accidental skin contact and needle-stick injuries involving infected fish would be the same as current conditions, which is rare.

4.7.5.2 Alternative 2 (Proposed Action)

Hatchery production under Alternative 2 would be the same as under Alternative 1 (Table 2.4-1). The pathogens and safe handling practices associated with hatchery operations (Subsection 3.7.3, Relevant Disease Vectors and Transmission) would be the same as under Alternative 1. As a result, under Alternative 2 there would be no changes in risk to human health from disease vectors and transmission relative to Alternative 1. All hatchery programs would continue to implement proper safety measures to minimize the potential for pathogens to occur (Subsection 3.7.3, Relevant Disease Vectors and Transmission). Thus, the potential for accidental skin contact and needle-stick injuries involving infected fish would be the same as under Alternative 1, which is rare.

4.7.5.3 Alternative 3 (Reduced Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would decrease under Alternative 3 by 8 percent (Table 2.4-1). Under Alternative 3, reduced production would likely decrease the potential for the transmission of pathogens because there would be fewer hatchery-origin fish to handle and consume compared to Alternative 1. All hatchery programs would continue to implement proper safety measures to minimize the potential for the occurrence of pathogens and their transfer to humans (Subsection 3.7.3, Relevant Disease Vectors and Transmission). Although a rare occurrence under Alternative 1, the potential for accidental skin contact and needle-stick injuries involving infected fish would be slightly less than Alternative 1 because of decreased hatchery production.

4.7.5.4 Alternative 4 (Increased Production)

Compared to Alternative 1, overall hatchery production of salmon and steelhead would increase under Alternative 4 by 16 percent (Table 2.4-1). Under Alternative 4, increased production would likely increase the potential for the transmission of pathogens because there would be more hatchery-origin fish to handle and consume compared to Alternative 1. All hatchery programs would continue to implement proper safety measures to minimize the potential for the occurrence of pathogens and their transfer to humans (Subsection 3.7.3, Relevant Disease Vectors and Transmission). With increased hatchery production, the potential for accidental skin contact and needle-stick injuries involving infected fish could increase as compared to Alternative 1, but occurrences would continue to be rare.

4.7.6 Mitigation Measures and Adaptive Management

As described in Subsection 4.1.1, Mitigation Measures and Adaptive Management, this EIS considers mitigation measures to reduce potential negative impacts associated with the alternatives. Mitigation measures in this EIS include existing BMPs that are not currently in use at all hatchery operations, and measures that would be applied over the long term under adaptive management (including updated and new BMPs).

An adaptive management process (Subsection 2.2.4, Adaptive Management) would occur under the action alternatives, which is not included under Alternative 1. Under adaptive management, mitigation measures would be implemented over time in individual hatchery programs to reduce risks to salmon and steelhead from hatchery programs (Subsection 4.1.1, Mitigation Measures and Adaptive Management, and individual species subsections in Subsection 4.2, Fish) and would likely also affect risks to other resources, such as human health. For example, a measure intended to reduce risks to fish by decreasing hatchery production would also reduce negative impacts to human health associated with hatchery chemicals, but would lead to fewer adult returns and associated harvest-related socioeconomic benefits from the hatchery program. Proposed potential mitigation measures are summarized in Table 4.2-7, Table 4.2-11, Table 4.2-15, and Table 4.2-18.

Under adaptive management, in addition to applicable updated or new BMPs that may become available, the primary proposed potential mitigation measures implemented to reduce or eliminate negative impacts to fish resources that would affect human health would be reducing hatchery program size (number of hatchery-origin fish released) and/or discontinuing hatchery programs. These changes would affect human health by decreasing the likelihood of accidental spills and releases, decreasing effluent releases into receiving waters of chemicals that have no established water quality criteria, and decreasing the potential for accidental skin contact and needle-stick injuries from infected fish.

4.8 Summary of Resource Effects

This subsection provides a summary of potential direct and indirect environmental effects on the physical, biological, and social environments that are associated with the alternatives. Cumulative effects associated with the alternatives are described in Chapter 5, Cumulative Effects. Each subsection listed below describes potential effects on a specific resource topic; each resource topic is described in a corresponding main subsection in Chapter 3, Affected Environment. The specific order of the resource effects summarized in this subsection is:

- Fish (Subsection 4.2)
- Socioeconomics (Subsection 4.3)
- Environmental Justice (Subsection 4.4)
- Wildlife (Subsection 4.5)
- Water Quality and Quantity (Subsection 4.6)
- Human Health (Subsection 4.7)

Table 4.8-1 summarizes predicted effects from implementation of the No-action Alternative (Alternative 1) and the action alternatives (Alternative 2 through Alternative 4). This table summarizes the detailed resource discussions in Subsection 4.2, Fish, through Subsection 4.7, Human Health. Refer to these subsections for context and background to support conclusions stated in Table 4.8-1. No preferred alternative has been identified in this draft EIS (Subsection 2.1, Introduction, and Subsection 2.6, Selection of a Preferred Alternative and an Environmentally Preferred Alternative).

Table 4.8-1. Summary of environmental consequences by resource and alternative that includes implementation of adaptive management for Alternative 2, Alternative 3, and Alternative 4.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Fish				
Listed Salmon, Steelhead, and Trout: Chinook salmon and summer-run chum salmon, steelhead, and bull trout	Hatchery production would pose a moderate risk and low benefit to the Chinook salmon ESU.	Risks would be reduced and benefits would increase through adaptive management compared to Alternative 1.	Overall risk to the Chinook salmon ESU would decrease, and the overall benefit would be the same as Alternative 1.	Overall risk to the Chinook salmon ESU would be similar to Alternative 1, and the overall benefit would increase.
	Hatchery production would pose a low risk to the Hood Canal summer-run chum salmon ESU.[3]		Same as Alternative 1.	Same as Alternative 1.
	Hatchery production would pose a moderate risk and low benefit to the steelhead DPS.		Overall risk to the steelhead DPS would decrease, and the overall benefit would be the same as Alternative 1.	Same as Alternative 1.
	Hatchery production would pose a low risk and low benefit to bull trout.		Same as Alternative 1.	Same as Alternative 1.
Non-listed Salmon: coho salmon, chum salmon, pink salmon, and sockeye salmon	Hatchery production would pose competition, predation, genetics, and hatchery facilities and operation risks and would provide total return, viability, and marine-derived nutrient benefits.	Risks would be potentially reduced and benefits would be potentially increased through adaptive management compared to Alternative 1.	Risks and benefits are further reduced compared to Alternative 2.	Risks and benefits are further increased compared to Alternative 2.

Table 4.8-1. Summary of environmental consequences by resource and alternative that includes implementation of adaptive management for Alternative 2, Alternative 3, and Alternative 4, continued.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Other Fish Species	Depending on the species, other fish species would be affected if they compete with, are prey of, or prey on salmon and steelhead.	Adaptive management would not be expected to affect abundance compared to Alternative 1.	Potential reductions in the food supply for fish species that prey on salmon and steelhead, and reduced risk to other fish species that are preyed on, compete with, or are caught in fisheries targeting salmon and steelhead compared to Alternative 1.	Potential increases in the food supply for fish species that prey on salmon and steelhead while also increasing risk to other fish that are preyed on, compete with, or are caught in fisheries targeting salmon and steelhead compared to Alternative 1.
Socioeconomics				
Commercial Salmon and Steelhead Fishing	Annual non-tribal and tribal commercial harvest value would be 2,679,392 fish and $15,577,897 in gross economic value.	Same as Alternative 1.	Commercial harvest value would decrease by 4 percent and gross economic value would decrease by 7 percent compared to Alternative 1.	Commercial harvest value would increase by 7 percent and gross economic value would increase by 10 percent compared to Alternative 1.
Recreational Salmon and Steelhead Fishing	Annual net economic value of recreational fisheries is $58,965,077. Recreational fishing trips and expenditures would be 997,380 trips and $70,245,440 in expenditures.	Same as Alternative 1.	Annual net economic value of recreational fisheries, fishing trips, and expenditures would decrease by 8 percent compared to Alternative 1.	Annual net economic value of recreational fisheries, fishing trips, and expenditures would increase by 18 percent compared to Alternative 1.
Regional and Subregional Economic Impacts	Annual hatchery operations and personal income would be $106,888,758 and 2,060 jobs. Overall personal income would be $92,249.981.	Same as Alternative 1.	Annual hatchery operations and personal income would decrease by 10 percent, jobs would decrease by 8 percent, and personal income would decrease by 8 percent compared to Alternative 1.	Annual hatchery operations and personal income would increase by 15 percent, jobs would increase by 13 percent, and personal income would increase by 14 percent compared to Alternative 1.
Fisheries in Major River Systems	Tribal commercial and recreational fisheries would occur in 15 major river systems.	Same as Alternative 1.	Decreases in hatchery production would have a major negative effect on fisheries for nine of the major river systems for at least one species of salmon and steelhead compared to Alternative 1.	Increases in hatchery production would have a major positive effect on fisheries for six of the major river systems for at least one species of salmon and steelhead compared to Alternative 1.

Table 4.8-1. Summary of environmental consequences by resource and alternative that includes implementation of adaptive management for Alternative 2, Alternative 3, and Alternative 4, continued.

Resource	**Alternative 1 (No Action)[1]**	**Alternative 2[2] (Proposed Action)**	**Alternative 3[2] (Reduced Production)**	**Alternative 4[2] (Increased Production)**
Ports and Fishing Communities	Annual personal income from commercial and recreational fishing would be $41,724,837 in north Puget Sound, $46,838,604 in south Puget Sound, and $5,686,540 in the Strait of Juan de Fuca. Annual employment from commercial and recreational fishing would be 975 jobs in north Puget Sound, 913 jobs in south Puget Sound, and 173 jobs in the Strait of Juan de Fuca.	Same as Alternative 1.	Annual personal income and employment from commercial and recreational fishing would decrease by 6 percent to 12 percent for each subregion compared to Alternative 1.	Annual personal income and employment from commercial and recreational fishing would increase by 10 percent to 19 percent for each subregion compared to Alternative 1.
Environmental Justice				
Native American Tribes of Concern	Annual tribal harvest would be 1,321,156 fish and tribal gross economic values would be $9,148,467. Harvest would contribute to ceremonial and subsistence uses.	Same as Alternative 1	Annual tribal harvest would decrease by 7 percent and tribal gross economic values would decrease by 11 percent compared to Alternative 1. Harvest would contribute to ceremonial and subsistence uses similar to Alternative 1.	Annual tribal harvest would increase by 8 percent and tribal gross economic values would increase by 11 percent compared to Alternative 1. Harvest would contribute to ceremonial and subsistence uses similar to Alternative 1.
Non-tribal User Groups of Concern	Annual net revenues for commercial fishers would be $3,335,926.	Same as Alternative 1	Annual net revenues for commercial fishers would decrease by 1 percent compared to Alternative 1.	Annual net revenues for commercial fishers would increase by 8 percent compared to Alternative 1.
Communities of Concern	Annual per capita income would range from $18,056 to $29,521 for King, Mason, Pierce, and Clallam Counties.	Same as Alternative 1.	Annual per capita income would decrease by less than 1 percent for each of the four counties compared to Alternative 1.	Annual per capita income would increase by less than 1 percent for the four counties compared to Alternative 1.

Table 4.8-1. Summary of environmental consequences by resource and alternative that includes implementation of adaptive management for Alternative 2, Alternative 3, and Alternative 4, continued.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Wildlife				
Hatchery Operations and Wildlife	Potential for slight transfer of pathogens from hatchery-origin fish to wildlife, hatchery weirs may restrict some wildlife movements, wildlife may benefit from salmon and steelhead carcasses, and hatchery program operations (e.g., use of screens and water) may have a negative effect on wildlife presence and mortality.	Same as Alternative 1.	Potential water use would decrease, which would be beneficial to wildlife, compared to Alternative 1.	Potential water use would increase, which would make slightly less water available for wildlife, compared to Alternative 1.
ESA-listed Species: Southern Resident killer whale	Southern Resident killer whales would occupy their existing habitat in the project area with a similar abundance, and would continue to prey on salmon, especially Chinook salmon.	Same as Alternative 1.	Supply of salmon as food would decrease (i.e., adult hatchery-origin Chinook salmon would decrease by 13 percent), which may negatively impact Southern Resident killer whales, compared to Alternative 1.	Supply of salmon as food would increase (i.e., adult hatchery-origin Chinook salmon would increase by 11 percent), which may benefit Southern Resident killer whales, compared to Alternative 1.
Non-listed Species: Birds	Bald eagles and other birds that feed on salmon and steelhead would continue to occupy their existing habitat in the project area with similar abundances, and would continue to feed on salmon and steelhead. Similarly, other birds that are not as dependent on salmon as a food supply would also continue to occur in the project area similar to existing conditions.	Same as Alternative 1.	Supply of hatchery-origin salmon and steelhead as food for bald eagles and other birds that feed primarily on salmon and steelhead would decrease up to 8 percent, compared to Alternative 1. This effect would generally not affect other birds that only occasionally feed on salmon and steelhead.	Supply of hatchery-origin salmon and steelhead as food for bald eagles and other birds that feed primarily on salmon and steelhead would increase up to 16 percent compared to Alternative 1. The effect on other birds that only occasionally feed on salmon and steelhead would be the same as Alternative 3.

Table 4.8-1. Summary of environmental consequences by resource and alternative that includes implementation of adaptive management for Alternative 2, Alternative 3, and Alternative 4, continued.

Resource	Alternative 1 (No Action)[1]	Alternative 2[2] (Proposed Action)	Alternative 3[2] (Reduced Production)	Alternative 4[2] (Increased Production)
Non-listed Marine Mammals: Steller sea lion, California sea lion, and harbor seal	Steller sea lions, California sea lions, and harbor seals would continue to occupy their existing habitat in the project area with similar abundances, and the species would continue to feed as generalists on fish species that include salmon and steelhead.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Other Wildlife Species	Other wildlife species would continue to occupy their existing habitat in the project area with similar abundances, and would continue to feed on a variety of prey including salmon and steelhead.	Same as Alternative 1.	Supply of hatchery-origin salmon and steelhead as food would decrease 8 percent, which would primarily affect river otter, compared to Alternative 1. Other wildlife species are generalists and feed on a variety of prey species, and thus would not be affected by the decrease in salmon and steelhead.	Supply of hatchery-origin salmon and steelhead as food would increase 16 percent, which would primarily benefit river otter. The effect on other wildlife species that are generalists and feed on a variety of prey species would be the same as Alternative 3.
Water Quality and Quantity	Hatchery operations would comply with NPDES permits. The potential would exist for effluents to periodically exceed permit limits and for instances of non-reporting, and the nutrient contributions from decomposition of salmon carcasses would continue.	Potential improvements in water quality and reduction in water use through adaptive management.	Same as Alternative 2.	Same as Alternative 2.
Human Health	Chemical and antibiotic use would be consistent with Federal and state guidelines. Potential exposure to pathogens.	Potential decrease in the use of chemicals and antibiotics through adaptive management.	Potential for further decrease in the use of chemicals and antibiotics relative to Alternative 2. Potential exposure to pathogens would be the same as Alternative 2.	Potential increase in the use of chemicals and antibiotics relative to Alternative 1. Potential exposure to pathogens would be the same as Alternative 2.

[1] An adaptive management process is not part of Alternative 1.

[2] Potential differences between the no-action and the action alternatives would be due to differences in hatchery production and application of adaptive management mitigation measures under the action alternatives.

[3] Effects of releases of listed hatchery-origin summer-run chum salmon are not evaluated in this EIS because they are addressed in a previous environmental review (NMFS 2002b, 2004b).

Chapter 5
Cumulative Effects

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5.0 CUMULATIVE EFFECTS

5.1 Introduction

The National Environmental Policy Act defines cumulative effects as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions” (40 CFR 1508.7). Chapter 3, Affected Environment, describes the baseline conditions for each resource and reflects the effects of past and existing actions. Chapter 4, Environmental Consequences, evaluates the direct and indirect effects of the alternatives on each resource’s baseline conditions. This chapter considers the cumulative effects of each alternative in the context of past actions, existing conditions, and reasonably foreseeable future actions and conditions.

5.2 Geographic and Temporal Boundaries of Cumulative Effects Analysis

The cumulative effects analysis area includes the project area as shown in Figure 1.4-1, and additionally includes the entire United States and Canadian portions of the Strait of Juan de Fuca, Strait of Georgia, and all connecting channels and adjoining waters, all of which encompasses an area collectively known as the Salish Sea (Figure 5.2-1). The area is also commonly referred to as the Georgia Basin, Strait of Juan de Fuca, and Puget Sound ecosystem. This cumulative effects area was determined based on the geography, topography, waterways, and natural interactions that occur among the ecosystems present in Puget Sound. Biological resources and human populations within the Salish Sea cumulative effects area share a common airshed, common watershed, and common flyway. The developed area has a population of approximately 7 million people with some population projections to 9.4 million by 2025 (Environment Canada - EPA 2008). As summarized by Quinn (2010), the Salish Sea ecosystem includes 6,950 square miles (18,000 square kilometers) of water, 42,470 square miles (110,000 square kilometers) of land area, and some 4,660 miles (7,500 kilometers) of marine shoreline (including islands). The largest single input of fresh water comes from the Fraser River, which drains a large part of British Columbia.

Provided below are known past, present, and future actions from a regional context that have occurred, are occurring, and are reasonably likely to occur within the cumulative effects analysis area. Expected future actions include climate change, human development, and planned restoration activities. Many plans, regulations, and laws are in place, as well as agreements between the United States and Canada (Environment Canada - EPA 2008), to minimize the effects of development and to restore habitat function (Subsection 1.7, Relationship to Other Plans, Regulations, and Laws). However, it is unclear if these plans, regulations, and laws will be successful in meeting their environmental goals and objectives. In addition, it is impossible to predict the magnitude of effects from future development and habitat restoration for several reasons: 1) the activities may not have yet been formally proposed, 2) mitigation measures specific to future actions may not have been identified for many proposed projects, and 3) there is uncertainty whether mitigation measures for these actions will be fully implemented. However, when combined with climate change, a general trend in expected cumulative effects can be estimated for each resource as described in Subsection 5.6, Cumulative Effects by Resource.

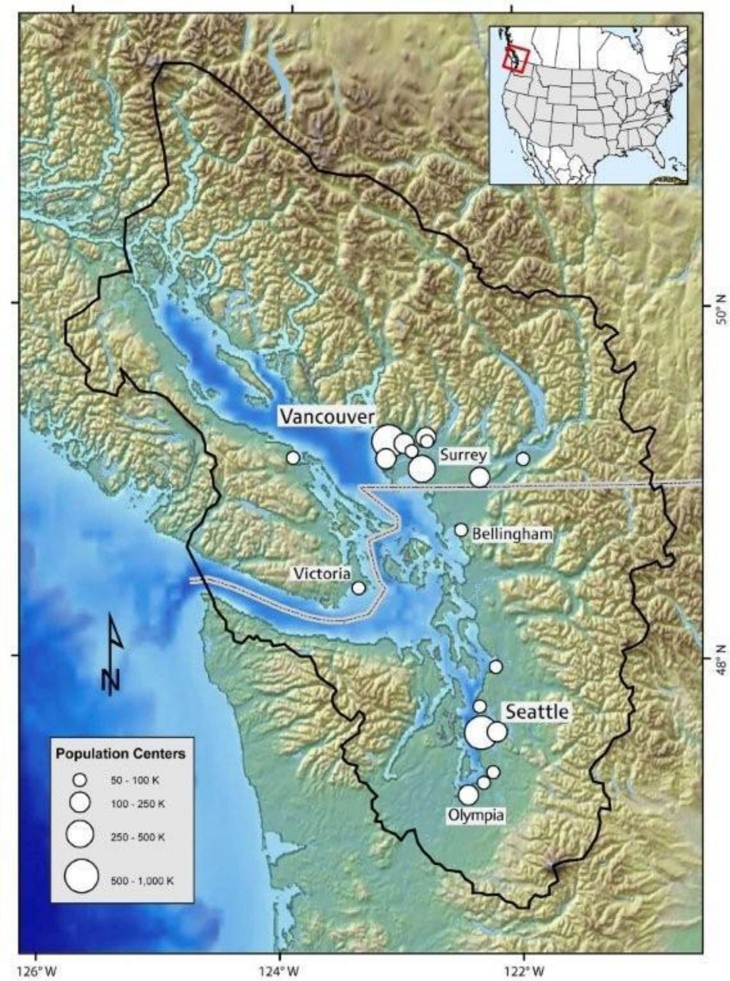

Figure 5.2-1. Cumulative effects analysis area.

Subsection 5.3, Historical Actions, summarizes past actions that affected the cumulative effects analysis area; Subsection 5.4, Current Conditions, describes current overall trends for the area; and Subsection 5.5, Future Actions, describes climate change effects, development, and habitat restoration activities and objectives supported by agencies and other non-governmental organizations to restore habitat in the cumulative effects analysis area. Finally, Subsection 5.6, Cumulative Effects by Resource, describes how these past, present, and future actions affect each resource evaluated in this EIS, and specifically focuses on the effects of alternatives, when possible. Because of the large geographic scope of this EIS, it is not feasible to conduct a detailed assessment of all project-level activities that have occurred, are occurring, or are planned in the future for the cumulative effects analysis area. Rather, this cumulative effects analysis qualitatively assesses the overall trends in cumulative effects considering past, present, and reasonably foreseeable future actions, and describes how the alternatives contribute to that trend.

The timeframe for this cumulative effects analysis is at least 15 years, although there is no defined term or duration for the RMPs or the EIS (Subsection 1.1, Introduction). The analysis of development and habitat restoration effects is based on potential certainty that actions will likely occur, and encompasses approximately three generations of salmon and steelhead (one generation takes about 5 years), which is the number of generations over which changes in response to management actions might reasonably be observed. Climate change is expected to continue to occur over the long term. Thus, the analysis of resource effects reflects shorter-term effects in relation to the scale of climate change. Localized future actions (e.g., urbanizing developments) have a greater potential to impose immediate, substantial cumulative effects on resources when combined with the direct and indirect effects analyzed in Chapter 4, Environmental Consequences. Considering the timeframe, this cumulative effects analysis provides expected trends, but recognizes that sufficient data are lacking to make definitive determinations of the magnitude of the effect.

5.3 Historical Actions

Humans occupied the shores and islands of the Salish Sea for at least the past 8,000 years (Stein 2000). Before Europeans arrived in the Salish Sea ecosystem, most human inhabitants were hunter-gatherers. They relied on sea life for food, animals for food and warm clothing, and trees for building materials. Indigenous peoples were known to use the waterways of the Salish Sea as trading routes. Fire was used to modify the environment, to clear areas to aid hunting, to promote berry production, and to support the growth of grasses for making nets, baskets, and blankets (Barsh 2003).

In the 1800s, with the arrival of the first Europeans, trapping and logging were initiated on a large scale, which changed the landscape. Washington State became one of the top five producers of timber, and salmon harvest increased by over 2,000 percent compared to harvest before European arrival. As natural resource extraction and the number of people in the area increased, the quality of the Salish Sea ecosystem declined. Most of the old-growth forest was harvested, and much forestland was converted to human-dominated uses, such as agriculture and urban development. The quantity and availability of tidal marsh and other freshwater estuarine ecosystem types declined, floodplains were altered, rivers and streams were channelized, estuaries were filled, shorelines were hardened and/or modified, water and air quality declined, pollution and marine traffic increased, and habitat was lost (British Columbia Ministry of Water, Land, and Air Protection [BCMWLAP] 2002; Puget Sound Partnership [PSP] 2012). Many of these actions affected salmon and steelhead (Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead; Subsection 3.2.5.2, Distribution and Abundance of Natural-origin Chinook Salmon). As a result, the number of marine-related species at risk in the Salish Sea ecosystem increased, as did the presence of non-native invasive species (Quinn 2010).

5.4 Current Conditions

As described in Subsection 5.3, Historical Actions, substantial changes have occurred to land uses and the marine environment in the Salish Sea cumulative effects analysis area, but the area remains one of the most ecologically diverse in North America, containing a wide range of species and habitats that span international boundaries (EPA 2011). The topography of the area creates highly variable local-scale climates and, in combination with diverse soil types, results in a wide variety of environmental conditions. This variety is important because it supports a diversity of fish species and life histories as described in Subsection 3.2, Fish. For example, the diversity (genetic and behavioral) represented by variation in Chinook salmon and steelhead life histories helps both species adapt to short-term and long-term changes in their environment over time (McElhany et al. 2000).

The Center for Biological Diversity (2005) identified 7,000 species of organisms that occur in Puget Sound, and the area is considered one of the most productive areas for salmon along the Pacific Coast (Lombard 2006). However, the World Wildlife Fund (2012) considers the remaining natural habitats in the Salish Sea area to be threatened from ongoing urbanization, agricultural practices, fire suppression, introduction of noxious weeds, flood control efforts, operation of hydroelectric dams, and logging. For example, as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, these human-induced factors (e.g., habitat modifications, water quality degradation, presence of dams and fish barriers, and other factors) have affected overall abundance, productivity, diversity, and distribution of salmon and steelhead in Puget Sound. In addition, aquaculture (farming of fish, shellfish, and aquatic plants in fresh and marine water for direct harvest), which is practiced in Washington and British Columbia, has the potential to affect other aquatic organisms. Altogether, these stressors under current conditions are expected to continue under future actions as described below.

5.5 Future Actions

Reasonably foreseeable future actions include climate change, development, and habitat restoration.

5.5.1 Climate Change

The changing climate is becoming recognized as a long-term trend that is occurring throughout the world. Within the Pacific Northwest, Ford (2011) summarized expected climate changes in the coming years as leading to the following physical and chemical changes (certainty of occurring is in parentheses):

- Increased air temperature (high certainty)
- Increased winter precipitation (low certainty)
- Decreased summer precipitation (low certainty)
- Reduced winter and spring snowpack (high certainty)
- Reduced summer stream flow (high certainty)
- Earlier spring peak flow (high certainty)
- Increased flood frequency and intensity (moderate certainty)
- Higher summer stream temperatures (moderate certainty)
- Higher sea level (high certainty)
- Higher ocean temperatures (high certainty)
- Intensified upwelling (moderate certainty)
- Delayed spring transition (moderate certainty)
- Increased ocean acidity (high certainty)

These changes will affect human and other biological ecosystems within the cumulative effects analysis area (Ecology 2012a). Changes to biological organisms and their habitats are likely to include physiological heat tolerance and metabolic costs, disease resistance, shifts in timing of life history events, changes in growth and development rates, changes in habitat and ecosystem structure, and rise in sea level and increased flooding (Littell et al. 2009; Johannessen and Macdonald 2009).

For the Pacific Northwest portion of the United States, Hamlet (2011) notes that climate changes will have multiple effects. Expected effects include:

- Overtaxing of storm water management systems at certain times
- Increases in sediment inputs into water bodies from roads
- Increases in landslides
- Increases in debris flows and related scouring that damages human infrastructure
- Increases in fires and related loss of life and property
- Reductions in the quantity of water available to meet multiple needs at certain times of year (e.g., for irrigated agriculture, human consumption, and habitat for fish)
- Shifts in irrigation and growing seasons
- Changes in plant, fish, and wildlife species' distributions and increased potential for invasive species
- Declines in hydropower production
- Changes in heating and energy demand
- Impacts to homes along coastal shorelines from beach erosion and rising sea levels

The most heavily affected ecosystems and human activities along the Pacific coast are likely to be near areas having high human population densities, and the continental shelves off Oregon and Washington (Halpern et al. 2009).

Several studies note that similar changes are expected to occur in British Columbia. For example, climate changes in Georgia Strait are expected to include warming of marine waters (Littell et al. 2009) and fresh waters (Perry 2009), and changes in river flow patterns from snow-melt-dominated conditions to rainfall-dominated conditions. Examples of the effects of climate change on human populations include loss of agricultural land because of inundation by rising sea levels, increases in storm intensity duration and frequency, salinization of municipal water intakes, and increases in the risk of tidal flat erosion and dike breaching and flooding (Natural Resources Canada [NRC] 2014).

5.5.2 Development

Future human population growth in the Seattle and Vancouver areas, and the areas between them, is expected to continue over the next 15 years (Metro Vancouver 2013; Puget Sound Regional Council 2013), which will result in increased demand for housing, transportation, food, water, energy, and commerce. These needs will result in changes to existing land uses because of increases in residential and commercial development and roads, increases in impervious surfaces, conversions of private agricultural and forested lands to developed uses, increases in use of non-native species and increased potential for invasive species, and redevelopment and infill of existing developed lands. The need to provide food and supplies to a growing human population in the cumulative effects analysis area will result in increases in shipping, increases in withdrawals of fresh water to meet increasing food and resource requirements, and increases in energy demands. Although the rate of urban sprawl has been decreasing in comparison to previous increases in the late 1900s (Puget Sound Regional Council 2012), development will continue to affect the natural resources in the cumulative effects analysis area.

To help protect environmental resources in the cumulative effects analysis area from potential future development effects, both the United States and Canada have Federal environmental protection agencies and Federal laws, regulations, and policies that are designed to conserve each nation's air, water, and land resources. Regulatory processes involve agency review, approval, and permitting of development actions. Regulatory examples include the Federal Endangered Species Act in the United States and the Species at Risk Act in Canada. Other examples include the Navigable Waters regulations of the Clean Water Act in the United States, and the Navigable Waters Protection Act in Canada. In the United States, aquaculture facilities (such as enclosed facilities for raising and selling fish, shellfish [including geoducks], and aquatic plants) are regulated by Washington State. In Canada, aquaculture facilities are regulated by British Columbia Department of Fisheries, and Fisheries and Oceans Canada. These environmental laws will continue to require agency review and approval of proposed activities.

In addition to Federal laws and processes, state and provincial laws, regulations, and guidelines will help decrease the effects of future commercial, industrial, and residential development on natural ecosystems. In Washington State, various habitat conservation plans (HCPs) have been implemented, such as the Washington Department of Natural Resources (DNR) Forest Practices HCP (DNR 2005), and other HCPs are in development (e.g., DNR Aquatic Lands HCP[1] and Washington Department of Fish and Wildlife [WDFW] Wildlife Areas HCP[2]). These plans will provide long-term, landscape-based protection of federally listed and non-listed species considered at risk of extinction in Washington's private and state forested lands. Other state laws, regulations, and guidance include the Washington State Environmental Policy Act, and its Endangered, Threatened, and Sensitive Species Act as described in Subsection 1.7.3, State Guidance and Regulations. A law unique to the State of Washington is the Growth Management Act (Chapter 36.70A Revised Code of Washington), which requires local land use planning and development of regulations, including identification and protection of critical areas from future development (Subsection 1.7.3.4, Washington State Growth Management Act).

Although the Province of British Columbia does not have comparable growth management laws and regulations for future development, the province reviews and approves future development primarily through its Environmental Assessment Act (which is separate from the Federal Canadian Environmental Assessment Act) and other laws and regulations (such as the Environment and Land Use Act, Environmental Management Act, Forest Act, Water Act, Water Protection Act, Wildlife Act, Fisheries Act, Shorelines Management Act, and Fish Protection Act). These provincial and state regulations will continue to help decrease habitat fragmentation, avoid residential development and urban sprawl in sensitive habitat and ecosystems, and decrease contamination to air, lands, and waterways.

In Washington, local land use laws, regulations, and policies will also help protect the natural environment from future development effects. For example, the Puget Sound Regional Council (PSRC) developed Vision 2040 to identify goals that support preservation and restoration of the natural environment ongoing with development through multicounty policies that address environmental stewardship (PSRC 2009). Vision 2040 is a growth management, environmental, economic, and transportation strategy for central Puget Sound. These objectives also include preserving open space, focusing on sustainable development, and planning for a comprehensive green space strategy. Other local policies and initiatives by counties and municipalities include designation of areas best suited for future development, such as local sensitive areas acts and shoreline protection acts.

In lower British Columbia, local zoning and development laws will help to protect open space from future development. The Greater Vancouver Regional District designates Green Zones to protect natural land assets (Greater Vancouver Regional District 2005). In addition, the Fraser River Estuary Management

[1] DNR Aquatic Lands HCP available at http://www.dnr.wa.gov/researchscience/topics/aquatichcp/pages/aqr_aquatics_hcp.aspx
[2] WDFW Wildlife Areas HCP available at http://wdfw.wa.gov/lands/wildlife_areas/hcp/

Plan was developed by a partnership of agencies and serves as a policy guide for municipalities and other agencies with jurisdiction or interest in the Fraser River estuary (Fraser River Estuary Management Program 2012). In ecologically sensitive areas, this plan is focused on protecting critical fish and wildlife functions. In addition, municipalities in British Columbia have community plans with policies and guidelines related to land use, development, services, amenities, and infrastructure related to future development (NRC 2014). The plans identify environmentally sensitive areas where future development is limited to protect environmental attributes.

In summary, in the Washington and British Columbia portions of the cumulative effects analysis area, Federal, state, and local laws, regulations, and policies will be applied with the intent to better enforce environmental protection for proposed future project developments. These laws, regulations, and policies include processes for public input, agency reviews, mitigation measures, permitting, and monitoring. The intent of these processes is to help ensure that development projects will occur in a manner that protects sensitive natural resources. The environmental goals and objectives of these processes are aimed at protecting ecosystems from activities that are regulated; however, not all activities are regulated to the same extent (e.g., large developments tend to be regulated more than smaller developments). Further, it is uncertain if all environmental goals and objectives can be successfully met by such processes. Unregulated or minimally regulated activities may lead to cumulative effects on sensitive natural resources over time. Thus, although Federal, state, and local laws, regulations, policies, and guidelines are in place to protect environmental resources from future development effects, there will continue to be some cumulative environmental degradation in the future from development, albeit likely to a lesser extent than has occurred historically when environmental regulatory protections did not exist or were not comprehensive and collaborative.

5.5.3 Habitat Restoration

To counterbalance the human-induced changes that will affect biodiversity in the cumulative effects analysis area (Subsection 5.5.2, Development), future funding for environmental restoration efforts will continue to help create a healthy environment and sustainable ecosystem (PSRC 2009; BCMWLAP 2002). United States Federal agencies and organizations are expected to continue to support habitat protection and restoration initiatives/processes in Puget Sound, including projects such as the Puget Sound Nearshore Ecosystem Restoration Project (Puget Sound Nearshore Ecosystem Restoration Partnership 2013), which is a partnership between the U.S. Army Corps of Engineers and WDFW for the purpose of identifying ecosystem degradation, formulating solutions, and recommending actions and projects to help restore Puget Sound. The Puget Sound Partnership (formerly the Shared Strategy for

Puget Sound) is a collaborative initiative that will continue efforts to recover the Puget Sound ecosystem (including listed salmon, steelhead, and other species) with the support of NMFS, U.S. Fish and Wildlife Service, Washington State, Puget Sound tribes, local governments, and key non-government organizations. In addition, implementation of salmon recovery plans in Puget Sound (72 Fed. Reg. 2493, January 19, 2007, for Chinook salmon, and 72 Fed. Reg. 29121, May 24, 2007, for Hood Canal summer-run chum salmon), will continue to recover salmon and steelhead and the habitats on which they depend in Puget Sound (Subsection 1.7.4.1, Recovery Plans for Puget Sound Salmon). It is expected that NMFS will continue to provide funding for habitat restoration initiatives through the Pacific Coastal Salmon Recovery Fund (NMFS 2011a). However, based on a recent review of the implementation of the Puget Sound Chinook salmon recovery plan (NMFS 2011b), habitat continues to decline and habitat protection tools currently in place continue to need improvement.

Federal Canadian funding for habitat restoration includes several ongoing and expected future funded programs supported by Environment Canada. These projects regularly provide annual funding for habitat restoration and include:

- B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program (designed to fund projects to restore fish and wildlife populations and habitats in watersheds impacted by hydroelectric generation facilities)
- Habitat Conservation Trust Fund (includes funds for habitat enhancement and restoration)
- Public Conservation Assistance Fund (with objectives similar to the Habitat Conservation Trust Fund)
- EcoAction Community Funding Program (with several objectives that include habitat enhancement and rehabilitation)

It is expected that Washington State will continue to support habitat restoration through actions similar to recent support efforts. In addition to cooperative partnerships with Federal agencies as described above, Ecology (2012b) reserves funding for cleanups of toxics in Puget Sound. Although receiving substantial Federal support, the Puget Sound Partnership is a state agency that was created to lead the recovery of the Puget Sound ecosystem (PSP 2010). The agency created, and is overseeing implementation of, a roadmap to a healthy Puget Sound. Objectives include prioritizing cleanup and improvement projects; coordinating Federal, state, local, tribal, and private resources; and ensuring that all agencies and funding partners are working cooperatively. Washington State also created the Salmon Recovery Funding Board, which administers Federal and Washington State funds to protect and restore salmon and steelhead habitat. Priorities for recovering the Puget Sound ecosystem include reducing land development pressure on ecologically important and sensitive areas, protecting and restoring floodplain function, and protecting and recovering salmon and freshwater resources (PSP 2012). In marine and freshwater areas, development will continue to be encouraged away from ecologically important and sensitive nearshore areas and estuaries, and efforts will be made to reduce sources of pollution into Puget Sound (including stormwater runoff). Approaches will be used to help preserve the natural functions of the ecosystem and support sustainable economic growth. Local community efforts, such as smaller community habitat restoration and protection efforts, will help protect sensitive areas in Puget Sound.

In British Columbia, the provincial Watershed Restoration Program under Forest Renewal British Columbia will continue to restore the productive capacity of fisheries, and forest and aquatic resources that have been impacted by past forest practices. The Watershed Restoration Program hastens the recovery of degraded environmental resources in logged watersheds by identifying the needs for proposed restoration projects and by designing and implementing restoration that re-establishes conditions more similar to those found in watersheds that are not degraded. Other provincial and local habitat restoration initiatives will be continued, including the Salmon Habitat Restoration Program, which has historically been supported by the Canadian Federal government, but is now supported by the provincial and local governments.

In summary, a variety of Federal, state, provincial, and local programs will help restore degraded habitat conditions in the cumulative effects analysis area. Collectively, these programs will help to counterbalance habitat degradation and long-term detrimental cumulative impacts to natural resources in the cumulative effects analysis area, which have previously contributed to Federal and state listings of fish and wildlife species (Subsection 3.2, Fish and Subsection 3.5, Wildlife).

5.6 Cumulative Effects by Resource

Provided below is an analysis of the cumulative effects of climate change, development, and habitat restoration under the alternatives and for each resource analyzed in this EIS. The resources for which cumulative effects are described are: fish, socioeconomics, environmental justice, wildlife, water quality and quantity, and human health.

5.6.1 Fish

Subsection 3.2, Fish, describes existing conditions, which include the effects of past and present conditions on listed and non-listed salmon and steelhead and other fish in the cumulative effects analysis area. These effects are from past and current climate change, development, and habitat restoration. The expected direct and indirect effects of the alternatives on listed and non-listed fish are described in Subsection 4.2, Fish. Future actions are described in Subsection 5.5, Future Actions. This subsection describes cumulative effects on fish that may occur as a result of implementing any of the alternatives at the same time as other future actions. Discussed are cumulative impacts in the context of salmon and steelhead in general, as well as other fish species with a relationship to salmon and steelhead that are evaluated in Subsection 4.2, Fish. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on fish resources.

5.6.1.1 Salmon and Steelhead

Salmon and steelhead abundance naturally alternates between high and low levels on large temporal and spatial patterns that may last centuries and on more complex ecological scales than can be easily observed (Rogers et al. 2013). Current run sizes of salmon and steelhead in the cumulative effects analysis area are about 36 percent of historical run sizes in British Columbia, and are about 8 percent of historical run sizes in Puget Sound (Lackey et. al. 2006). Thus, cumulative effects on salmon and steelhead may be greater than the direct and indirect effects of each alternative as analyzed in Subsection 4.2, Fish, for all alternatives. This subsection provides brief overviews of the effects of climate changes, development, and habitat restoration on salmon and steelhead, and focuses on cumulative effects by each risk and benefit category described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and as analyzed in Subsection 4.2, Fish.

In addition to hatchery production of salmon and steelhead in Puget Sound (described in Subsection 3.2, Fish), hatchery production and salmon aquaculture also occur in the Canadian portion of the cumulative effects analysis area. The Canadian Salmonid Enhancement Program uses hatcheries, along with other strategies, to conserve and rebuild populations of natural-origin salmon and to provide fishing opportunities for Canadians (MacKinlay et al. 2004). In 2002, these hatcheries raised 173 million salmon, steelhead, and trout (Chinook salmon, 30 percent; chum salmon, 42 percent; coho salmon, 11 percent; pink salmon, 10 percent; sockeye salmon, 7 percent; steelhead, less than 1 percent; and cutthroat trout, less than 1 percent). Total time in hatcheries for these fish is 10 months or less with subsequent release into freshwater or marine environments. Releases are from 18 major hatcheries, 21 community hatcheries, and 16 public involvement or educational hatcheries. Releases in 2009 (most recent information available) were 300 million fish. The majority of the 2009 fish released were sockeye salmon (about half the fish released) followed by chum salmon, Chinook salmon, pink salmon, coho salmon, steelhead, and cutthroat trout (Sandher et al. 2010). Aquaculture operations also occur in British Columbia where salmon are raised in marine pens to adulthood with subsequent seafood processing and no fish releases into the freshwater or marine environment. These aquaculture operations raise almost exclusively Atlantic salmon. These hatchery releases within the Salish Sea, along with other observed environmental trends as described in the following subsections, would affect continued long-term viability of natural-origin salmon and steelhead. Proposed changes in hatchery production under the alternatives analyzed in this EIS would affect risks and benefits, and proposed mitigation measures under adaptive management that are associated with the alternatives would help decrease overall risks to salmon and steelhead.

5.6.1.1.1 Climate Change

The effects of climate change on salmon and steelhead are described in general in ISAB (2007), and would vary among species and among species' life history stages. Effects of climate change may affect virtually every species and life history type of salmon and steelhead in the cumulative effects analysis area (Glick et al. 2007; Mantua et al. 2009). Cumulative effects from climate change, particularly changes in streamflow and water temperatures, would likely impact hatchery-origin and natural-origin salmon and steelhead life stages in various ways as described below and shown in Table 5.6-1. Under all alternatives, impacts to salmon and steelhead from climate change are expected to be similar, because climate change would impact fish habitat for each alternative in the same manner.

5.6.1.1.2 Development

Previous and new developments (such as residential, commercial, transportation, and energy development); accidental discharges of oil, gas, and other hazardous materials; and the potential for landowner and developer noncompliance with regulations continue to affect aquatic habitat used by salmon and steelhead (Puget Sound Action Team 2007). Although regulatory changes for increased environmental protection (such as local critical areas ordinances), monitoring, and enforcement have helped reduce impacts of development on salmon and steelhead in fresh and marine waters, development may continue to reduce salmon and steelhead habitat, decrease water quality, and contribute to salmon and steelhead mortality. These developments result in environmental effects such as land conversion, sedimentation, impervious surface water runoff to streams, changes in stream flow because of increased consumptive uses, shoreline armoring effects, channelization in lower river areas, barriers to fish passage, and other types of environmental changes that would continue to affect hatchery-origin and natural-origin salmon and steelhead (Quinn 2010).

Table 5.6-1. Examples of potential impacts of climate change by salmon and steelhead life stage under all alternatives.

Life Stage	Effects
Egg	1) Increased water temperatures and decreased flows during spawning migrations for some species would increase pre-spawning mortality and reduce egg deposition. 2) Increased maintenance metabolism would lead to smaller fry. 3) Lower disease resistance may lead to lower survival. 4) Changed thermal regime during incubation may lead to lower survival. 5) Faster embryonic development would lead to earlier hatching. 6) Increased mortality for some species because of more frequent winter flood flows as snow level rises. 7) Lower flows would decrease access to or availability of spawning areas.
Spring and Summer Rearing	1) Faster yolk utilization may lead to early emergence. 2) Smaller fry are expected to have lower survival rates. 3) Higher maintenance metabolism would lead to greater food demand. 4) Growth rates would be slower if food is limited or if temperature increases exceed optimal levels; growth could be enhanced where food is available, and temperatures do not reach stressful levels. 5) Predation risk would increase if temperatures exceed optimal levels. 6) Lower flows would decrease rearing habitat capacity. 7) Sea level rise would eliminate or diminish the rearing capacity of tidal wetland habitats for rearing salmon, and would reduce the area of estuarine beaches for spawning by forage fishes.
Overwinter Rearing	1) Smaller size at start of winter is expected to result in lower winter survival. 2) Mortality would increase because of more frequent flood flows as snow level rises. 3) Warmer winter temperatures would lead to higher metabolic demands, which may also contribute to lower winter survival if food is limited, or higher winter survival if growth and size are enhanced. 4) Warmer winters may increase predator activity/hunger, which can also contribute to lower winter survival.

Sources: ISAB (2007), Glick et al. (2007), Beamish et al. (2009), and Beechie et al. (2013).

The primary cause of these continuing development changes is the continued increase in human population in the cumulative effects analysis area, which also leads to fisheries management challenges associated with over fishing (Puget Sound Action Team 2007). Development would more likely affect species that reside in lower river areas (such as floodplains and estuaries) most directly because that is where development tends to be concentrated. Effects from development are expected to affect salmon and steelhead similarly for all alternatives because preferred development sites would not change by alternative scenario.

5.6.1.1.3 Habitat Restoration

Restoration of habitat in the cumulative effects analysis area will improve salmon and steelhead habitat in general under all alternatives, with particular benefits to freshwater and estuarine environments considered to be important for the survival and reproduction of fish. As a result, habitat restoration would be expected to improve fish survival in local areas (Puget Sound Action Team 2007). However, habitat restoration alone will not substantially increase survival and abundance of salmon and steelhead without improvements in the factors and risks known to affect salmon and steelhead survival as described in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead. In addition, habitat restoration is dependent on continued funding, which is difficult to predict when economic recessions occur or governments experience deficits. Benefits from habitat restoration are expected to affect salmon and steelhead survival similarly for all alternatives.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify, but are expected to occur in localized areas where the activities occur. These actions may not fully, or even partially, mitigate for the impacts of climate change and development on fish and wildlife and their associated habitats. However, climate change and development will continue to occur over time and affect aquatic habitat, while habitat restoration (which is dependent on funding and is localized in areas where agencies and stakeholders' habitat restoration actions occur) is less certain under all alternatives.

In summary, aquatic habitat may continue to degrade over time under all alternatives, but degradation may be reduced or avoided in areas where restoration and protection occurs and where the environmental protection goals and objectives are being met under various initiatives/processes.

5.6.1.1.4 Competition and Predation Risks

As described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, competition is used in this EIS to describe conditions when hatchery-origin fish compete with natural-origin fish for food and space, and predation is described as occurring when hatchery-origin fish prey on natural-origin fish. Climate change and development effects to salmon and steelhead may reduce fish habitat and result in increased competition and predation compared to that described Subsection 4.2, Fish. Although habitat may be improved through restoration efforts, climate change and development may result in short- and long-term losses of habitat quality and quantity. Reductions in habitat may increase competition and predation risks within and among salmon and steelhead species (Appendix B, Hatchery Effects and Evaluation Methods for Fish). In contrast, improved habitat conditions and increased food sources for salmon and steelhead (e.g., from habitat restoration), may ameliorate competition and predation risks, particularly in the context of other environmental threats that may impede salmon and steelhead recovery (Appendix B, Hatchery Effects and Evaluation Methods for Fish).

In summary, cumulative effects from climate change and development on competition and predation risks would add to the competition and predation risks described under Subsection 4.2, Fish, and would be proportional to the amount of hatchery production under the alternatives. Compared to existing conditions (Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish) and Alternative 1, detrimental impacts to natural-origin salmon and steelhead from cumulative effects would be greatest under Alternative 4 (which has the most hatchery production), lowest under Alternative 3 (which has the least hatchery production), and intermediate under Alternative 2 (which has the same hatchery production levels as Alternative 1).

5.6.1.1.5 Genetic Risks

Climate change and development have the potential to exacerbate genetic risks to salmon and steelhead. For example, small salmon and steelhead population sizes can be further reduced to critical levels by the effects of climate change and development, posing genetic risks to within-population diversity (Appendix B, Hatchery Effects and Evaluation Methods for Fish). Furthermore, climate change and development may result in habitat changes that affect the way groups of fish are adapted to be genetically similar or different from each other. These habitat changes may include the extent to which water of suitable volume and temperature exists for adult salmon and steelhead to reach spawning areas (Appendix B, Hatchery Effects and Evaluation Methods for Fish). It may also affect patterns of straying in natural-origin and hatchery-origin fish, which may affect genetic diversity that prevents fish from being able to adapt to changing environmental conditions, and thus persist over time (Subsection 5.5.1, Climate Change). Some local genetic benefits to salmon and steelhead from habitat restoration may occur, but these benefits would not likely benefit salmon and steelhead for the entire cumulative effects analysis area.

In summary, cumulative effects from climate change and development to genetic risks would add to the genetic risks described under Subsection 4.2, Fish, and would be proportional to the amount of hatchery production under the alternatives. Thus, compared to Alternative 1, detrimental effects to natural-origin salmon and steelhead in the cumulative effects analysis area would be greatest under Alternative 4 (which has the most hatchery production), lowest under Alternative 3 (which has the least hatchery production), and intermediate under Alternative 2 (which has the same hatchery production levels as Alternative 1).

5.6.1.1.6 Hatchery Facilities and Operation Risks

Risks posed by hatchery facilities and operations are described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and include genetic, survival, disease, straying, competition, predation, water quality and quantity, and barrier risks. These risks are based on hatchery facility design, operation, and maintenance. In the long term, some local climate change effects from hatchery facilities and their operation may occur to salmon and steelhead (e.g., flood damage to hatchery infrastructure and operations [e.g., roads], disruption of water flow resulting in difficulty in attracting broodstock, and increased flow-related siltation that could smother egg incubation trays). However, these effects would be localized and temporary and would not likely affect salmon and steelhead in the short term or over the entire cumulative effects analysis area.

In summary, cumulative effects from climate change, development, and habitat restoration would be unlikely to affect hatchery facility and operation risks in the next 15 years, resulting in no cumulative effects in the analysis area beyond that described in Subsection 4.2, Fish.

5.6.1.1.7 Abundance Benefits

As described in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, hatchery-origin salmon and steelhead abundance increases commercial, tribal, and recreational fishing opportunities. Although climate change, development, and habitat restoration would not affect the number of juvenile fish produced by hatcheries, these three factors considered under cumulative effects may affect survival of the hatchery-origin fish to adulthood, and thus affect adult abundance and the extent to which related conservation and fishing objectives are met. Climate change and development would most likely decrease adult hatchery-origin salmon and steelhead survival (Subsection 5.6.1.1.1, Climate Change, and Subsection 5.6.1.1.2, Development), while habitat restoration may increase local hatchery-origin salmon and steelhead survival.

In summary, cumulative effects from climate change, development, and habitat restoration would generally be expected to decrease survival of hatchery-origin fish to adulthood, and the decrease would be proportional to the amount of hatchery production under the alternatives. Compared to Alternative 1, detrimental impacts to abundance would be greatest under Alternative 4 (which has the most hatchery production), lowest under Alternative 3 (which has the least hatchery production), and intermediate under Alternative 2 (which has the same hatchery production levels as Alternative 1).

5.6.1.1.8 Viability Benefits

Natural-origin salmon and steelhead populations and ESUs are viable when they have a negligible risk of extinction because of factors such as small population size, variable environmental conditions because of human activities, and genetic diversity changes (McElhany et al. 2000). The VSP concept (McElhany et al. 2000) is used by NMFS to evaluate the conservation status of natural-origin salmon and steelhead, and is used in this EIS to evaluate the benefits to natural-origin salmon and steelhead from conservation hatchery programs. Conservation hatchery programs are described in Subsection 2.2.2.1, Artificial Production Strategies. The viability benefit associated with conservation hatchery programs can help foster resiliency of fish populations in the face of uncertain environmental conditions (Appendix B, Hatchery Effects and Evaluation Methods for Fish). The VSP concept relies on four parameters: 1) abundance (the number of natural-origin spawners), 2) productivity (the ratio of natural-origin offspring produced per parent), 3) diversity (the genetic variety within and between populations), and 4) spatial structure (the distribution of populations across a watershed or watersheds) (Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish).

Climate change and development in the cumulative effects analysis area may reduce the abundance and productivity of natural-origin salmon and steelhead for all alternatives because of mechanisms such as:

- Increased mortality of salmon and steelhead because of more frequent and seasonally different flood flows, changed thermal regime during incubation, and lower disease resistance (Table 5.6-1)
- Higher metabolic demands on fish because of warmer winter temperatures, which may also contribute to lower survival in winter if food is limiting (Table 5.6-1)
- Increased predator activity because of warmer winter temperatures, which can also contribute to lower winter survival (Table 5.6-1)

Similarly, climate change and development may also impact the spatial structure and diversity of natural-origin salmon and steelhead for all alternatives, compared to direct and indirect conditions described in Subsection 4.2, Fish.

It is anticipated that cumulative effects of climate change and development on overall viability of natural-origin salmon and steelhead species in terms of individual abundance, productivity, spatial structure, and diversity parameters would occur over the next 15 years and beyond. Along with the viability benefits from conservation hatchery programs described above and that are analyzed in the EIS, it is also possible that habitat restoration may improve some VSP parameters within local areas of the cumulative effects analysis area.

In summary, for all alternatives, cumulative effects from climate change and development would decrease the viability of natural-origin salmon and steelhead overall, and would decrease the viability benefits from conservation hatchery programs. Compared to Alternative 1, detrimental impacts to viability would generally be greatest under Alternative 4 (which has the most hatchery production), lowest under Alternative 3 (which has the least hatchery production), and intermediate under Alternative 2 (which has the same hatchery production levels as Alternative 1).

5.6.1.1.9 Marine-derived Nutrient Benefits

After spawning naturally, salmon and steelhead carcasses decompose in streams and thus return nutrients from the ocean to freshwater habitat. Hatchery-origin carcasses resulting from hatchery operations are also placed in streams to increase marine-derived nutrients in aquatic habitat (Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish). To the extent fewer natural-origin adult salmon and steelhead spawn in the future because of climate change (Table 5.6-1) and development, the relative importance of marine-derived nutrient contributions from hatchery-origin fish may be greater than described in Subsection 4.2, Fish, under all alternatives. Increased natural production of salmon and steelhead from habitat restoration actions may mitigate for these potential cumulative effects, but it is unlikely that habitat restoration could fully mitigate for the combined negative effects of climate change and development in the cumulative effects analysis area. Cumulative effects from climate change, development, and habitat restoration on marine-derived nutrient benefits under the alternatives would be consistent with the marine-derived benefits described in Subsection 4.2, Fish.

In summary, cumulative effects from climate change and development would offset the benefits from habitat restoration and marine-derived nutrient benefits to watersheds. In comparison to Alternative 1, detrimental impacts to marine-derived nutrient benefits would be proportional to the amount of hatchery production under the alternatives. The lowest marine-derived nutrient benefit would occur under Alternative 3 (which would have the least hatchery production), whereas Alternative 4 (which would have the most hatchery production) would have the highest marine-derived nutrient benefit, and Alternative 2 (which would have the same hatchery production levels as Alternative 1) would have an intermediate marine-derived nutrient benefit.

5.6.1.2 Other Fish Species with a Relationship to Salmon and/or Steelhead

Other fish species that have a relationship to salmon and steelhead include bull trout, rainbow trout, coastal cutthroat trout, sturgeon and lamprey, forage fish, groundfish, and resident freshwater fish (Subsection 3.2, Fish). Similar to salmon and steelhead species, these fish species require and use a diversity of habitats (Subsection 3.2, Fish). However, similar to effects described above for salmon and steelhead, these other fish species may also be affected by climate change and development because of the overall potential for loss or degradation of aquatic habitat or the inability to adapt to warmer water temperatures (i.e., Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS). In addition, climate change and development may attract non-native aquatic plants that may, over time, out-compete native aquatic plants that provide important habitat to native fish (Patrick et al. 2012).

The combined effects of climate change and development within the cumulative effects analysis area would likely be negative for other fish species as generally described for salmon and steelhead (Subsection 5.6.1.1, Salmon and Steelhead). As discussed in Subsection 5.6.1.1.3, Habitat Restoration, the extent to which habitat restoration actions may mitigate impacts from climate change and development is difficult to predict. It is possible that habitat restoration actions could have localized benefits for some fish species other than salmon and steelhead.

In summary, cumulative effects from climate change, development, and habitat restoration on other fish species that have a relationship to salmon and steelhead under the alternatives would likely result in a decrease in the abundance of those fish species in the analysis area. These effects would be greatest under Alternative 4 where risks to those species are highest compared to Alternative 1, because Alternative 4 would result in an increase in hatchery-origin fish that would compete with the other fish species for food and habitat. Effects would be lowest under Alternative 3, which would have the lowest number of hatchery-origin fish that would compete with the other fish species compared to Alternative 1. Under Alternative 2, effects to other fish would be intermediate because Alternative 2 would have the same number of hatchery-origin fish produced as under Alternative 1. The benefits to other fish species from marine-derived nutrients from hatchery-origin fish carcasses in streams would help to offset these effects under all alternatives.

5.6.2 Socioeconomics

Subsection 3.3, Socioeconomics, describes how past and existing conditions have influenced socioeconomic factors in the socioeconomics analysis area (Subsection 4.3.2, Analysis Area). These conditions represent the effects of many years of climate change, development, and habitat restoration.

The expected effects of the alternatives on socioeconomics are described in Subsection 4.3, Socioeconomics. Future actions are described in Subsection 5.5, Future Actions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on socioeconomic resources.

Although unquantifiable, climate change and development actions may reduce the number of salmon and steelhead available for harvest over time as described in Subsection 5.6.1, Fish. This, in turn, reduces the income earned by commercial fishers, and the number of salmon and steelhead exported to outside economies relative to conditions considered in Subsection 4.3, Socioeconomics. As a result, the cumulative effects on gross and net economic values for commercial fishers may differ from that considered in Subsection 4.3, Socioeconomics. If abundance of salmon and steelhead decreases as a result of future climate change combined with development in the cumulative effects area, cumulative gross and net economic values for commercial fisheries may be lower than described in Subsection 4.3, Socioeconomics, unless prices increase as a result of reduced supply. However, the wide availability of farmed fish may not support increased prices for natural-origin salmon (Appendix I, Socioeconomic Impact Methods), particularly in British Columbia where fish farms are more prevalent.

Climate change combined with development in the cumulative effects analysis area may additionally affect the cost recreational anglers incur or their willingness to pay. If fewer fish are available for harvest and more restrictions are in place (e.g., reduced bag limits and fishing seasons), fewer recreational fishers may be willing to pay for the opportunity to fish or travel to the area to fish. As a result, cumulative effects on gross and net economic values for recreational fishers may lead to values lower than those considered in Subsection 4.3, Socioeconomics, as well as lead to decreased economic benefits to local communities than those considered in Subsection 4.3, Socioeconomics.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These actions may not fully, or even partially, mitigate for the impacts of climate change and development on the abundance of fish that would be available for commercial or recreational harvest, and therefore, economic benefits from commercial and recreational fishing.

In summary, it is likely that cumulative effects from climate change and development would decrease the number of fish available for harvest, the income obtained by commercial fishers, the number of salmon and steelhead exported to outside economies, and gross and net economic values for commercial and recreational fishers in the analysis area. The decreases would be proportional to the amount of hatchery production under the alternatives. Under Alternative 4 (which would have the most hatchery production compared to Alternative 1), these negative cumulative effects would be offset to some extent by the increase in hatchery-origin fish produced for harvest, and this offset would be greater than Alternative 1 because more hatchery-origin fish would be released. Alternative 3, which would have the lowest hatchery production compared to Alternative 1, would provide the lowest opportunity to offset climate change and development effects, while Alternative 2 (which would have the same hatchery production levels as under Alternative 1) would be intermediate, compared to the other alternatives, in offsetting the cumulative impacts from climate change and development.

5.6.3 Environmental Justice

Subsection 3.4, Environmental Justice, describes how past and present conditions have influenced environmental justice in the analysis area (Subsection 4.4.2, Analysis Area). These conditions represent the effects of many years of climate change, development, and habitat restoration. Subsection 3.4, Environmental Justice, also describes methods for identifying environmental justice user groups and communities of concern. Environmental justice user groups and communities of concern within the cumulative effects analysis area include Indian tribes that fish for salmon and steelhead, low income or minority communities, and low income or minority fishing groups. The expected effects of the alternatives on environmental justice are described in Subsection 4.4, Environmental Justice. Future actions are described in Subsection 5.5, Future Actions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on environmental justice user groups and communities of concern.

In addition to tribal commercial salmon and steelhead harvest (including salmon and steelhead eggs), a portion of tribal fish harvests is also used to meet ceremonial and subsistence needs, the latter of which serve as an indicator of cultural viability. As described in Subsection 5.6.2, Socioeconomics, climate change and development will likely reduce the number of salmon and steelhead available for harvest. As a result, cumulative effects may lead to less commercial, ceremonial, and subsistence harvest by tribes than described in Subsection 4.4, Environmental Justice, for all alternatives. A decrease in harvest may also affect tribal salmon fishing revenues and tribal fishing employment. Similarly, cumulative effects may lead to less harvest and less net revenue for non-tribal user groups of concern, as well as less per capita income in communities of concern than that considered in Subsection 4.4, Environmental Justice, for all alternatives.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These habitat actions may not fully, or even partially, mitigate for the effects of climate change and development on available fish for future revenues for environmental justice user groups of concern and communities of concern.

In summary, it is likely that cumulative effects from climate change and development would affect environmental justice user groups and communities of concern resulting in less commercial, ceremonial, and subsistence harvest available to these groups, and the decreases would be proportional to the amount of hatchery production under the alternatives. Compared to Alternative 1, negative impacts to environmental justice user groups of concern and communities of concern would be greatest under Alternative 3 (which has the least hatchery production) because fewer hatchery-origin fish would be produced to compensate for losses under climate change and development, lowest under Alternative 4 (which has the most hatchery production), and intermediate under Alternative 2 (which has the same hatchery production levels as Alternative 1).

5.6.4 Wildlife

Subsection 3.5, Wildlife, describes how past and present conditions have influenced wildlife in the analysis area (Subsection 4.5.1, Introduction). These conditions represent the effects of many years of climate change, development, and habitat restoration. The effects of the alternatives on wildlife in Puget Sound are described in Subsection 4.5, Wildlife. Future actions for the overall cumulative effects analysis area are described in Subsection 5.5, Future Actions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on wildlife.

As described in Subsection 4.5.3, Hatchery Operations and Wildlife, hatchery facilities have the potential to affect wildlife through the transfer of toxic contaminants and pathogens, hatchery predator control programs and weirs, provision of marine-derived nutrients from salmon and steelhead carcasses, and other hatchery operations. Future actions (including climate change, development, and habitat restoration) would not alter these hatchery facility operation effects in the cumulative effects analysis area beyond that described in the EIS analysis.

As described in Subsection 5.6.1, Fish, climate change and development in the cumulative effects analysis area may reduce the abundance and productivity of natural-origin salmon and steelhead populations. Hatchery-origin salmon and steelhead may be similarly affected. Consequently, the total number of salmon and steelhead available as prey to wildlife may be lower than that considered in Subsection 4.5.4, Predator-prey Relationships between Wildlife and Salmon and Steelhead, for all alternatives. Reduced abundance of salmon and steelhead would also decrease the number of salmon and steelhead carcasses available to wildlife for scavenging. Effects would be most detrimental to wildlife species that have a strong relationship with salmon and steelhead, including Southern Resident killer whale, common merganser, bald eagle, and Caspian terns. Cumulative effects to these species may include changes in distribution in response to changes in the distribution of their food supply, decreases in abundance, and decreases in reproductive success compared to that described in Subsection 4.5, Wildlife. Effects to other wildlife species that have a recurring relationship with salmon and steelhead may also occur depending on how their overall aquatic prey base (which includes salmon and steelhead) would also be affected by climate change, development, and habitat restoration.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These actions may not fully, or even partially, mitigate for the effects of climate change and development on salmon and steelhead abundances.

In summary, it is likely that cumulative effects from climate change, development, and habitat restoration would affect those wildlife species that have a strong relationship with salmon and steelhead, and may impact other wildlife based on whether their overall food supply would decrease or otherwise change in some way (e.g., distribution, composition) as a result of climate change, development, and habitat restoration. Thus, wildlife distribution may change and wildlife abundance and reproductive success may decrease because of climate change and development in the analysis area for all alternatives, and the decreases would be proportional to the amount of hatchery production under the alternatives. Under Alternative 4 (which would have the most hatchery production compared to Alternative 1), these negative cumulative effects would be offset to some extent by the increase in hatchery-origin fish produced, and this offset would be greater than Alternative 1 because more hatchery-origin fish would be released. Alternative 3, which would have the lowest hatchery production compared to Alternative 1, would provide the lowest opportunity to offset climate change and development effects, while Alternative 2 (which would have the same hatchery production levels as under Alternative 1) would be intermediate compared to the other alternatives in offsetting the cumulative impacts from climate change and development. The marine-derived nutrient benefits from salmon and steelhead carcasses would help to offset these impacts under all alternatives.

5.6.5 Water Quality and Quantity

Subsection 3.6, Water Quality and Quantity, describes how past and present conditions have influenced water quality and quantity in the analysis area (Subsection 4.6.1, Analysis Area). These conditions represent the effects of many years of climate change, development, and habitat restoration. The effects of the alternatives on water quality and quantity are described in Subsection 4.6, Water Quality and Quantity. Future actions in the overall cumulative effects analysis area are described in Subsection 5.5, Future Actions. This subsection considers effects that may occur as a result of the alternatives being implemented at the same time as other anticipated future actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on water quality and quantity.

Successful operation of Federal, state, and tribal hatcheries depends on a constant supply of high quality surface, spring, or groundwater that, after use in hatchery facilities, is discharged to adjacent receiving environments (Subsection 3.6, Water Quality and Quantity). Climate change and development are expected to affect water quality by increasing water temperatures and affect water quantity by changing seasonality and magnitude of river flows. Although existing regulations are intended to help protect water quality and quantity from effects related to future development, the effectiveness of these regulations over time is likely to vary. Future habitat restoration would likely improve water quality and quantity (such as helping to decrease water temperatures through shading, decrease sedimentation, decrease water diversions, and protect aquifers and recharge areas). Overall, cumulative effects of climate change and development on water quality and quantity are more likely to impair water quality and reduce water quantity than is described in Subsection 4.6, Water Quality and Quantity. These effects may be offset to some extent by habitat restoration; however, these habitat actions may not fully, or even partially, mitigate for the impacts of climate change and development on water quality and quantity, but this is the goal of many of the restoration programs.

In summary, cumulative effects from climate change, development, and habitat restoration would likely impact water quality (particularly water temperature changes) and water quantity (increased demand on limited water supplies) in the analysis area more than that described in Subsection 4.6, Water Quality and Quantity) for all alternatives. The effects would be expected to be similar among all alternatives.

5.6.6 Human Health

Subsection 3.7, Human Health, describes how past and present conditions have influenced human health in the analysis area (Subsection 4.7.1, Analysis Area). These conditions represent the effects of many years of climate change, development, and habitat restoration. The expected effects of the alternatives on human health are described in Subsection 4.7, Human Health. Future actions are described in Subsection 5.5, Future Actions. This subsection considers potential impacts that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on human health.

As described in Subsection 3.7, Human Health, hatchery facilities use a variety of chemicals to maintain a clean environment for the production of disease-free hatchery-origin fish. Although, in general, consumption of fish provides nutritional values, hatchery-origin fish have the potential to accumulate hatchery chemicals prior to release. In addition, a number of diseases from parasites, viruses, and bacteria are potentially harmful to human health and may be transmitted from fish species to humans, primarily through seafood consumption (e.g., improperly or undercooked fish) or handling of infected fish or fish carcasses.

In summary, climate change, development, and habitat restoration actions in the cumulative effects analysis area are not expected to alter or affect the use of these chemicals, the transfer of toxic contaminants from fish to humans, or affect the transmission of diseases from fish to humans. As a result, no cumulative effects would be expected beyond effects already discussed in Subsection 4.7, Human Health, for all alternatives.

Chapter 6
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Chapter 7
Distribution List

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Federal and State Agencies

Council of Environmental Quality
Department of Fisheries and Oceans, Government of Canada
NMFS Northwest Fisheries Science Center
U.S. Army Corps of Engineers, (Seattle District)
U.S. Department of the Interior, Bureau of Indian Affairs
U.S. Fish and Wildlife Service, Western Washington Office
U.S. Fish and Wildlife Service, Portland Oregon Office
U.S. Environmental Protection Agency, Region 10
Washington Governor's Salmon Recovery Office
Puget Sound Partnership
Washington Department of Fish and Wildlife, Olympia Office

Elected Officials

Washington Governor's Office
U.S. Representatives, Washington State
U.S. Senators, Washington State

Utilities

Puget Sound Energy
Seattle City Light
Tacoma Public Utilities

Puget Sound and Olympic Peninsula Native American Tribes

Jamestown S'Klallam Tribe
Lower Elwha Klallam Tribe
Lummi Indian Nation
Makah Indian Tribe
Muckleshoot Indian Tribe
Nisqually Indian Tribe
Nooksack Indian Tribe
Port Gamble S'Klallam Tribe
Puyallup Tribe
Sauk-Suiattle Indian Tribe
Skokomish Tribe

Skagit System Cooperative
Snoqualmie Tribe
Squaxin Island Tribe
Stillaguamish Tribe
Suquamish Tribe
Swinomish Indian Tribal Community
Tulalip Tribes
Upper Skagit Tribe

Columbia River Basin Native American Tribes
Cowlitz Indian Tribe
Yakima Indian Nation

Councils and Commissions
Columbia River Inter-tribal Fish Commission
Hood Canal Coordinating Council
Northwest Indian Fisheries Commission
Northwest Power and Conservation Council
Pacific Fishery Management Council
Pacific Salmon Commission
Pacific States Marine Fisheries Commission
Point No Point Treaty Council

Organizations and Associations
American Rivers
Building Industry Association of Washington
Center for Biological Diversity
Coastal Conservation Association, Washington
Earth Justice
Fishing Vessel Owner's Association
Long Live the Kings
Marine Conservation Biology Institute
Native Fish Society
Northwest Sportfishing Industry Association
NW Energy Coalition
Ocean Conservancy
Pacific Biodiversity Institute
Pacific Coast Federation of Fishermen's Associations

Pacific Rivers Council
People for Puget Sound
Seafood Producers Coop
Seattle Audubon Society
Sierra Club
The Mountaineers
Trout Unlimited
Washington Association of Realtors
Washington Environmental Council
Washington State Council of the Federation of Fly Fishers
Washington State Farm Bureau
Wild Fish Conservancy
Wild Salmon Center
Wild Steelhead Coalition

Libraries

Anacortes Public Library
Clallam Bay Library
Everett Public Library
Jefferson County Library
King County Library System, Bellevue
Kitsap Regional Library
Mount Vernon City Library
North Olympic Library System, Main Library, Port Angeles
Olympia Timberland Library
Pierce County Library
Port Orchard Library
Seattle Public Library, Main Library
Sno-Isle Libraries
Tacoma Public Library
Washington State Library
Whatcom County Library

Individuals*

Paul Friesma

* Additional individuals were contacted via email and sent an electronic link to the draft EIS.

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List of Preparers

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8 LIST OF PREPARERS

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Margaret Spence, Contractor Project Manager, Water Quality and Quantity support, Human Health support	Parametrix	B.S. Mathematical Sciences, M.S. Applied Statistics-Biometry
Kyle Brakensiek, Salmon and Steelhead	ICF International	B.S. Fisheries, M.S. Fisheries
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Tina Loucks-Jaret, Technical Editor	Petals to Protons	B.S. Environmental Studies, B.S. Botany, M.S. Technical Communication
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Lars Mobrand, Salmon and Steelhead	ICF International	B.S. Chemistry, Ph.D. Biomathematics
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8.1 Agencies and Individuals Consulted for Development of the EIS

The following organizations and individuals contributed to development of the EIS:

- NMFS Protected Resources Division (Lynne Barre and Teresa Mongillo on killer whales; Gary Sims on tribal resources)
- NMFS Sustainable Fisheries Division (Rob Jones on hatchery production and salmon and steelhead, Lance Kruzic and salmon and steelhead)
- NMFS Northwest Fisheries Science Center (Mark Plummer on socioeconomics and environmental justice; Lyndal Johnson on water quality and quantity, and human health)
- USFWS (Jeffrey Chan on bull trout; Yvonne Detlaff on hatchery production)
- NWIFC (Mike Grayum and Terry Wright on tribal resources, Will Beattie on fisheries and hatchery production, Dietrich Schmitt on hatchery production, Ken Currens and Adrian Spidle on fish genetics, Grant Kirby on hatchery plans, Bruce Stewart on fish disease pathogens and hatchery management methods)
- WDFW (Jim Scott, Heather Bartlett, Bruce Sanford, Andy Appleby, Kent Dimmit, Darrell Mills, and James Dixon on hatchery production; Catie Mains on hatchery carcasses)

During development of the EIS, NMFS also consulted with the following tribes[1], organizations, and individuals:

- Jamestown S'Klallam Tribe (Ron Allen and Scott Chitwood on tribal resources)
- Lower Elwha Klallam Tribe (Frances Charles, Robert Elofson, Doug Morrill, and Larry Ward on tribal resources)
- Lummi Indian Nation (Clifford Cultee, Alan Chapman, Randy Kinley, and Ryan Vasak on tribal resources)
- Muckleshoot Indian Tribe (Virginia Cross, Dennis Moore, Richard Johnson, Paul Hage, and Alan Stay on tribal resources)
- Nisqually Tribe (Cynthia Iyall and David Troutt on tribal resources)

[1] The first name shown for each tribe is the tribal chairperson as of the time of scoping in 2011. Other tribal individuals are those that attended briefings on the EIS.

- Nooksack Indian Tribe (Robert Kelly Jr and Ned Currance on tribal resources)
- Point No Point Treaty Council (Randy Harder on tribal resources)
- Port Gamble S'Klallam Tribe (Jeromy Sullivan, Paul McCollum, and Abby Welch on tribal resources)
- Puyallup Tribe (Herman Dillon, Russ Ladley, Blake Smith, and Chris Phinney on tribal resources)
- Sauk-Suiattle Indian Tribe (Janice Mabee on tribal resources)
- Skagit System Cooperative (Lorraine Loomis on tribal resources)
- Skokomish Tribe (Charles Miller, Joseph Pavel, and Dave Herrera on tribal resources)
- Snoqualmie Tribe (Joeseph Mullen on tribal resources)
- Squaxin Island Tribe (David Lopeman on tribal resources)
- Stillaguamish Tribe (Shawn Yanity and Kip Killibrew on tribal resources)
- Suquamish Tribe (Leonard Foresman on tribal resources)
- Swinomish Indian Tribal Community (Brian Cladoosby on tribal resources)
- Tulalip Tribes (Melvin Shelton, Terry Williams, Mike Crewson, and Kit Rawson on tribal resources)
- Upper Skagit Tribe (Jennifer Washington on tribal resources)
- Coastal Conservation Association (Andrew Marks on fish resources)
- Long Live the Kings (Lars Mobrand [under contract] on fish resources, hatchery resources)
- Wild Fish Conservancy (Kurt Beardslee, Nick Gayeski, and Jamie Glasgow on fish resources)

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Puget Sound Hatchery Programs and Facilities

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Table A-1. Chinook salmon hatchery programs and facilities.

Salmon species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chinook salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chinook	Georgia Strait	Nooksack	**Skookum Creek Hatchery (January 2006)**	SF Nooksack	Spring	Integrated Recovery	Conservation	Lummi Indian Nation	Subyearling/May	200,000	200,000	200,000	Skookum Creek Hatchery	SF Nooksack RM 14.3
Chinook	Georgia Strait	Nooksack	**Kendall Creek Hatchery spring Chinook (2005) (August 2005)**	NF Nooksack	Spring	Integrated Recovery	Conservation	WDFW	Subyearling/May	750,000	750,000	750,000	Kendall Creek Hatchery	NF Nooksack RM 46; NF Nooksack at confluence with Deadhorse Creek RM 63.5; NF Nooksack at Excelsior Campground RM 65; NF Nooksack RM 55 on Canyon
Chinook	Georgia Strait	Nooksack	Lummi Bay Hatchery summer/fall Chinook (November 2000)	Green R. lineage (out-of-ESU)	Summer/fall	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Subyearling/May	2,000,000	1,500,000	2,000,000	Lummi Bay Hatchery	Lummi Bay; Nooksack River RM 1.5
Chinook	Georgia Strait	Nooksack	Samish Hatchery fall Chinook subyearling (August 2005)	Green R. lineage (out-of-ESU)	Summer/fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/May-June	4,000,000	4,000,000	4,000,000	Samish Hatchery	Samish River RM 10.5
Chinook	Georgia Strait	Nooksack	Samish Hatchery fall Chinook yearling (August 2005)	Green R. lineage (out-of-ESU)	Summer/fall	Isolated harvest	Harvest augmentation	WDFW	Yearling/March	100,000	100,000	100,000	Samish Hatchery	Samish River RM 10.5
Chinook	Georgia Strait	San Juan Islands (Orcas)	Glenwood Springs Hatchery (August 2005)	Green R. lineage (out-of-ESU)	Summer/fall	Isolated harvest	Harvest augmentation	Long Live The Kings	Subyearling/July	300,000	300,000	300,000	Glenwood Springs Hatchery	Eastsound, Orcas Island (One HGMP)
				Green R. lineage (out-of-ESU)	Summer/fall	Isolated harvest	Harvest augmentation	Long Live The Kings	Yearling - April	250,000	250,000	250,000	Glenwood Springs Hatchery	Eastsound, Orcas Island
Chinook	Whidbey Basin	Skagit	**Marblemount fall chinook (August 2005)**	Lower Skagit	Fall	Integrated research	Indicator stock	WDFW	Subyearling/June	222,000	222,000	222,000	Marblemount Hatchery	Baker River RM 1
Chinook	Whidbey Basin	Skagit	**Marblemount spring chinook subyearling (August 2005)**	Cascade	Spring	Isolated harvest	Indicator stock/Harvest augmentation	WDFW	Subyearling/June	250,000	250,000	250,000	Marblemount Hatchery	Cascade River, tributary to the Skagit River at RM 78.5
Chinook	Whidbey Basin	Skagit	**Marblemount spring chinook yearling (August 2005)**	Cascade	Spring	Isolated harvest	Indicator stock/Harvest augmentation	WDFW	Yearling/April	150,000	150,000	150,000	Marblemount Hatchery	Cascade River, tributary to the Skagit River at RM 78.5
Chinook	Whidbey Basin	Skagit	**Marblemount summer chinook (August 2005)**	Upper Skagit	Summer	Integrated research	Indiactor stock	WDFW	Subyearling/May	200,000	200,000	200,000	Marblemount Hatchery	Skagit River mainstem RM 91
Chinook	Whidbey Basin	Stillaguamish	**Harvey Creek Hatchery NF Stillaguamish summer Chinook (March 2003)**	NF Stillaguamish	Summer	Integrated Recovery	Conservation	Stillaguamish Tribe	Subyearling/May	45,000	45,000	45,000	Harvey Creek Hatchery	Transferred to Whitehorse Springs Hatchery - Joint program w/WDFW. Captive brood
Chinook	Whidbey Basin	Stillaguamish	**Whitehorse Pond summer Chinook (August 2005)**	NF Stillaguamish	Summer	Integrated Recovery	Conservation	WDFW	Subyearling/May	200,000	200,000	420,000	Whitehorse Pond	Whitehorse Spring Ck (RM 1.5); trib to NF Stilly at RM 28
Chinook	Whidbey Basin	Stillaguamish	**South Fork Stillaguamish Chinook natural stock restoration program (August 2007)**	SF Stillaguamish	Fall	Integrated Recovery	Conservation	Stillaguamish Tribe	Subyearling/May	45,000	45,000	45,000	Harvey Creek Hatchery	Brenner Hatchery, SF Stillaguamish River RM 31.0

Table A-1. Chinook salmon hatchery programs and facilities, continued.

Salmon species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chinook salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chinook	Whidbey Basin	Snohomish	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip spring Chinook program (March 2004)	Cascade	Spring	Isolated harvest	Harvest augmentation	Tulalip Tribes	Yearling/March	0	0	0	Bernie Kai-Kai Gobin Salmon Hatchery	Tulalip Bay, Port Susan
Chinook	Whidbey Basin	Snohomish	**Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip summer/fall Chinook program (July 2005)**	Skykomish	Summer/ Fall	Integrated harvest	Harvest augmentation	Tulalip Tribes	Subyearling/May	1,700,000	1,700,000	1,700,000	Bernie Kai-Kai Gobin Salmon Hatchery	Tulalip Bay, Port Susan
Chinook	Whidbey Basin	Snohomish	**Wallace River fingerling summer Chinook salmon (August 2005)**	Skykomish	Summer	Integrated harvest	Harvest augmentation	WDFW	Subyearling/June	1,000,000	500,000	1,000,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36
Chinook	Whidbey Basin	Snohomish	**Wallace River yearling Summer Chinook salmon (August 2005)**	Skykomish	Summer	Integrated harvest	Harvest augmentation	WDFW	Yearling/April	250,000	125,000	500,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36
Chinook	Central/South Sound	Lake Washington	**Issaquah Fall Chinook Salmon (August 2005)**	Sammamish	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/May	2,000,000	2,000,000	2,000,000	Issaquah Hatchery	Issaquah Creek RM 3.0, tributary to Lake Sammamish
Chinook	Central/South Sound	Lake Washington	Portage Bay Hatchery Chinook salmon (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated research	Research	University of Washington	Subyearling/May	180,000	180,000	180,000	Portage Bay Hatchery	Portage Bay, Ship Canal, Lake Washington/Union
Chinook	Central/South Sound	Kitsap Peninsula	Grovers Creek Hatchery and satellite rearing ponds (July 2000)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	Suquamish Tribe	Subyearling/May-June	2,800,000	2,800,000	2,800,000	Grovers Creek Hatchery/Gorst Creek Rearing Ponds	Grovers Creek (500K); Websters Creek (150K); Clear Creek Rearing pond (50K); Gorst Creek Rearing Ponds (2,100K)
				Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	Suquamish Tribe	Yearling/March	150,000	150,000	150,000	Gorst Creek Rearing Ponds, Websters Pond	Websters Creek (50k/yr) and Gorst Creek Rearing Ponds (150K/yr) (Sinclair Inlet)
Chinook	Central/South Sound	Duwamish/Green	**Soos Creek fall Chinook fingerling program (August 2005)**	Green	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/June	3,200,000	1,600,000	3,200,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33
Chinook	Central/South Sound	Duwamish/Green	**Soos Creek/Icy Creek fall Chinook yearling program (August 2005)**	Green	Fall	Integrated harvest	Harvest augmentation	WDFW	Yearling/April	300,000	150,000	300,000	Soos Creek Hatchery/Icy Creek Hatchery	Icy Creek, tributary to the Green River at RM 48.3
Chinook	Central/South Sound	Duwamish/Green	**Keta Creek fall Chinook (May 2003)**	Green	Fall	Integrated harvest	Harvest augmentation/research	Muckleshoot Tribe	Subyearling/March	600,000	300,000	600,000	Keta Creek Hatchery	Upper Green River tribs above Howard Hanson Dam (RM 60.5)
Chinook	Central/South Sound	Puyallup	**Voights Creek fall Chinook fingerling program (August 2005)**	Puyallup	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/June	1,600,000	800,000	1,600,000	Voights Creek Hatchery	Voights Creek (RM .5), trib to Carbon River at RM 4.0, trib to Puyallup River at RM 17.8
Chinook	Central/South Sound	Puyallup	**Clarks Creek (Diru) fall Chinook (December 2005)**	Puyallup	Fall	Integrated harvest	Harvest augmentation	Puyallup Tribe	Subyearling/late April-June	400,000	200,000	1,000,000	Clarks Creek Hatchery	Upper Puyallup River watershed (RM 31-49 - includes Mowich R., Meadow, Deer, Rushingwater Creeks); Diru Creek (trib to Puyallup RM 5.7) acclimation sites

Table A-1. Chinook salmon hatchery programs and facilities, continued.

Salmon species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chinook salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chinook	Central/South Sound	White	**White River spring Chinook (May 2003)**	White	Spring	Integrated Recovery	Conservation	Muckleshoot Tribe	Subyearling/June	260,000	260,000	260,000	White River Hatchery	White River RM 23.4
				White	Spring	Integrated Recovery	Conservation	Muckleshoot Tribe	Yearling/April	90,000	90,000	90,000	White River Hatchery	White River RM 23.4
Chinook	Central/South Sound	White	**Puyallup White River acclimation sites (August 2002)**	White	Spring	Integrated Recovery	Conservation	Puyalup Tribe	Subyearling/June	840,000	840,000	840,000	White River Acclimation Ponds	Clearwater R (trib to White River at RM 35.3), Huckleberry Creek (trib at RM 53.1), Cripple Creek (trib to W Fork White at RM 2)
Chinook	Central/South Sound	Carr Inlet/South Sound	**White River spring Chinook - Hupp Springs Hatchery (August 2002)**	White	Spring	Isolated Recovery	Conservation	WDFW	Subyearling/May	250,000	250,000	250,000	Hupp Springs Hatchery	Hupp Springs Hatchery on Minter Creek RM 3.0, tributary to Carr Inlet, South Puget Sound
				White	Spring	Isolated Recovery	Conservation	WDFW	Yearling/April	85,000	85,000	85,000	Hupp Springs Hatchery	Hupp Springs Hatchery on Minter Creek RM 3.0, tributary to Carr Inlet, South Puget Sound
Chinook	Central/South Sound	Carr Inlet/South Sound	Minter Creek fall Chinook fingerling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Subyearling/May	1,800,000	1,800,000	1,800,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to Carr Inlet, South Puget Sound
Chinook	Central/South Sound	Chambers Creek, South Puget Sound	Garrison Springs fall Chinook Fingerling Program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Subyearling/April-May	850,000	850,000	850,000	Garrison Springs Hatchery	Chambers Creek RM 0.5 and Lake Steilacoom at RM 5.5
Chinook	Central/South Sound	Chambers Creek, South Puget Sound	Chambers Creek fall Chinook yearling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Yearling/April-May	200,000	200,000	2,820,000	Chambers Creek Hatchery	Chambers Creek RM 0.5
Chinook	Central/South Sound	Nisqually	**Nisqually Hatchery at Clear Creek (July 2000)**	Nisqually	Fall	Isolated harvest	Harvest Augmentation	Nisqually Tribe	Subyearling/May-June	3,400,000	1,700,000	3,700,000	Clear Creek Hatchery	Clear Creek, tributary to Nisqually River at RM 6.3
Chinook	Central/South Sound	Nisqually	**Nisqually Hatchery at Kalama Creek (July 2000)**	Nisqually	Fall	Isolated harvest	Harvest Augmentation	Nisqually Tribe	Subyearling/May-June	600,000	300,000	600,000	Kalama Creek Hatchery	Kalama Creek, tributary to Nisqually River at RM 9.2
Chinook	Central/South Sound	Deschutes	Tumwater Falls Fall Chinook fingerling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Subyearling/April-June	3,800,000	3,800,000	5,800,000	Tumwater Falls Hatchery	Deschutes River RM 0.2
Chinook	Central/South Sound	Deschutes	Tumwater Falls fall Chinook yearling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Yearling/April	200,000	200,000	200,000	Tumwater Falls Hatchery	Percival Cove, mouth of Percival Creek, trib to Capital Lake, Budd Inlet, S Puget Sound
Chinook	Hood Canal	Skokomish	**George Adams fall Chinook fingerling program (August 2005)**	Skokomish	Fall	Integrated harvest	Harvest Augmentation	WDFW	Subyearling/May-June	3,800,000	1,900,000	3,800,000	George Adams Hatchery	Purdy Creek RM 1.8, tributary to the Skokomish River ay RM 4.0
Chinook	Hood Canal	Skokomish	**Rick's Pond fall Chinook program (August 2005)**	Skokomish	Fall	Integrated harvest	Harvest Augmentation	WDFW	Yearling/April	120,000	60,000	120,000	George Adams Hatchery	Rick's Pond, spring tributary to the Skokomish River at RM 2.9
Chinook	Hood Canal	Finch Creek, west Hood Canal	Hoodsport fall Chinook fingerling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Subyearling/June	2,800,000	2,800,000	2,800,000	Hoodsport Hatchery	Finch Creek RM 0.0, tributary to west Hood Canal
Chinook	Hood Canal	Finch Creek, west Hood Canal	Hoodsport fall Chinook yearling program (August 2005)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest Augmentation	WDFW	Yearling/May	120,000	120,000	120,000	Hoodsport Hatchery	Finch Creek RM 0.0, tributary to west Hood Canal

Table A-1. Chinook salmon hatchery programs and facilities, continued.

Salmon species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chinook salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chinook	Hood Canal	Hamma Hamma	**Hamma Hamma fall Chinook fingerling program (August 2005)**	Mid Hood Canal	Fall	Integrated Recovery	Conservation	Long Live The Kings	Subyearling/May-June	110,000	110,000	110,000	Hamma Hamma Hatchery/George Adams Hatchery	John Creek, tributary to the Hamma Hamma River at RM 2.0
Chinook	Strait of Juan de Fuca	Dungeness	**Dungeness Spring Chinook program (August 2005)**	Dungeness	Spring	Integrated Recovery	Conservation	WDFW	Subyearling/May-June	100,000	100,000	100,000	Dungeness and Hurd Creek Hatcheries	Upper Dungeness River & Gray Wolf Acclimation Pond (RM 1.0); Dungeness River RM 10.5
				Dungeness	Spring	Integrated Recovery	Conservation	WDFW	Yearling/April	100,000	100,000	100,000	Dungeness and Hurd Creek Hatcheries	Dungeness River RM 10.5
Chinook	Strait of Juan de Fuca	Elwha	**Elwha River fummer/fall Chinook program (November 2012)**	Elwha	Summer/ Fall	Integrated Recovery	Conservation	WDFW	Subyearling/June	2,500,000	2,500,000	2,500,000	Elwha Channel Hatchery	Elwha River RM 2.9
				Elwha	Summer/ Fall	Integrated Recovery	Conservation	WDFW	Yearling/April	400,000	400,000	400,000	Morse Creek Hatchery	Elwha River RM 2.9 (200K) and Morse Creek (RM 1.0) tributary to eastern SJF

Totals	**45,317,000**	**37,182,000**	**51,307,000**
Subyearlings	42,802,000	35,002,000	45,922,000
Yearlings	2,515,000	2,180,000	5,385,000

Table A-2. Steelhead hatchery programs and facilities.

Species	Steelhead major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Steelhead population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Steelhead	Northern Cascades	Nooksack	Kendall Creek Hatchery Winter Steelhead (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augment	WDFW	Yearling/May	150,000	75,000	150,000	Kendall Creek Hatchery	NF Nooksack RM 46.
Steelhead	Northern Cascades	Nooksack	Whatcom Creek Hatchery (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	35,000	35,000	35,000	Whatcom Creek Hatchery	Samish River RM 10.5
				Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	Bellingham Technical College/WDFW	Yearling/May	5,000	5,000	10,000	Whatcom Creek Hatchery	Whatcom Creek RM 0.5
Steelhead	Northern Cascades	Skagit	Barnaby Slough Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	200,000	100,000	200,000	Barnaby Slough	Skagit River RM 70.2.
Steelhead	Northern Cascades	Skagit	Marblemount Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	334,000	167,000	364,000	Marblemount Hatchery	Cascade River, tributary to the Skagit River at RM 78.5
Steelhead	Northern Cascades	Stillaguamish	Whitehorse Pond Summer Steelhead Program (August 2005)	Skamania Hatchery-lineage (out of DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	70,000	35,000	70,000	Whitehorse Pond	Whitehorse Spring Ck (RM 1.5); trib to NF Stilly at RM 28; Canyon Creek; Red Bridge (RM 55); Silverton (RM 60).
Steelhead	Northern Cascades	Stillaguamish	Whitehorse Pond Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	150,000	75,000	150,000	Whitehorse Pond	Whitehorse Spring Ck (RM 1.5); trib to NF Stilly at RM 28; Pilchuck Creek; Canyon Creek
Steelhead	North Cascades	Snohomish	Reiter Pond Summer Steelhead Program (August 2005)	Skamania Hatchery-lineage (out of DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	250,000	125,000	250,000	Reiter Ponds	Reiter Pond 140K (RM 45); NF Skykomish @ Index 10K; Sultan R. 20K; Raging R. 50K.
Steelhead	Northern Cascades	Snohomish	Reiter Pond Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	250,000	125,000	250,000	Reiter Ponds	Reiter Pond at Skykomish River RM 45; NF Skykomish @ Index 10K; Sultan R. 20K; Monroe 20K; Howard Ck.15K; Barr Ck. 15K; Tolt R. 5K; Pilchuck R. 15K.
Steelhead	Northern Cascades	Snohomish	Tokul Creek Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	185,000	92,500	185,000	Tokul Creek Hatchery	Tokul Creek (RM 0.5), tributary of the Snoqualmie River at RM 39, which is tributary to the Snohomish River at RM 20.5; and Snoqualmie River watershed sites (Duvall, mouth and upriver of Tolt R., Raging River)
Steelhead	Northern Cascades	Snohomish	Wallace River Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	20,000	10,000	20,000	Wallace Hatchery	Wallace River RM 4.0, tributary to Skykomish at RM 36
Steelhead	Northern Cascades	Green	Palmer Ponds Winter Steelhead Program (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	150,000	75,000	208,000	Palmer Ponds	Palmer Ponds at Green River RM at 56.1
				Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	20,000	10,000	20,000	Icy Creek Hatchery	Icy Creek, tributary to the Green River at RM 48.3
				Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	35,000	17,500	35,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
				Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	15,000	7,500	15,000	Flaming Geyser (Pond)	Flaming Geyser Park (Green River) at RM 44.3

Table A-2. Steelhead hatchery programs and facilities, continued.

Species	Steelhead major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Steelhead population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Steelhead	Northern Cascades	Green	Palmer Ponds Summer Steelhead Program (August 2005)	Skamania Hatchery-lineage (out of DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	30,000	15,000	30,000	Palmer Ponds	Palmer Ponds at Green River RM at 56.1
				Skamania Hatchery-lineage (out of DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	30,000	15,000	30,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
				Skamania Hatchery-lineage (out of DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	20,000	10,000	20,000	Icy Creek Hatchery	Icy Creek, tributary to the Green River at RM 48.3
Steelhead	Northern Cascades	Green	**Green River Wild Stock Winter Steelhead Program (February 2010)**	Green River	Winter	Integrated Recovery	Conservation	WDFW	Yearling/May	50,000	50,000	50,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
Steelhead	Central and South Puget Sound	White	**White River Winter Steelhead Supplementation Program (September 2006)**	White River	Winter	Integrated Recovery	Conservation	WDFW, Puyallup Indian Tribe and Muckleshoot Indian Tribe	Yearling/May	35,000	35,000	35,000	Diru Creek Hatchery and White River Hatchery	White River RM 24.3, which is tributary to the Puyallup River at RM 10.1.
Steelhead	Central and South Puget Sound	Puyallup	Voights Creek Winter Steelhead (August 2005)	Chambers Ck lineage (out of DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	200,000	100,000	200,000	Voights Creek Hatchery	Voights Creek (RM .5), trib to Carbon River at RM 4.0, trib to Puyallup River at RM 17.8
Steelhead	Hood Canal and Strait of Juan de Fuca	Skokomish	**Hood Canal Steelhead Supplementation Project (October 2009)**	Skokomish River	Winter	Integrated Recovery	Conservation	WDFW and Long Live the Kings	Yearlings - April-May; Adults - March 1	34,900	34,900	34,900	McKernan Hatchery	South Fork Skokomish River
		Dewatto		Eastside Hood Canal Tributaries	Winter	Integrated Recovery	Conservation	WDFW and Long Live the Kings	Yearlings - April-May; Adults - March 1	7,653	7,653	7,653	LLTK Lilliwaup Hatchery	Dewatto River
		Duckabush		Westside Hood Canal Tributaries	Winter	Integrated Recovery	Conservation	WDFW and Long Live the Kings	Yearlings - April-May; Adults - March 1	6,897	6,897	6,897	LLTK Lilliwaup Hatchery	Duckabush River
Steelhead	Hood Canal and Strait of Juan de Fuca	Dungeness	Dungeness Winter Steelhead Program (August 2005)	Dungeness River	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	10,000	5,000	10,000	Dungeness Hatchery	Dungeness River RM 10.5
Steelhead	Hood Canal and Strait of Juan de Fuca	Elwha	**Lower Elwha Fish Hatchery (August 2012)**	Elwha River	Winter	Integrated Recovery	Conservation	Lower Elwha Klallam Tribe	Yearling/May	175,000	175,000	175,000	Lower Elwha Hatchery	Elwha River RM 0.3
									Totals	**2,468,450**	**1,408,950**	**2,561,450**		

Table A-3. Coho salmon hatchery programs and facilities, continued.

									Life stage, time, and number of fish by alternative					
Salmon species	Chinook salmon major population group (Coho salmon MPGs have not been determined)	Watershed	Hatchery program name and HGMP date (in parenthesis)	Coho salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4	Primary facility	Release location(s)
Coho	Strait of Georgia	Nooksack	Kendall Creek Coho Program (March 2003)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	300,000	150,000	300,000	Kendall Creek Hatchery	NF Nooksack RM 46.
Coho	Strait of Georgia	Nooksack	Lummi Nation Coho Salmon (March 2003)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/May	1,000,000	500,000	2,000,000	Skookum Creek Hatchery	SF Nooksack RM 14.3
				Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/May	1,000,000	500,000	2,000,000	Lummi Bay Hatchery	Lummi Bay, north Puget Sound
Coho	Strait of Georgia	Nooksack	Squalicum Harbor Coho Net Pen (March 2003)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/April	5,000	5,000	5,000	Kendall Creek Hatchery	Bellingham Bay, north Puget Sound
Coho	Strait of Georgia	San Juan Islands	San Juan (Roche Harbor) Net Pen Coho Program (March 2003)	Skagit (Cascade) River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/June	15,000	15,000	15,000	Marblemount Hatchery	Roche Harbor, northern San Juan Island
Coho	Strait of Georgia	San Juan Islands	Glenwood Springs Coho (March 2003)	Nooksack-lineage	Normal-timed	Isolated harvest	Harvest augmentation	Long Live the Kings	Fry/April	10,000	10,000	10,000	Glenwood Springs Hatchery	Westsound, Orcas island
				Nooksack-lineage	Normal-timed	Isolated harvest	Harvest augmentation	LLTK	Yearling/April	100,000	100,000	100,000	Glenwood Springs Hatchery	Eastsound, Orcas island
Coho	Whidbey Basin	Skagit	Marblemount Coho Program (March 2003)	Skagit (Cascade) River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/June	250,000	125,000	250,000	Marblemount Hatchery	Cascade River Rm 1.0, tributary to the Skagit River at RM 78.5
				Skagit (Cascade) River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	100,000	50,000	100,000	Marblemount Hatchery	Indian Slough, Padilla Bay, northern Puget Sound
Coho	Whidbey Basin	Skagit	Baker Lake Coho (March 2003)	Skagit (Baker)	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Fry/April-May	120,000	60,000	310,000	Baker Trout Pond complex	Sulphur Creek Facility, trib to Lake Shannon at Baker River RM 9.0
				Skagit (Baker)	Normal-timed	Isolated Harvest	Harvest augmentation	WDFW	Yearling/May-June	60,000	30,000	60,000	Baker Trout Pond complex	Baker Lake, Lake Shannon and mouth of Baker River (RM 1.0), tributary to the Skagit River
Coho	Whidbey Basin	Skagit	Oak Harbor Net Pen Coho Program (March 2003)	Skagit	Normal-timed	Isolated Harvest	Harvest augmentation	WDFW	Yearling/June	30,000	30,000	30,000	Marblemount Hatchery	Oak Harbor Marine, Oak Harbor, Saratoga Passage
Coho	Whidbey Basin	Stillaguamish	Stillaguamish Coho Program (March 2004)	Stillaguamish	Normal-timed	Integrated harvest/recovery	Harvest augmentation/conservation	Stillaguamish Tribe	Yearling/May-June	54,000	27,000	54,000	Harvey Creek Hatchery/North Fork/Johnson Creek Hatchery	Harvey Creek Hatchery RM 2.0 on Harvey/Armstrong Creek, trib to the Stillaguamish River at RM 15.3
Coho	Whidbey Basin	Snohomish	Tulalip Coho Program (March 2004)	Skykomish	Normal-timed	Integrated Harvest	Harvest augmentation	Tulalip Tribes	Yearling/May-June	1,000,000	1,000,000	1,000,000	Tulalip Salmon Hatchery, Bernie Kai-Kai Gobin Salmon Hatchery, Wallace River Hatchery	Tulalip Creek and Tulalip Bay, Port Susan
Coho	Whidbey Basin	Snohomish	Wallace River Coho Program (March 2003)	Skykomish	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Yearling/May	150,000	75,000	300,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36
Coho	Whidbey Basin	Snohomish	Mukilteo Net Pen Coho Program (March 2003)	Skykomish	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/June	20,000	20,000	20,000	Wallace River Hatchery	Mouth of the Snohomish River (RM 0, Port Gardner Bay)

Table A-3. Coho salmon hatchery programs and facilities, continued.

									Life stage, time, and number of fish by alternative					
Salmon species	**Chinook salmon major population group (Coho salmon MPGs have not been determined)**	**Watershed**	**Hatchery program name and HGMP date (in parenthesis)**	**Coho salmon population**	**Species race or run**	**Hatchery program type**	**Hatchery program purpose**	**Hatchery operator**	**Life stage and time**	**Alternative 1 and 2**	**Alternative 3**	**Alternative 4**	**Primary facility**	**Release location(s)**
Coho	Whidbey Basin	Snohomish	Possession Point Coho Program (March 2003)	Skykomish	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/May	50,000	50,000	50,000	Wallace River Hatchery	Possession Point, mouth of Everett Bay, Puget Sound
Coho	Central/South Sound	Lake Washington	Laebugton Net Pen Coho Program (March 2003)	Issaquah Creek (x Green River)	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/June	25,000	25,000	25,000	Issaquah Creek Hatchery	Port of Edmonds, Public Fishing Pier
Coho	Central/South Sound	Lake Washington	Issaquah Coho Program (March 2003)	Issaquah Creek (x Green River)	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Yearling/April	450,000	450,000	450,000	Issaquah Creek Hatchery	Issaquah Creek RM 3.0, tributary to Lake Sammamish
Coho	Central/South Sound	Lake Washington	Portage Bay (UW) Coho Program (March 2003)	Lake Washington	Selected	Isolated harvest/research	Harvest augmentation/ Research	UW	Yearling (accelerated subyearling)	90,000	90,000	90,000	Portage Bay Hatchery	Portage Bay, Ship Canal, Lake Union
Coho	Central/South Sound	Lake Washington	Ballard Net Pen Coho Program (August 2005)	Issaquah Creek (x Green River)	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearlings/June	30,000	30,000	30,000	Issaquah Creek Hatchery	Ray's Boathouse Restaurant (Ballard), central Puget Sound
Coho	Central/South Sound	Green	Soos Creek Coho Program (March 2003)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Yearling/May	600,000	300,000	600,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
Coho	Central/South Sound	Green	Crisp Creek Ponds - On-station (October 2004)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe	Yearling/May	200,000	100,000	300,000	Crisp Creek Rearing Ponds	Crisp Creek RM 1.1, tributary to the Green River at RM 40.1
Coho	Central/South Sound	Green	Elliot Bay Netpens (October 2004)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe/Suquamish Tribe	Yearling/June	395,000	395,000	395,000	Soos Creek Hatchery	northeastern Elliot Bay, central Puget Sound
Coho	Central/South Sound	Green	Marine Technology Center Coho Program (March 2003)	Green	Normal-timed	Isolated harvest	Education	WDFW	Fry/April	15,000	15,000	15,000	Soos Creek Hatchery	Sehurst Park (on Puget Sound) in Burien, Washington
				Green	Normal-timed	Isolated harvest	Education	WDFW	Yearling/May	10,000	10,000	10,000	Soos Creek Hatchery	Sehurst Park (on Puget Sound) in Burien, Washington
Coho	Central/South Sound	Green	Des Moines Net Pen Coho Program (March 2003)	Green	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearlings/June	30,000	30,000	30,000	Soos Creek Hatchery	Des Moines Marina, central Puget Sound
Coho	Central/South Sound	Green	Agate Pass Seapens (March 2003)	Minter Creek	Normal-timed	Isolated harvest	Harvest augmentation	Suquamish Tribe	Yearlings/June	600,000	600,000	600,000	Agate Pass Netpens, Minter Creek Hatchery	Agate pass, Port Madison, central Puget Sound
Coho	Central/South Sound	Puyallup	Voights Creek Coho Program (March 2003)	Puyallup (Voights Creek Hatchery)	Normal-timed	Integrated harvest	Harvest augmentation	WDFW	Yearlings/April, May	780,000	390,000	1,180,000	Voights Creek Hatchery	Voights Creek (RM .5), trib to Carbon River at RM 4.0, trib to Puyallup River at RM 17.8
Coho	Central/South Sound	Puyallup	Puyallup Tribes' Puyallup Acclimation Sites (March 2003)	Puyallup (Voights Creek Hatchery)	Normal-timed	Integrated recovery	Restoration	Puyallup Tribe	Yearlings/April-May	200,000	200,000	200,000	Voights Creek Hatchery and 3 acclimation ponds above Electron Dam	Rushingwater Acclimation Pond, RM 0.5 on Rushingwater Creek, trib to Mowich River at RM 1.1; Mowich River Acclimation Pond, RM 0.2 on Mowich River; Cowskull Creek Acclimation Pond,
Coho	Central/South Sound	Carr Inlet	Minter Creek Coho (March 2003)	Minter Creek	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearlings/May-July	1,044,000	1,040,000	1,040,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to northern Carr Inlet in south Puget Sound
Coho	Central/South Sound	Nisqually	Kalama Creek Hatchery Fall Coho (April 2003)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Nisqually Tribe	Yearling/April	350,000	175,000	350,000	Kalama Creek Hatchery	Kalama Creek, tributary to Nisqually River at RM 9.2

Table A-3. Coho salmon hatchery programs and facilities, continued.

Salmon species	Chinook salmon major population group (Coho salmon MPGs have not been determined)	Watershed	Hatchery program name and HGMP date (in parenthesis)	Coho salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative: Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4	Primary facility	Release location(s)
Coho	Central/South Sound	Nisqually	Clear Creek Hatchery Fall Coho (April 2003)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Nisqually Tribe	Yearlings/April	630,000	315,000	630,000	Clear Creek Hatchery	Clear Creek, tributary to Nisqually River at RM 6.3
Coho	Central/South Sound	South Puget Sound	Squaxin Island / South Sound Net Pens (March 2003)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Squaxin Island Tribes and WDFW	Yearlings/May-June	2,600,000	2,600,000	3,200,000	South Sound Net-pens,	Peale Passage, deep South Puget Sound
Coho	Hood Canal	Skokomish	George Adams Coho Yearling Program (March 2003)	Mixed Puget Sound, localized to Skokomish River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearlings/post April-15	300,000	150,000	300,000	George Adams Hatchery	
Coho	Hood Canal	Port Gamble Bay/Little Boston Creek	Port Gamble Coho Net Pens (March 2003)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	Port Gamble S'Klallam Tribe/USFWS	Yearlings/April-May	400,000	400,000	600,000	Quilcene NFH, Port Gamble Net pens	Port Gamble Bay, northern Hood Canal
Coho	Hood Canal	Quilcene	Quilcene Coho Net Pen (March 2003)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	Skokomish Tribe and USFWS	Yearlings/April-May	200,000	200,000	450,000	Quilcene NFH, Quilcene Bay Net pens	Quilcene Bay, northwestern Hood Canal
Coho	Hood Canal	Big Quilcene River	Quilcene National Fish Hatchery Coho Salmon Production Program (June 2010)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	USFWS	Yearlings/April-May	400,000	400,000	400,000	Quilcene NFH	Big Quilcene River RM 2.8
Coho	Strait of Juan de Fuca	Discovery Bay	Snow Creek Coho - Supplementation (August 2005)	Snow Creek	Normal-timed	Integrated recovery	Restoration	WDFW	Unfed fry/March-May	36,000	36,000	36,000	Snow/Andrews Creek remote incubator sites; Hurd Creek Hatchery	Snow Creek RM 4.0; Andrews Creek RM 1.5, trib to Snow Creek
				Snow Creek	Normal-timed	Integrated recovery	Restoration	WDFW	Subyearling/November	9,000	9,000	9,000	Hurd Creek Hatchery	Crocker Lake, Snow Creek watershed
				Snow Creek	Normal-timed	Integrated recovery	Restoration	WDFW	Yearlings/February	9,000	9,000	9,000	Hurd Creek Hatchery	Crocker Lake, Snow Creek watershed
Coho	Strait of Juan de Fuca	Dungeness	Dungeness River Coho (March 2003)	Dungeness-mixed origin	Early-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/June	500,000	250,000	500,000	Dungeness Hatchery and Hurd Creek Hatchery	Dungeness River RM 10.5
Coho	Strait of Juan de Fuca	Elwha	Lower Elwha Fish Hatchery (August 2012)	Elwha	Normal-timed	Integrated Harvest	Harvest augmentation	Lower Elwha Klallam Tribe	Yearling/May	425,000	425,000	425,000	Lower Elwha Hatchery	Elwha River RM 0.3

Totals	**14,592,000**	**11,391,000**	**18,478,000**
Yearling	14,102,000	11,111,000	17,798,000
Subyearling	9,000	9,000	9,000
Fry	181,000	121,000	371,000

Table A-4. Fall-run chum salmon and summer-run chum salmon hatchery programs and facilities, continued.

Salmon species	Major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chum salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	Whatcom Creek Chum Program (August 2005)	Nooksack	Fall	Isolated Harvest	Education/Harvest Augmenetation	Bellingham Technical College/WDFW	Fed fry/May	2,000,000	2,000,000	4,000,000	Whatcom Creek Hatchery, Kendall Creek Hatchery	Whatcom Creek RM 0.5, tributary to Bellingham Bay
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Skagit	Upper Skagit Hatchery (November 2003)	Skagit	Fall	Integrated harvest/education	Harvest augmentation/education	Upper Skagit Indian Tribe	Fed fry/May	400,000	400,000	400,000	Upper Skagit Hatchery	Red Creek tributary to Skagit River at RM 22.9
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Stillaguamish	Stillaguamish (Harvey Creek) Chum Program (March 2003)	Stillaguamish	Fall	Integrated education	Education/Harvest Augmenetation	Stillaguamish Tribe	Unfed and fed fry/April-May	250,000	250,000	250,000	Harvey Creek Hatchery	Harvey Creek Hatchery RM 2.0 on Harvey/Armstrong Creek, trib to the Stillaguamish River at RM 15.3
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Snohomish	Bernie Kai-Kai Gobin Salmon Hatchery Tulalip Chum (March 2004)	Walcott Slough (localized to release site)	Fall	Isolated Harvest	Harvest augmentation	Tulalip Tribes	Fed fry/May	8,000,000	8,000,000	12,000,000	Bernie Kai-Kai Gobin Salmon Hatchery	Battle Creek RM 0.3, Tulalip Bay, Port Susan
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Green	Keta Creek Hatchery (October 2004)	East Kitsap (localized)	Fall	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe	Fed fry/April-May	2,000,000	2,000,000	2,000,000	Keta Creek Hatchery	Crisp Creek RM 1.1, tributary to the Green River at RM 40.1

Table A-4. Fall-run chum salmon and summer-run chum salmon hatchery programs and facilities, continued.

Salmon species	Major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chum salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	East Kitsap	Cowling Creek Hatchery and Satellite Incubation and Rearing Facilities (March 2003)	Chico Creek (East Kitsap)	Fall	Integrated Harvest	Harvest augmentation	Suquamish Tribe	Unfed fry/April	600,000	600,000	600,000	Cowling Creek Hatchery	Dogfish Creek (Liberty Bay), Clear and Barker Creeks (Dyes Inlet), and Steele Creek (Burke Bay); all are East Kitsap tribs
Chum	Fall chum MPGs have not been designated. Chinook MPG is Central/South Sound	East Kitsap		Chico Creek (East Kitsap)	Fall	Integrated Harvest	Harvest augmentation	Suquamish Tribe	Fed fry/May	1,200,000	1,200,000	1,200,000	Cowling Creek Hatchery	Cowling Creek, tributary to Miller bay, East Kitsap
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Puyallup	Diru Creek Late Fall Chum (March 2003)	Chambers Creek (localized)	Late Fall	Integrated Harvest	Harvest augmentation	Puyallup Indian Tribe	Fed fry/April-May	2,000,000	2,000,000	2,000,000	Diru Creek Hatchery	Diru Creek RM 0.25, tributary to Clarks Creek, trib to Puyallup River at RM 5.8
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Carr Inlet	Minter Creek Chum Program (April 2004)	Elson Creek (Skookum Inlet), localized	Fall	Integrated Harvest	Harvest augmentation	WDFW	Fed fry/April	2,000,000	2,000,000	2,000,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to northern Carr Inlet in south Puget Sound
Chum	Fall-run chum salmon MPGs have not been designated. Listed summer-run chum salmon population is Hood Canal. Chinook salmon MPG is Hood Canal.	Skokomish	McKernan Fall Chum Program (March 2003)	Finch Creek	Fall	Isolated Harvest	Harvest augmentation	WDFW	Fed fry/April	10,000,000	10,000,000	15,000,000	McKernan Hatchery	Weaver Creek RM 1.0, tributary to the Skokomish River at RM

Table A-4. Fall-run chum salmon and summer-run chum salmon hatchery programs and facilities, continued.

Salmon species	Major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chum salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chum	Fall chum MPGs have not been designated. Listed summer chum population is Hood Canal. Chinook salmon MPG is Hood Canal.	Enetai Creek (south Hood Canal)	Skokomish Hatchery Fall Chum (March 2003)	Walcott Slough/Quilcene (localized to release site)	Fall	Isolated Harvest	Harvest augmentation	Skokomish Tribe	Fed fry/April	2,500,000	2,500,000	2,500,000	Enetai Hatchery	Enetai Creek, tributary to south Hood Canal north of the Skokomish River
Chum	Fall chum MPGs have not been designated. Area includes listed Hood Canal summer chum population, and the Hood Canal Chinook MPG.	Finch Creek (west Hood Canal)	Hoodsport Fall Chum (March 2003)	Finch Creek	Fall	Isolated Harvest	Harvest augmentation	WDFW	Fed fry/April	12,000,000	12,000,000	15,000,000	Hoodsport Hatchery	Finch Creek, westside tributary to Hood Canal
Chum	Hood Canal. No MPGs for summer-run chum salmon	Tahuya River	**Union/Tahuya Summer Chum (June 2000)**	Hood Canal	Summer	Integrated Recovery	Conservation	WDFW and Long Live the Kings	Fry	352,000			George Adams Hatchery	Tahuya River RM 1.0
Chum	Hood Canal. No MPGs for summer-run chum salmon	Lilliwaup Creek	**Lilliwaup Creek Summer Chum (October 1999)**	Hood Canal	Summer	Integrated Recovery	Conservation	WDFW and LLTK	Fry	168,000			Lilliwaup Hatchery	Lilliwaup Creek RM 0.5
Chum	Fall-run chum salmon MPGs have not been designated. Area includes the listed Hood Canal summer-run chum salmon population, and the Hood Canal Chinook salmon MPG.	Port Gamble Bay (north Hood Canal)	Port Gamble Hatchery Fall Chum (March 2003)	Walcott Slough (localized to release site)	Fall	Isolated Harvest	Harvest augmentation	Port Gamble S'Klallam Tribe	Fed fry/April-May	500,000	500,000	500,000	Little Boston Hatchery	Little Boston Creek, Port Gamble Bay, north Hood Canal.

Table A-4. Fall-run chum salmon and summer-run chum salmon hatchery programs and facilities, continued.

Salmon species	Major population group	Watershed	Hatchery program name, HGMP date (in parenthesis), and listing status (listed or proposed for listing shown in bold)	Chum salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Chum	Fall-run chum salmon MPGs have not been designated. Chinook MPG is Strait of Juan de Fuca	Elwha	Lower Elwha Fish Hatchery (August 2012)	Elwha	Fall	Integrated Recovery	Conservation	Lower Elwha Klallam Tribe	Fed fry/March-April	1,025,000	1,025,000	1,025,000	Lower Elwha Hatchery	Elwha River RM 0.3

Totals	44,995,000	44,475,000	58,475,000

Table A-5. Pink salmon hatchery programs and facilities, continued.

Salmon species	Major population group	Watershed	Hatchery program name and HGMP date (in parenthesis)	Pink salmon population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
									Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	Whatcom Creek Pink Program (August 2005)	Nooksack (localized to release site)	Normal	Isolated Harvest	Education/Harvest Augmentation	Bellingham Technical College/WDFW	Fed fry/April	1,000,000	1,000,000	1,000,000	Whatcom Creek Hatchery	Whatcom Creek RM 0.5, tributary to Bellingham Bay
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Hood Canal	Finch Creek (western Hood Canal)	Hoodsport Pink Salmon Program (March 2003)	Dungeness/Dosewallips (localized to the release site)	Normal	Isolated Harvest	Harvest Augmentation	WDFW	Fed fry/April	500,000	500,000	1,000,000	Hoodsport Hatchery	Finch Creek, western Hood Canal
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Strait of Juan de Fuca	Elwha	Elwha River Pink Salmon Preservation and Restoration Program (August 2012)	Elwha	Normal	Integrated Recovery	Conservation	Lower Elwha Klallam Tribe (and WDFW)	Fed fry/March	3,000,000	3,000,000	3,000,000	Lower Elwha Hatchery	Elwha River, RM 1.3

Totals	**4,500,000**	**4,500,000**	**5,000,000**

Table A-6. Sockeye salmon hatchery programs and faciliies.

Watershed	Hatchery program name and HGMP date (in parenthesis)	Population	Species race or run	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage, time, and number of fish by alternative				Primary facility	Release location(s)
							Life stage and time	Alternative 1 and 2	Alternative 3	Alternative 4		
Skagit/Baker	Baker Lake Sockeye Program (March 2003)	Baker River (ESU)	Early Summer	Integrated Harvest	Conservation	WDFW	Fry/February-May	1,000,000	1,000,000	1,000,000	Baker Lake Sockeye Spawning Beach facilities	Baker Lake at various boat launches (from beach #4) and ChannelCreek (from beach #3), a Baker Lake tributary.
		Baker River (ESU)	Early Summer	Integrated Harvest	Conservation	WDFW	Fingerling/June and September	120,000	120,000	120,000	Baker Lake Sockeye Spawning Beach facilities	Baker Lake at various boat launches (from beach #4) and ChannelCreek (from beach #3), a Baker Lake tributary.
		Baker River (ESU)	Early Summer	Integrated Harvest	Conservation	WDFW	Yearling/April	5,000	5,000	5,000	Baker Lake Sockeye Spawning Beach facilities	Baker Lake at various boat launches (from beach #4) and ChannelCreek (from beach #3), a Baker Lake tributary.
Lake Washington	Cedar River Sockeye Program (August 2005)	Lake Washington (localized Baker river stock)	Early Summer	Intgrated Harvest	Conservation/Harvest	WDFW	Fry/January-April	34,000,000	34,000,000	34,000,000	Cedar River Hatchery	Cedar River RM 21.7, 2.3, and 0.5

Totals	**35,125,000**	**35,125,000**	**35,125,000**

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Appendix B

Hatchery Effects and Evaluation Methods for Fish

For a list of acronyms used in this appendix, see Acronyms and Abbreviations in EIS

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This appendix provides background information that supports EIS Subsection 3.2, Fish, and EIS Subsection 4.2, Fish, by providing information on:

- General effects (risks and benefits) of hatchery programs on natural-origin salmon and steelhead
- Methods and rating criteria used for evaluation of risks and benefits to fish from Puget Sound hatchery programs

This appendix supports evaluations of existing conditions for salmon and steelhead, and also supports species-specific analyses of effects on salmon and steelhead at the population or basin scale, which are provided in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population; Appendix G, Hood Canal Summer-run Chum Salmon Effects Analysis by Population; and Appendix H, Steelhead Effects Analysis by Basin. Information on the affected environment and environmental consequences of hatchery programs and hatchery-origin fish on individual fish species in the analysis area is provided in EIS Subsection 3.2, Fish, and EIS Subsection 4.2, Fish, respectively.

1.0 General Factors that Affect the Presence and Abundance of Salmon and Steelhead

Although the EIS is focused on the effects of hatchery programs on listed and unlisted salmon and steelhead and other fish species in Puget Sound, it is important to understand that hatchery programs are but one of a variety of natural and human-caused factors that have affected and will continue to affect these species. These factors have affected the abundance, productivity, diversity, and distribution of salmon and steelhead in Puget Sound. In addition to hatchery programs, previous NMFS salmon status reviews (Myers et al. 1998; Good et al. 2005; Ford 2011), recovery plans (72 Fed. Reg. 2493, January 19, 2007; 72 Fed. Reg. 29121, May 24, 2007), and other documents (WSCC 2005) describe a range of past and current limiting factors and threats to listed salmon and steelhead, including:

- **Hatcheries.** Production from hatcheries helps increase the number of salmon and steelhead available for harvest and, depending on the management intent and type of program, can help improve population status. However, hatchery production also generally results in increased risk of competition, predation, and loss of genetic diversity in natural-origin fish. Hatchery facilities can increase the potential for disease transfer from hatchery-origin fish to natural-origin fish, as well as affect water quality and quantity in the hatchery vicinity.
- **Habitat.** Freshwater habitat modified from development and land use practices related to agriculture, forestry, industry, and residential uses can alter stream hydrology and natural

stream channels; reduce riparian cover and large woody debris in streams; and increase sedimentation and flooding.

- **Water Quality and Quantity.** Water quality in streams used by salmon and steelhead can be affected by channel modification, sediment input, increases in stream temperature and surface water runoff, and releases of toxic pollutants. Withdrawals of surface water and groundwater can affect the amount, timing, and availability of water in streams to support salmon and steelhead.
- **Dams and Diversions.** Construction of dams, water diversion structures, and hydroelectric operations can block salmon and steelhead migration routes, entrain migrating juveniles, change stream flow patterns, and alter natural water temperature regimes.
- **Culverts.** Road construction and installation of culverts can block and/or limit fish access to spawning and rearing areas.
- **Shoreline Modifications.** Armoring, bulk-heading, dredging, filling, dock and pier construction, riparian vegetation and pocket estuary removal, urbanization, and industrialization can alter shorelines of importance to juvenile salmon and steelhead freshwater migration in estuaries and marine waters. Loss of shoreline aquatic vegetation can affect salmon and steelhead foraging, resting, and spawning opportunities.
- **Fish Harvest.** Harvest can affect natural-origin salmon and steelhead abundance and diversity over time, and use of fishing gear can result in incidental losses of fish.
- **Predation.** Direct predation by aquatic, terrestrial, and avian species results in salmon and steelhead mortality, including mortality from introduced species or predators whose abundance has increased due to human-caused changes.
- **Ocean Conditions.** Broad-scale, cyclic changes in climatic and ocean conditions drive salmon productivity (e.g., El Niño events), and are important to how and where populations of salmon are sustained over the short term and long term.
- **Climate Change.** Changes in climate can alter the abundance, productivity, and distribution of salmon and steelhead through changes in water temperatures and seasonal stream flow regimes, which then affect the type and extent of aquatic habitat that is suitable for viable salmon and steelhead.

In a review of these factors, NMFS concluded that the effects on salmon and steelhead habitat continue to suppress prospects for recovery of listed natural-origin salmon and steelhead, including current and continuing degradation and loss of habitat essential for their survival and productivity (NMFS 2011a).

However, all of the past and current factors as described above have affected salmon and steelhead populations, distribution, and overall survival.

2.0 General Effects (Risks and Benefits) of Hatchery Programs on Salmon and Steelhead

2.1 Risks

A risk in this EIS is defined as the possibility of a loss or injury to natural-origin salmon and steelhead from the development and use of hatchery facilities, hatchery programs, and hatchery-origin fish.

The potential for adverse ecological effects, including competition and predation, posed by hatchery-origin salmon and steelhead on natural-origin salmon and steelhead is largely determined by the degree to which the species occupy the same habitats at the same time. Reviewing the complex and variable life histories exhibited by juvenile salmon and steelhead illustrates where and when species interactions may occur in freshwater and marine habitats (Holt 1977; SIWG 1984). Differences in species occurrences, abundance, size of natural-origin and hatchery-origin fish, and the location and timing of hatchery-origin fish releases affect the extent of interactions. Behavioral differences related to foraging, aggression, social density, territorial fidelity, migration, habitat preferences, and predator response also influence ecological interactions between hatchery-origin and natural-origin salmon and steelhead (Flagg et al. 2000; Einum and Fleming 2001). Physical environmental factors (such as water temperature, light, river flow, tidal stage, and water turbidity) may additionally influence interactions among and between species (Gregory and Levings 1998).

Ecological interactions may also be indirect (Wootton 1993). For example, predator abundance may increase in response to the increased abundance of one prey species and result in additional mortality on a second, less abundant prey species (Roby et al. 2003). If the local abundance of hatchery-origin fish attracts predators, commingled natural-origin juvenile salmon and steelhead may experience higher predation mortality. In contrast, abundant hatchery-origin fish can also reduce predation on natural-origin fish if this abundance does not attract additional predators to the area. The ecological interactions may be exacerbated by climatic phenomenon, such as oceanic conditions (Subsection 1.0, General Factors that Affect the Presence and Abundance of Salmon and Steelhead; Pearcy and McKinnell [2007]).

Competition and predation effects that may occur between hatchery-origin and natural-origin fish are discussed below.

2.1.1 Competition

Competition occurs when demand for limited resources (e.g., food and/or space) by two or more organisms exceeds available supply. Adverse impacts of competition on natural-origin fish from hatchery-origin fish may result from direct interactions (i.e., hatchery-origin fish interfere with access to limited resources by natural-origin fish) or indirect interactions (i.e., use of a limited resource by hatchery-origin fish reduces the amount of that resource available for natural-origin fish) (SIWG 1984). Specific types of competition between juvenile hatchery-origin and natural-origin fish include competition for food and for rearing and migration areas.

Of the many factors affecting natural-origin salmon and steelhead populations, competition for resources is believed to exert the greatest influence on juvenile salmon and steelhead survival (Hillman and Mullan 1989; Hillman et al. 1989; Cannamela 1993; Healey and Reinhardt 1995). Competition occurs naturally within and between species, and the severity of effects on salmon and steelhead survival and productivity is dependent on fish density and the quality and availability of habitat. Regardless of the presence of hatchery-origin fish, competition contributes to the mortality typically experienced by juvenile salmon and steelhead during their early life history in fresh water, and during their first few months in marine waters.

Hatchery-origin fish of different life stages may compete with natural-origin fish for food and spawning and rearing space. Juvenile, subadult, and adult hatchery-origin fish may compete with natural-origin salmon and steelhead for food resources and rearing space in freshwater, estuary, and marine habitats (Flagg et al. 2000; Naish et al. 2008). When adult hatchery-origin fish and natural-origin fish occur at the same time and place, hatchery-origin spawners may also compete with natural-origin spawners for mates and spawning habitat. In comparison to natural-origin fish species competing among other natural-origin fish species but without the presence of hatchery-origin fish; in most instances, natural-origin salmon and steelhead have different juvenile and adult life history strategies. These strategies effectively partition use of limited resources, thereby reducing the extent of competitive interactions among salmon and steelhead in nature (Nilsson 1967; SIWG 1984; Groot and Margolis 1991; Taylor 1991).

2.1.1.1 Freshwater Areas

2.1.1.1.1 Juvenile Fish

Juvenile hatchery-origin salmon and steelhead released into the natural environment primarily compete with natural-origin salmon and steelhead for resources when the hatchery-origin fish migrate downstream or sometimes residualize (described below). Species that rear in fresh water for 1 or more years make a physiological transition to become smolts and then typically out-migrate rapidly (e.g., steelhead, coho salmon, and spring-run Chinook salmon). Hatchery programs that pose the least competition risk are those that mimic the out-migration of natural-origin fish by producing rapidly migrating smolts that use rivers and streams as corridors to the ocean. However, this is difficult to fully achieve in practice. All natural-origin smolts do not out-migrate at the same time; timing of smoltification can vary by 45 or more days within a single population (Quinn 2005; Achord et al. 2007). In contrast, most hatchery-origin fish are released over a shorter time period (e.g., 2 weeks).

To help reduce risks to natural-origin fish, hatchery programs in Puget Sound are generally operated to release hatchery-origin juvenile fish as smolts after the peak of natural-origin salmon and steelhead out-migration periods. Hatchery-origin fish therefore out-migrate from high risk freshwater areas quickly and have a reduced opportunity to interact with the typically smaller natural-origin fish (PSTT and WDFW 2004). This strategy to release fish that rapidly migrate downstream to the estuary and marine environment reduces the risk of interaction and limits prospects for substantial competition with natural-origin fish reared in streams, rivers, and lakes (Flagg et al. 2000).

However, hatchery releases typically include some fish that have not yet reached the smolt stage, as well as some fish that are past the smolt stage. After release, these types of hatchery-origin fish are likely to out-migrate slowly, if at all. Hatchery-origin fish that fail to out-migrate and, instead, live in fresh water are called residuals. Compared to fish that out-migrate promptly, residuals have a greater opportunity to compete with natural-origin fish for food and space. Although most non-migratory hatchery-origin juveniles (residuals) may not survive, they may compete with natural-origin fish when present (McMichael et al. 1997). Releases of large numbers of fry or pre-smolts also have greater potential for competitive effects because interactions would occur for the periods needed for the fish to become smolts and out-migrate (up to 3 years in the case of steelhead).

SIWG (1984) reviewed the freshwater resource competition risks posed by hatchery-origin fish to natural-origin salmon and steelhead. They categorized species combinations to determine if the risk (high, low, or unknown) of competition by hatchery-origin fish would have a negative impact on natural-origin salmon and steelhead in freshwater areas (Table B-1). SIWG (1984) concluded that natural-origin Chinook salmon, coho salmon, and steelhead have a high risk of competition effects (both interspecific and intraspecific) from hatchery-origin fish representing any of these three species.

Table B-1. Risk of hatchery-origin salmon and steelhead competition on natural-origin salmon and steelhead in freshwater areas.

Hatchery-origin Species	Natural-origin Species Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	H	L	L	L	H	H
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	H	L	L	L	H	H
Chinook Salmon	H	L	L	L	H	H

Source: SIWG (1984)
Note: H = High risk; L = Low risk; and U = Unknown risk of an impact occurring.

In particular, large releases of hatchery-origin fish could displace natural-origin fish from their preferred habitats within the vicinity of hatchery release locations (Steward and Bjornn 1990; Pearsons et al. 1994; Riley et al. 2004). Young natural-origin juveniles may be competitively displaced by hatchery-origin fish, especially when hatchery-origin fish are more numerous, are of equal or greater size, and (if hatchery-origin fish are released as pre-smolts) the hatchery-origin fish become residuals before natural-origin fry emerge from redds (Pearsons et al. 1994; Tatara and Berejikian 2012). Tatara and Berejikian (2012) also found that the density of natural-origin and hatchery-origin fish relative to habitat-carrying capacity likely has a considerable influence on competitive interactions. However, Riley et al. (2004) found that small-scale releases of hatchery-origin Chinook salmon or coho salmon have few substantial ecological effects on natural-origin salmon fry in small coastal Washington streams, particularly when natural-origin fry occur at low densities.

Although freshwater release locations for most Puget Sound hatchery programs are in streams or rivers, some hatchery programs release fish into lake systems. Lake-rearing Chinook salmon life history strategies are ecologically unique compared to most Puget Sound Chinook salmon life history strategies, because the more common ocean-type Chinook salmon rarely occur in lakes throughout their natural distribution. Where Chinook salmon use lake systems, the potential for and the effects of intraspecific and interspecific competitive interactions may differ from hatchery effects on natural-origin fish in riverine habitats. This requires additional consideration of potential spatial and temporal effects associated with the release location within the lake system, including the timing of hatchery-origin fish releases relative to natural-origin salmon rearing and out-migration periods in lake basins.

In general, the potential effect of hatchery-origin salmon and steelhead competition on the behavior, and hence survival, of natural-origin fish depends on the degree of spatial and temporal overlap with hatchery-origin fish, relative fish sizes, and relative abundance of the two groups (Steward and Bjornn 1990). Effects would also depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990). Competition is greatest when hatchery-origin fish are more numerous than natural-origin fish, hatchery-origin fish are of equal or greater size, and/or hatchery-origin fish are released high in watersheds, thereby increasing the extent of overlap in area and the time in which competitive interactions may occur.

2.1.1.1.2 Adult Fish

Natural-origin salmon and steelhead spawners compete for habitat and mates (Naish et al. 2008). Salmon and steelhead females compete for redd sites, whereas males compete to fertilize eggs. Competition for spawning sites can substantially affect reproduction but the magnitude of the effects depends on the relative abundance, size, spawning date, and habitat preferences of the spawners involved (Essington et al. 2000). Hatchery-origin salmon and steelhead that spawn naturally in the project area may compete with their natural-origin counterparts for suitable spawning sites and mates (Flagg et al. 2000), thereby increasing competition risks to the natural-origin fish, particularly when suitable spawning habitat is limited.

Information on competition between hatchery-origin and natural-origin spawners is based largely on controlled semi-natural experiments (Fleming and Gross 1992, 1993; Berejikian et al. 1997, 2001). Results are mixed and inconclusive. For example, it is not clear if the captive-reared spawners used in the studies behave the same as naturally produced spawners.

Adult competition risks are generally limited to interactions between hatchery-origin and natural-origin fish of the same species. Although Chinook salmon may interact with other species in some Puget Sound rivers when they use the same reaches for spawning (such as chum salmon or pink salmon), hatchery production of these species is confined to locations where inter-species adult interactions are unlikely (e.g., Finch Creek in Hood Canal; Tulalip Creek) or are not substantial (e.g., Purdy Creek in Hood Canal). This EIS does not evaluate the risk of adult competition to natural-origin adult Chinook salmon, beyond noting its potential significance in systems where the available area of spawning habitat is believed to constrain production. However, this EIS does evaluate the effects of adult competition risks on Hood Canal summer-run chum salmon, because of the vulnerability of that species to this type of risk. For all other species, adult competition risk is not evaluated due to the lack of information on the occurrence of the risk.

2.1.1.2 Estuarine and Marine Areas

Hatchery-origin juveniles, smolts, and subadults can compete with natural-origin fish in estuarine and marine areas, leading to negative impacts on natural-origin fish in instances where preferred food may be limiting (SIWG 1984; Dawley et al. 1986). SIWG (1984) assessed potential intraspecific and interspecific risks to natural-origin salmon associated with hatchery-origin fish regarding resource competition in marine waters and determined most risks were unknown due to lack of data (Table B-2). In the early marine life stage, when natural-origin fish enter marine waters and fish are concentrated in relatively small areas, food may be in short supply and competition is most likely to occur. This period is of especially high concern for intraspecific and interspecific resource competition from hatchery-origin chum salmon and pink salmon to natural-origin chum salmon and pink salmon (Simenstad et al. 1980; Bax 1983; SIWG 1984) (Table B-2).

Table B-2. Risk of hatchery-origin salmon and steelhead competition on natural-origin salmon and steelhead in nearshore marine areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	**Pink Salmon**	**Chum Salmon**	**Sockeye Salmon**	**Coho Salmon**	**Chinook Salmon**
Steelhead	H	U	U	L	U	U
Pink Salmon	U	H	H	U	U	U
Chum Salmon	U	H	H	U	U	U
Sockeye Salmon	L	U	U	H	U	U
Coho Salmon	U	U	U	U	H	U
Chinook Salmon	U	U	U	U	U	H

Source: SIWG (1984)
Note: H = High risk; L = Low risk; and U = Unknown risk of an impact occurring.

Declines in average body size and weight-at-age of Pacific salmon observed during the 1980s and 1990s across the North Pacific Ocean were hypothesized by Holt et al. (2008) because of the abundance of hatchery-origin fish. However, research has not always concluded that competition by hatchery-origin fish exerts a density-dependent effect of reducing the growth and survival of natural-origin fish. McNeil (1991) found no clear density-dependent relationship between hatchery-origin and natural-origin fish that indicated competition was occurring in the marine environment. In most areas, descriptive studies of spatial and temporal overlap between hatchery-origin and natural-origin fish remain the basis for inferring the potential risks from hatchery-origin fish.

In the Campbell River estuary in British Columbia, Levings et al. (1986) did not find evidence of competition between natural-origin and hatchery-origin Chinook salmon, because the release of hatchery-origin fish did not appear to reduce the residence time of natural-origin fish, and there was no evidence of a density-dependent relationship between the two rearing types. The hatchery-origin fish also had a negligible effect on the growth of natural-origin Chinook salmon due to the tendency of hatchery-origin fish to inhabit deeper water, resulting in little dietary overlap between the two groups, as well as shorter residence time for hatchery-origin fish in the estuary (Levings et al. 1986; also see Fresh et al. 1979; Healey 1982; Myers and Horton 1982; Rowse and Fresh 2003). Duffy (2003) found similar growth rates between hatchery-origin and natural-origin fish in south Puget Sound in contrast to variable but higher growth rates for natural-origin fish in north Puget Sound. In this same study, Duffy (2003) noted obvious differences in juvenile salmon and steelhead diets between north and south Puget Sound. Other descriptive studies have also documented differences, similarities, and trends in salmon and steelhead diets that bear on assessments of competition from hatchery-origin fish (Healey 1980; McCabe et al. 1986; Macdonald et al. 1987; Brodeur 1990).

With the exception of small-scale chum salmon programs in the Skagit, Green, and Stillaguamish Rivers, pink salmon and chum salmon hatcheries in Puget Sound are located close to marine waters; therefore, there is minimal potential for competition or predation effects in fresh water on natural-origin populations. Few studies have examined the interactions of hatchery-origin and natural-origin pink salmon and chum salmon, but large hatchery-origin fish releases, such as those that occur in southern Hood Canal from the Hoodsport Hatchery and George Adams Hatchery, have the potential to affect the survival of natural-origin fish in the nearshore marine environment through food resource competition (Johnson et al. 1997).

An important consideration when evaluating competition in marine waters is that the actual number of juvenile hatchery-origin fish that reach Puget Sound marine waters is likely less than the total number released into fresh water from hatchery facilities. Mortality from piscivorous bird and fish predation, adverse flow conditions (floods, drought leading to stranding), and anthropogenic impacts (e.g., potential dewatering from hydroelectric dam operations, adverse water quality conditions from pollution, diversions into water bypass projects, and water intake screen entrainment) can substantially reduce post-release hatchery-origin fish survival to the estuary. The actual mortality levels resulting from these factors are affected by the timing, fish release numbers, and locations of the hatchery-origin fish release site. For example, Fresh et al. (1980) found that chum salmon juveniles released into a Hood Canal stream had a survival rate of 94 percent from the release point to the lower portion of the stream near the estuary when released at night, whereas when they were released at midday the survival rate decreased to 72 percent.

Migration mortality increases with the distance hatchery-origin fish travel to reach an estuary. Freshwater survival for chum salmon juveniles was estimated to be 74 percent for fry released at RM 1.4 of a Puget Sound stream, and 48 percent for fry released at about RM 6.2. The authors concluded from these data that increased exposure to predators decreases survival (Fresh et al. 1980). Seiler et al. (2001) used comparative recovery rate data from hatchery-origin subyearling Chinook salmon released upstream of juvenile out-migrant traps on the Skagit River to conclude that less than half the hatchery-origin Chinook salmon survived the downstream journey to migrate past the traps. The traps were located on the Skagit River at RM 17, and the hatchery-origin Chinook salmon subyearling smolts were released from three sites located at RMs 56, 70, and 87.

Given the above studies, the proportion of the total estimated number of juvenile hatchery-origin salmon and steelhead reaching the Puget Sound estuary after release from hatchery facilities may range from nearly 100 percent for fish liberated directly into or very near the estuary to 50 percent or less for juvenile fish released in relatively low numbers and many river miles removed from marine waters. The actual number of juvenile hatchery-origin salmon and steelhead that may, therefore, be of concern regarding estuarine competition and carrying-capacity effects on natural-origin Chinook salmon is likely much less than the stated freshwater release levels.

Hatchery-origin juveniles, smolts, and subadults can compete with natural-origin fish in estuarine and marine areas and negatively impact natural-origin fish in areas where preferred food may be limiting. In the early marine life stages, when natural-origin fish enter marine waters and fish are concentrated in relatively small areas, food may be in short supply and competition is most likely to occur. This period is of especially high concern when hatchery-origin chum salmon and pink salmon compete with natural-origin chum salmon and pink salmon for food resources.

2.1.2 Predation

Hatchery-origin salmon and steelhead may prey on co-occurring natural-origin salmon and steelhead juveniles. Studies have documented predation by coho salmon smolts on juvenile Chinook salmon, sockeye salmon, pink salmon, and chum salmon (Hargreaves and LeBrasseur 1986; Ruggerone and Rogers 1992; Hawkins and Tipping 1999). Juvenile hatchery-origin steelhead have also been shown to prey on natural-origin Chinook salmon and sockeye salmon juveniles (Menchen 1981; Cannamela 1993; Sharpe et al. 2008).

2.1.2.1 Freshwater Areas

Risks of predation on natural-origin fish are greatest in natural freshwater habitats adjacent to and downstream from the hatchery release sites where hatchery-origin fish are likely to be most concentrated.

Literature reviews of effects of hatchery-origin salmon and steelhead on natural-origin fish suggest that the potential for predation on natural-origin salmon and steelhead by hatchery-reared smolts is highly variable and depends on the relative size, number, and distribution of predators and prey; responses of predators; and the amount of time predators and prey share habitat areas (SIWG 1984; Flagg et al. 2000; Riley et al. 2004; Naish et al. 2008; Naman and Sharpe 2012). Much of what follows is excerpted from these reviews.

Most studies of predation in fresh water suggest that hatchery-origin fish may prey on fish that are up to 50 percent of their length (Pearsons and Fritts 1999; HSRG 2004), whereas other studies suggest that hatchery-origin predators prefer smaller prey, generally up to 33 percent of their length (Horner 1978; Hillman and Mullan 1989; CBFWA 1996). Hatchery-origin fish that do not migrate and take up residence (residuals) have the potential to be predators for longer time periods.

Risks to natural-origin salmon and steelhead attributable to direct predation (direct consumption) or indirect predation (increases in predation due to attraction of predators) can result from hatchery-origin salmon and steelhead releases. Hatchery-origin fish may prey upon juvenile natural-origin salmon and steelhead at several stages of their life history. Because of their location, size, and time of emergence, newly emerged natural-origin salmon and steelhead fry are likely to be the most vulnerable to predation by releases of hatchery-origin fish. This vulnerability may be greatest when fry emerge from the gravel and may decrease as fry grow and move into shallow shoreline areas (USFWS 1994). Newly released hatchery-origin smolts have the potential to prey on smaller natural-origin fry and parr that are encountered in fresh water as the smolts migrate to the ocean. In general, natural-origin salmon and steelhead are most vulnerable to predation when abundance of natural-origin fish is depressed and predator abundance is high, in small streams where migration distances are long, and when environmental conditions favor high visibility (SIWG 1984).

SIWG (1984) categorized species combinations to determine if there is a high, low, or unknown risk of direct predation by hatchery-origin fish that would have a negative impact on natural-origin salmon and steelhead in fresh water. Predation risks in fresh water were found to be greatest to natural-origin pink salmon, chum salmon, and sockeye salmon from releases of larger sized hatchery-origin coho salmon, Chinook salmon, and steelhead (Table B-3).

Table B-3. Risk of hatchery-origin salmon and steelhead predation on natural-origin salmon and steelhead in freshwater areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	**Pink Salmon**	**Chum Salmon**	**Sockeye Salmon**	**Coho Salmon**	**Chinook Salmon**
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Source: SIWG (1984)
Note: H = high risk, L = low risk, and U = unknown risk of an impact occurring.

Predation is influenced by the relative abundances of predators and prey. Low prey abundance may affect the ability of predators to catch prey, while high prey abundance may swamp predators and limit their impact. A number of complex and inter-related factors may affect predation potential including behavior (e.g., schooling, movements during the day and night), habitat preference, physiological status (e.g., readiness to transition from fresh water to marine water), and physical condition of the environment (e.g., visibility due to light and turbidity, and temperature).

2.1.2.2 Estuarine and Marine Areas

SIWG (1984) categorized the risk of direct predation by hatchery-origin fish on natural-origin salmon and steelhead in marine waters (Table B-4). Predation risks in marine waters were found to be greatest to natural-origin pink salmon, chum salmon, and sockeye salmon from releases of yearling hatchery-origin coho salmon, Chinook salmon, and steelhead (Table B-4).

Duffy et al. (2005, 2010) found that juvenile Chinook salmon preyed on fish, consuming mostly sand lance and, in some instances, juvenile pink salmon. Yearling Chinook salmon were more reliant on fish prey, including pink salmon, chum salmon, and subyearling Chinook salmon. Juvenile pink salmon and chum salmon were the main prey of yearling coho salmon in north and south Puget Sound (Duffy 2009). The diets of hatchery-origin Chinook salmon and coho salmon in marine environments are generally similar to those of natural-origin fish. Similar to freshwater conditions, Chinook salmon and coho salmon may prey on fish up to 50 percent of their length in marine areas (Brodeur 1991).

Table B-4. Risk of hatchery-origin salmon and steelhead predation on natural-origin salmon and steelhead in nearshore marine areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	Pink Salmon	Chum salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Source: SIWG (1984)
Note: H = high risk, L = low risk, and U = unknown risk of an impact occurring.

In summary, of all the hatchery-origin fish released, the larger Chinook salmon, coho salmon, and steelhead that are released at the yearling life stage have the greatest potential to be predators, and the smaller natural-origin pink salmon, chum salmon, and sockeye salmon have the greatest potential to be prey.

2.1.3 Genetics

The ability of natural-origin salmon and steelhead to home to streams of their birth with great accuracy and fidelity has helped these species develop genetic characteristics that are locally adapted and result in different salmon and steelhead species using unique aquatic habitats for food, cover, and spawning. However, production of hatchery-origin fish can result in genetic risks to natural-origin fish through reductions or changes in genetic diversity among and within populations, which erodes the ability of natural-origin fish to adapt to local conditions (Hard et al. 1992; Cuenco et al. 1993; Waples and Drake 2004). The effects of these genetic changes occur in categories discussed in this subsection: loss of within-population diversity, hatchery-induced selection (sometimes called domestication), and loss of among-population diversity and outbreeding depression. These effects can contribute to a loss of fitness in natural-origin fish, which is also described in this subsection. In most cases, genetic change is caused by the hatchery environment or by management of the hatchery program, and does not become an issue until mating occurs between hatchery-origin and natural-origin fish, either of the same or different populations. The following discussion describes the specific genetic risks relevant to Puget Sound salmon and steelhead.

2.1.3.1 Loss of Within-population Diversity

Genetic diversity is the suite of traits that allows populations to survive and adapt in response to environmental change. Loss of within-population genetic diversity is the reduction in quantity, variety, and combinations of genes in populations (Busack and Currens 1995). It would be difficult to totally control random loss of within-population genetic diversity in hatchery populations (Busack and Currens 1995). If broodstock obtained from a local natural-origin population does not reflect the range of genetic diversity of the population, subsequent interbreeding between natural-origin and hatchery-origin fish may, in turn, reduce the diversity of the natural-origin population. Therefore, hatchery broodstocks should ideally represent the variation in run timing, age composition, size, and fecundity that is observed in local natural-origin populations. In practice, however, it is difficult to randomly choose broodstock that includes or adequately represents all traits, particularly because relatively few spawners are needed to maintain hatchery-origin populations. However, by maximizing the number of adults used for broodstock, balancing sex ratios, and maintaining age structures, loss of diversity due to artificial propagation can be minimized.

Changes in genetic diversity within populations can occur via genetic drift. Genetic drift in hatchery and natural environments is caused by natural selection (Busack and Currens 1995), and occurs because progeny from one generation represent a sample of the genetic diversity of the parent population. Thus, over generations, genetic material can be lost, especially when population sizes are small (Busack and Currens 1995).

Genetic drift is governed by the effective population size, which is usually smaller than the actual number of fish that spawn because of genetic considerations such as discrete generations, equal sex ratios, random mating patterns, and other assumptions about family size. In hatchery programs, genetic drift can occur by using too few broodstock, using more females than males (or vice versa), pooling gametes (eggs or sperm), changing the age structure, or allowing progeny of some matings to have greater survival than others (Gharrett and Shirley 1985; Simon et al. 1986; Withler 1988; Waples 1991; Campton 1995). Some hatchery stocks have less genetic diversity and higher rates of genetic drift than naturally produced populations, presumably as a result of the small number of spawners used at hatcheries (Waples et al. 1990). Busack and Currens (1995) found that it would be difficult to totally control genetic drift in hatchery populations; however, by controlling broodstock numbers, sex ratios, and age structures, losses could be minimized. Risks of genetic drift by using too few spawners can be minimized by having hatcheries with large effective population sizes and by controlling the rate of straying of hatchery-origin fish into naturally produced populations.

Allendorf and Ryman (1987) report a loss of less than 1 percent of the genetic variation in a salmon or steelhead population each generation when there are at least 50 spawners. They recommend at least 100 fish of each sex (200 individuals) to maintain adequate genetic variability in hatchery stocks. Others have suggested that the long-term adaptive potential of an isolated population (without gene flow into it) is conserved with at least 500 individuals (Nelson and Soule 1987). Waples (1990) suggested that 100 effective breeders per year are necessary to maintain genetic variation in salmon and steelhead populations. As discussed in HGMPs for Chinook salmon in Puget Sound, most hatchery programs maintain effective spawning population sizes well above 1,000 fish, and, in some cases, above 10,000 fish.

Changes in genetic diversity within populations can also occur via the genetic mechanism of inbreeding depression (inbreeding) (i.e., mating between closely related individuals). Although inbreeding may not lead directly to changes in genetic diversity, interactions with other population factors can indirectly lead to changes. If the environment is selective for or against a specific trait, the combined effects of this environmental selectivity and inbreeding could indirectly result in reduced genetic diversity (Busack and Currens 1995). Although inbreeding is a concern, evidence of it occurring is generally not available for natural-origin or hatchery-origin populations of salmon or steelhead (Hard and Hershberger 1995). This is largely because the amount of genetic drift that has already occurred in natural-origin populations as a result of hatchery influences is generally unknown, and because few genetic analysis techniques are available to measure this effect.

2.1.3.2 Hatchery-induced Selection

Hatchery-induced selection (also referred to as domestication) is the process whereby genetic characteristics of hatchery populations become different from their source populations as a result of selection in hatchery environments (Busack and Currens 1995). Hatchery environments expose juvenile salmon to different conditions and selective pressures than the natural environment. Hatchery-induced selection can be intentional or unintentional. Intentional selection occurs when only spawners that have some trait of economic or other value (such as size, age at maturity, or fat content) are used for broodstock. Unintentional selection, for example, occurs when only the first fish to be sexually mature are used for spawning. In addition to selection for traits that are adaptive in the hatchery environment, of concern is the unintentional selection against (or relaxation of selection for) traits that would be adaptive in the natural environment.

Various studies have demonstrated the effects of hatchery-induced selection on salmon and steelhead. Species that are reared in hatcheries for a relatively short amount of time (e.g., subyearling Chinook salmon, chum salmon, and pink salmon) are less likely to be genetically changed by hatchery rearing than are species with longer freshwater rearing times (e.g., coho salmon, yearling Chinook salmon, and steelhead) (Berejikian and Ford 2004). Studies of steelhead in Washington and Oregon have shown that offspring of hatchery-origin steelhead and offspring from mixtures of hatchery-origin and natural-origin parents, experience lower survival under natural conditions. For example, Araki et al. (2007) estimated a 25 percent loss in fitness per generation in the hatchery. Effects are more acute when non-local steelhead stocks are used in hatchery programs (Leider et al. 1990).

Interbreeding that results in gene flow between hatchery-origin and natural-origin fish in nature can introduce hatchery-adapted traits into the natural-origin stock, potentially affecting the genetic diversity and fitness of their progeny.

Hatchery-induced selection can be reduced by hatchery practices, such as randomly selecting broodstock from throughout the run, using sufficient numbers of natural-origin broodstock to ensure that the contribution of selection in the natural environment outweighs inadvertent hatchery-induced selection in the hatchery, and employing appropriate spawning protocols to avoid genetic risks (Kapuscinski and Miller 1993). The proportionate natural influence (PNI) and proportion of hatchery-origin spawners (pHOS) (HSRG et al. 2004) are useful metrics for gauging hatchery-induced selection risks where information is available because the metrics quantify the estimated contribution and relationship between hatchery-origin and natural-origin spawners.

2.1.3.3 Loss of Among-population Diversity and Outbreeding Depression

Genetic differences among natural-origin salmon and steelhead populations arise as a natural consequence of their homing tendencies. Adult salmon and steelhead return with high fidelity to the streams of their birth. This leads to a relatively high degree of genetic separation among populations and to differences that are beneficial to fish survival in their dynamic local environments.

Despite the strong tendency of salmon and steelhead to return to their home streams, some return to and spawn in other streams, a process called straying. If strays successfully reproduce, this results in gene flow. Straying is common in salmon and steelhead but varies in pattern and intensity (Quinn 1993), including hatchery-origin fish (Westley et al. 2013). Straying is thought to serve a useful purpose in nature by reducing the loss of genetic diversity that occurs through genetic drift, and by providing opportunities for the species to naturally colonize or re-colonize vacant habitat.

Straying is generally not beneficial when it results in gene flow from unnatural sources or occurs at unnatural levels, and can have two adverse effects (loss of among-population diversity, and outbreeding depression). Loss of among-population diversity can compromise the adaptive potential of populations and render natural-origin populations less resilient (Hard et al. 1992; Cuenco et al. 1993; NRC 1996;

Waples 1996). There is a clear negative correlation between among-population diversity and gene flow from hatcheries (e.g., Phelps et al. 1994; Ayllon et al. 2006). However, there are exceptions to this general finding, whereby genotypes from indigenous salmon and steelhead populations were found to persist even where releases of hatchery-origin fish have been extensive (Phelps et al. 1994, 1997; Narum et al. 2006; Small et al. 2010).

The other effect from gene flow is outbreeding depression, which can reduce fitness (i.e., survival) in the first or subsequent generations after interbreeding. Outbreeding depression from excessive gene flow from non-local hatchery-origin salmon and steelhead into natural-origin populations (introgression) can reduce the fitness of individual populations (Ford 2002; Hansen 2002; McGinnity et al. 2003). Introgression may impair the fitness of natural-origin populations by introducing genetic traits that are less suited for survival in that particular environment, or by diluting the frequency of traits in the natural-origin population that are specifically adapted to that environment (Busack and Currens 1995). The greater the geographic separation between source and recipient populations, the greater the likelihood that genetic differences exist (ICTRT 2007). Therefore, hatchery-origin fish whose origins are geographically distant will likely differ from local natural populations, regardless of additional differences that may occur due to the impact of the hatchery-rearing environment (Subsection 2.1.3.2, Hatchery-induced Selection), resulting in outbreeding depression (Philipp et al. 2002; Miller et al. 2004; Darwash and Hutchings 2009). Hatchery-origin fish from distant sources may, therefore, pose a greater risk to the genetic diversity of a local natural-origin population than hatchery-origin fish originating from the same local natural-origin population. In contrast, relative genetic introgression risks are associated with the extent to which a hatchery-origin population is related to the natural-origin population (Eldridge and Naish 2007; Eldridge and Killebrew 2008; Eldridge et al. 2009).

Published studies presenting empirical evidence of the effects of outbreeding depression are few; this evidence is mostly from studies of plants in greenhouse settings or invertebrates in laboratory settings. There are few studies of outbreeding in vertebrates (Edmands 2007), and fewer with fishes (e.g., Gharrett et al. 1999; Philipp et al. 2002; Darwash and Hutchings 2009; Dann et al. 2010). A salient characteristic of these studies is that they are based on distantly related populations. The studies generally involve populations that are geographically or genetically separated much more than populations that are likely to have gene flow between them. It is unclear how much outbreeding depression occurs from genetic exchange between populations with similar life histories within an ESU/DPS, or even between ESUs/DPSs.

RIST (2009) reviewed studies that examined correlations between the abundance of hatchery-origin fish and various measures of natural-origin salmon survival, abundance, and productivity. They concluded that, in general, gene flow from hatchery populations into natural-origin populations is likely to reduce natural-origin population productivity, while acknowledging that such information is not available for ocean-type fall-run Chinook salmon. The authors deemed that limiting natural spawning of hatchery-origin fish should be an effective approach to reduce risks to productivity.

Hatchery stray rates can be estimated from sampling escapement, but few empirical studies have estimated gene flow. Grant (1997) summarized a NMFS-sponsored workshop convened in 1995 that addressed how much gene flow can occur and still remain compatible with the long-term conservation of local adaptations and genetic diversity among natural-origin populations. Grant (1997) found that, based on selection effects in other animals, a gene flow rate of greater than 5 percent between local and non-local populations would lead to replacement of neutral and locally adapted genes. However, gene flow is expected to be much less than 5 percent when the stray rate of non-local fish into a local population is 5 percent because not all fish that stray will spawn successfully.

Integrated hatchery programs use local broodstocks and are intended to maintain the genetic characteristics of source populations. If broodstock obtained from local source populations does not reflect the genetic diversity of those populations, subsequent interbreeding between natural-origin and hatchery-origin fish may reduce the diversity of the natural-origin population (Subsection 2.1.3.1, Loss of Within-Population Diversity).

Finally, it is important to note that genetic differences between populations (among-population diversity) may or may not include effects of hatchery-induced selection, but that outbreeding effects result from genetic differences between distinct populations due to their origins, separate from hatchery-induced selection.

2.1.3.4 Loss of Fitness

The primary overarching concerns associated with the genetic risks described above (loss of within-population genetic diversity, hatchery-induced selection, and loss of among-population genetic diversity), are loss of fitness and productivity associated with interbreeding between hatchery-origin and natural-origin fish. Several studies compared the relative fitness of hatchery-origin fish to natural-origin fish. Berejikian and Ford (2004) reviewed available studies of the relative fitness of salmon and steelhead regarding the origin of the hatchery broodstock (local or non-local) and the extent of hatchery-induced selection (number of generations the broodstock had been used in the hatchery). They found that most studies of relative fitness involved steelhead, and that management scenarios where the hatchery-origin fish were non-local had been subjected to considerable hatchery-induced selection. Relative fitness was highest in the one study involving a first generation hatchery-origin population of local origin, and lowest for hatchery stocks of non-local origin. Hatchery-origin stocks that had been propagated for the greatest number of generations of hatchery rearing were associated with decreased fitness relative to the natural-origin population, as was also the case where non-local hatchery broodstock was used.

Most other relative fitness studies of fish populations outside Puget Sound have reached similar conclusions. Araki et al. (2008) found that non-local hatchery-origin broodstocks tend to have lower relative fitness than local broodstocks. Leider et al. (1990) reported diminished survival and natural reproductive success for the progeny of non-native hatchery-origin steelhead when compared to natural-origin steelhead. The lower fitness of the naturally produced offspring of hatchery-origin steelhead could be the result of long-term artificial and hatchery-induced selection in the hatchery-origin fish, or due to use of a non-indigenous hatchery stock that had not adapted to the recipient stream (Leider et al. 1990). Chilcote (2003) reported a strong negative correlation between the proportion of naturally spawning hatchery-origin fish and population productivity among Oregon natural-origin steelhead populations. In contrast, Cramer et al. (2005) found that the productivity of natural-origin Mid-Columbia River steelhead was not diminished by the presence of hatchery-origin adults in the spawning population. The performance of spring Chinook salmon from a supplementation program was similar to the natural-origin spring Chinook salmon population in a study in the Columbia River basin (Hess et al. 2012).

As noted by Berejikian and Ford (2004) and RIST (2009), there are no relative fitness studies involving species whose life histories involve minimal time in fresh water (e.g., chum salmon, pink salmon, and subyearling fall-run Chinook salmon). Because relative fitness studies for these species and life stages were generally not available for review, relative fitness was based on inferences from the best information available for other species and life stages. For example, RIST (2009) found minimal or no evidence of differences in relative fitness for hatchery programs that had recently been developed. The authors also found that, although any artificial breeding and rearing will result in some degree of genetic change, information was insufficient on the rate of fitness loss in programs releasing subyearlings for any species to make strong conclusions about the rate of fitness loss due to hatchery propagation that follows this release strategy.

Genetic risks that are intrinsic to hatchery programs can be distinguished from those associated with hatchery practices (Campton 1995; Brannon et al. 2004). Proper hatchery management protocols can reduce some of the genetic risks on both hatchery-origin and natural-origin salmon and steelhead. The fitness effects posed by interbreeding from fish released from programs using low intervention approaches (e.g., limited number of generations in hatchery facilities, semi-natural rearing conditions) are likely to be substantially reduced and, in some cases, may be beneficial to natural-origin populations. For example, results from hatchery-based supplementation and reintroduction programs designed to preserve and restore ESA-listed Hood Canal summer-run chum salmon indicate that hatcheries can bolster the abundances of natural-origin fish, and re-establish naturally spawning populations in watersheds where they have become extirpated (WDFW and PNPTT 2007). Releasing hatchery-origin fish early in the life-cycle will probably result in less intense hatchery-induced selection; moreover, species or life-history types typically released from hatcheries as subyearlings may be less influenced by hatchery-induced selection than species that are typically released as yearlings (RIST 2009).

2.1.4 Hatchery Facilities and Operation

Hatchery programs pose risks to salmon and steelhead and the environment from the physical existence of the hatchery facilities as well as their operation. Guidelines and recommendations for successful hatchery practices (best management practices [BMPs]) to meet identified management objectives are useful to describe hatchery facilities and operation risk factors. EIS Subsection 2.2.2.1, Artificial Production Strategies, and Appendix A in WDFW and PSTT (2004) describe how different hatchery strategies (isolated or integrated hatchery programs) can be used to meet different management objectives (harvest and/or conservation). The seven subsections below describe hatchery facilities and operation risk factor categories consistent with NMFS hatchery effects categories and risk minimization measures included in its biological opinions (e.g., NMFS 2012), as well as HSRG recommendations and analytical approaches (HSRG 2004).

2.1.4.1 Broodstock Choice, Broodstock Collection, and Adult Holding

Guidelines and BMPs associated with the choice of broodstock for hatchery programs, methods of broodstock collection, and adult holding practices within hatchery facilities are important because these activities affect physical and behavior characteristics and survival of the subsequent hatchery-origin progeny. Characteristics of the broodstocks used should be consistent with the needs of the harvest or conservation management objective. For example, the preference is to use broodstock that represents the locally adapted natural-origin population in the watershed where the hatchery-origin fish are to be released. Broodstock collection factors include how similar or different the potential broodstock are to the natural-origin fish in the stream, whether broodstock are collected in sufficient numbers to minimize undesired genetic effects, effects on the natural population from broodstock collection, and whether guidelines are used by the hatchery operator to manage contributions of hatchery-origin fish spawning naturally. Adult holding factors include maintaining broodstock in water that is free of disease, is of suitable temperature, and is protected by detection systems that alert operators of system failures.

2.1.4.2 Spawning and Incubation

Guidelines and BMPs for activities associated with spawning and incubation factors were developed to ensure appropriate representation of the source broodstock and egg survival. Spawning guidelines and BMPs include ensuring that males and females are mated randomly, all broodstock have equal opportunity to contribute to progeny, and adequate health sampling and disease control is maintained. Practices for incubation should ensure that the eggs from the broodstock contribute equally and that egg and fry survival is maximized, diseases are identified and controlled, and facility conditions are adequately controlled to guard against failures.

2.1.4.3 Rearing and Release

Guidelines and BMPs associated with rearing and release factors are important to maintain the representativeness of the source broodstock, to maximize survival during rearing and after the fish are released, and to ensure that the hatchery-origin fish meet hatchery program management objectives (e.g., harvest or conservation). Rearing practices include randomly removing excess juveniles so that all families have an equal chance of surviving; confirming that released fish behave in a manner that is similar to natural-origin fish, including returning to spawn at the desired locations as adults; certifying that fish diseases are identified and controlled; and meeting water rights and screening criteria to ensure adequate flow conditions. Practices to reduce the risk of catastrophic loss include rearing fish in multiple facilities, rearing fish for the shortest period possible, using acclimation facilities where appropriate, and applying procedures that minimize fish disease.

Recommended practices for release of hatchery-origin fish include use of locations and release at life stages that maximize homing fidelity (e.g., acclimation facilities); marking and tagging hatchery-origin fish to distinguish between hatchery-origin and natural-origin populations, and to assist in preventing hatchery-origin fish from straying; and releasing fish of a size that is within the range of the natural-origin population and that minimizes competition or predation with natural-origin fish.

2.1.4.4 Disease

Bacterial, viral, fungal, and parasitic pathogens responsible for fish diseases can be present in both natural-origin and hatchery-origin salmon and steelhead (Hershberger et al. 2013). However, there can be uncertainty associated with the source of some fish disease pathogens (Williams and Amend 1976; Hastein and Lindstad 1991). Elliott and Pascho (1994) demonstrated that the incidence of some pathogens in naturally spawning populations may be higher than in hatchery-origin populations. Although pathogens may cause a high rate of post-release mortality among hatchery-origin fish, available information does not suggest that hatchery-origin fish routinely infect naturally produced salmon and steelhead in the Pacific Northwest (Enhancement Planning Team 1986; Steward and Bjornn 1990).

However, there are some rearing conditions that result in hatchery-origin fish having an increased risk of carrying pathogens. This is because hatchery-origin fish are reared at relatively high densities, which can increase stress and lead to greater occurrence and spread of disease. In contrast, natural-origin fish rear in streams at relatively low densities, which results in less potential for disease outbreaks among natural-origin fish populations. It is possible that releases of hatchery-origin fish may lead to the loss of natural-origin fish if hatchery-origin fish are carrying a pathogen not carried by natural-origin fish, if that pathogen is transferred to natural-origin fish, and/or if the transfer leads to a disease outbreak. Table B-5 summarizes the diseases found in natural-origin and hatchery-origin salmon and steelhead, describes factors that influence their susceptibility to disease outbreaks, and provides the potential for fish pathogen transmission within and between natural-origin and hatchery-origin salmon and steelhead. Guidelines and BMPs developed by HSRG (2004) to minimize disease are reviewed to determine the potential risk of spreading fish diseases to natural-origin salmon and steelhead populations.

2.1.4.5 Water Quantity and Quality

Hatchery facilities may indirectly affect natural-origin fish by altering water quality and quantity in the streams where hatchery facilities are located. Water withdrawals for hatchery operations from natural-origin salmon and steelhead spawning and rearing areas can diminish stream flows in reaches downstream of the water intake to where the outflow from the hatchery re-enters the stream. Flow can be diminished to the point where migration and spawning behavior and rearing survival of natural-origin salmon and steelhead in the affected area is impeded. Water withdrawals may also affect other stream-dwelling organisms on which natural-origin salmon and steelhead feed. Risks associated with water withdrawals can generally be minimized by complying with water right permits and meeting NMFS screening criteria (NMFS 2011b; NMFS 2004a). Water rights issued for hatchery operations are conditioned to prevent salmon migration, rearing, or spawning areas from becoming dewatered. Screening criteria for water withdrawal devices set forth conservative standards that help minimize the risk of harming naturally produced salmon, steelhead, and other aquatic fauna. General effects of hatchery dewatering are described under the EIS Hatchery Facilities and Operation subsections for each of the salmon and steelhead species evaluated in Subsection 3.2, Fish.

To help ensure that fish are not affected by water quality changes as a result of hatchery operations, HSRG developed operational guidelines regarding protection of water quality for broodstock collection, spawning, incubation, rearing, and release (HSRG 2004).

1 Table B-5. Fish diseases that may affect salmon and steelhead hatchery production in Puget Sound.

Disease (Pathogen)	Disease Type	Species Affected	Susceptible Life Stages	Symptoms	Treatment	Impact
Coldwater Disease *(Flavobacterium psychrophilum)*	Bacterial	Primarily affects coho salmon and steelhead. Chinook salmon, chum salmon, and sockeye salmon are moderately affected.	Fry to fingerling stages	External skin lesions and gill swelling	Antibiotics in feed Improved rearing condition	Most prevalent disease in Puget Sound. Losses can range up to 15 to 20 percent but are more likely in the 0.5 to 5 percent range.
Furunculosis *(Aermonas salmonicida)*	Bacterial	Species most affected are Chinook salmon and coho salmon. Steelhead, sockeye salmon, and chum salmon are moderately affected.	Juveniles and adults equally affected	Skin lesions and internal hemorrhaging	Antibiotics in feed for juvenile fish Antibiotic injections for adult fish	Associated with warm water. Juvenile losses are in the 0.5 to 5 percent range. Adult losses can range up to 25 to 30 percent.
Bacterial Kidney Disease *(Renibacterium salmoninarum)*	Bacterial	Species most affected are spring Chinook salmon and coho salmon. Sockeye salmon and fall Chinook salmon are moderately affected.	Yearlings and adults	Pustules in the kidney	Segregate eggs; Improve rearing conditions; Antibiotics in feed for juveniles, Injections for adults.	Biggest impact on spring Chinook salmon between yearling and adult stages. Coho salmon mortality occurs during rearing in marine water.
Columnaris (*Flavobacterium columnare)*	Bacterial	Species most affected are steelhead, Chinook salmon, coho salmon, and sockeye salmon	Juvenile to adult	Skin and gill lesions	Therapeutants added to water. Antibiotics in feed	Not widespread. Primarily a problem when temperature > 55ºF.
Enteric Redmouth Disease (*Yersinia ruckeri)*	Bacterial	Species most affected are Chinook salmon, steelhead, and trout. Chum salmon and sockeye salmon are moderately affected. Coho salmon are resistant.	Fry to fingerling stages	Bacterial septicemia	Immersion vaccination or antibiotics in feed	Not widespread. Losses occur early in spring (February to April) and usually in the 0.5 to 1 percent range.
Vibriosis (*Vibrio anguillarum + V. ordalii)*	Bacterial	Chinook salmon and coho salmon held in sea pens are most affected. Chum salmon are moderately affected.	Juvenile to adult	Bacterial septicemia	Immersion vaccination or antibiotics in feed or injected	Loss primarily associated with warm water. Losses can occur in the 0.5 to 5 percent range.

Table B-5. Fish diseases that may affect salmon and steelhead hatchery production in Puget Sound, continued.

Disease (Pathogen)	**Disease Type**	**Species Affected**	**Susceptible Life Stages**	**Symptoms**	**Treatment**	**Impact**
External Protozoan Parasite Infections *Ichthyobodo spp. Trichodina spp. Gyrodactylus spp. Icthyopthirius spp.*	Parasite	Species most affected is steelhead but all salmon and trout are susceptible.	Juveniles most susceptible	Skin and gill irritation	Therapeutants added to the water	External parasites typically compromise the host, but are not, by themselves, responsible for high losses. *Ichthyobodo* spp. is the exception to that rule. Steelhead losses can be high, at 25 to 50 percent without treatment.
Nanophyetus *(Nanophyetus salmincola)*	Parasite	Species most affected are Chinook salmon, coho salmon, and chum salmon.	Juveniles most susceptible	Skin and gill irritation and kidney swelling	No treatments available. Avoidance is only effective strategy.	Disease is primarily restricted to south Puget Sound.
Proliferative Kidney Disease *(Tetracapsoloides bryosalmonae*	Parasite	Species most affected are steelhead and coho salmon. Chinook salmon are moderately affected.	Juveniles most susceptible	Severe kidney swelling	No treatments available. Avoidance is the only effective strategy.	Substantial losses within limited range; steelhead mortality can reach 20 to 30 percent.
Infectious Hematopoetic Necrosis (*Infectious hematopoetic necrosis virus)*	Viral	Species most affected are sockeye salmon and steelhead. Chinook salmon are moderately impacted. Coho salmon are resistant.	Fry stage is most susceptible	Breakdown of blood forming tissues; severe anemia	Avoidance is the only effective treatment.	Limited range in Puget Sound/Washington coast, usually associated with sockeye salmon; can cause substantial losses (up to 70 to 80 percent).
Viral Hemorrhagic Septicemia (*Viral hemorrhagic septicemia virus)*	Viral	Most often detected in adult coho salmon in Washington. Challenge tests have shown steelhead and sockeye salmon are also susceptible.	Fry stage most susceptible	Viremia causes internal hemorrhaging.	Avoidance is the only effective treatment.	No disease outbreaks have occurred in Washington. Impact is low due to egg/fish transfer restrictions.

Table B-5. Fish diseases that may affect salmon and steelhead hatchery production in Puget Sound, continued.

Disease (Pathogen)	**Disease Type**	**Species Affected**	**Susceptible Life Stages**	**Symptoms**	**Treatment**	**Impact**
Erythrocytic Inclusion Body Syndrome (*EIBS virus)*	Viral	Species most affected are coho salmon and spring Chinook salmon; often associated with coldwater disease.	Yearling stage most susceptible	Anemia	Minimize handling stress during outbreak	Stress-induced disease; impact low.
Saprolegniosis *(Saprolegnia* sp.*)*	Fungus	All species	All stages, primarily in adults	Affects respiration	Therapeutants (formalin) added to the rearing water	Impact can be quite high on pre-spawning adults.

From reviews of existing hatchery facilities, there are only four hatchery facilities in Puget Sound where dewatering of stream reaches has the potential to affect fish and aquatic organisms. All four hatcheries have been in operation for at least 25 years (one has operated since 1917).

The hatcheries and streams affected are:

- North Fork/Johnson Creek Hatchery (Johnson Creek, Stillaguamish River)
- Little Boston Creek Hatchery (Little Boston Creek in Hood Canal)
- Voights Creek Hatchery (Voights Creek, Carbon River/Puyallup River)
- Minter Creek Hatchery (Minter Creek, Carr Inlet in South Sound)

Operation of the North Fork/Johnson Creek Hatchery program has a potential to result in dewatering effects on natural-origin coho salmon, steelhead, cutthroat trout, and potentially bull trout that rear or migrate in reaches of Johnson Creek adjacent to the hatchery. Withdrawal of water for the Little Boston Creek Hatchery program may affect natural-origin chum salmon and cutthroat trout. Water withdrawal for the Voights Creek Hatchery program could affect rearing and migrating Chinook salmon, coho salmon, chum salmon, pink salmon, steelhead, and cutthroat trout. Natural-origin Chinook salmon, coho salmon, fall-run chum salmon, steelhead, and cutthroat trout could be affected by water withdrawal at Minter Creek Hatchery.

However, in general, water withdrawals at each of the above four hatcheries occur near the stream mouths and the hatcheries are no more than approximately 0.5 RM upstream. Thus, the areas currently affected by the withdrawals are of limited length and are likely unsubstantial, especially considering the much larger areas occupied by the potentially affected fish populations. In summary, the effects on fish species from dewatering through water withdrawals are likely to be minimal, because the withdrawals affect limited areas on tributaries that are small and do not form major spawning areas for the species.

More detailed information on hatchery compliance with applicable water quality regulations are addressed in EIS Subsection 3.6, Water Quality and Quantity.

2.1.4.6 Hatchery Barriers to Fish Migration

Hatchery operations involve physical structures that can alter migrations and reduce survival of fish. These structures are typically artificial, although in some cases natural features that inhibit fish passage may also be used in hatchery operations. Structures used to collect hatchery broodstock include weirs or fish ladder-trap combinations associated with barriers such as dams. Structures can present partial or complete barriers to adult and juvenile fish, fish can be injured upon contact with the structure, and handling natural-origin fish at the structure can result in reduced survival. Weirs and traps used for broodstock collection may be temporary, and only used for a short time when the specific salmon and/or steelhead broodstock are returning. However, some facilities have permanent structures that can affect all migrating species, and require active transport of fish around the structure, as may be required to meet management objectives. Trapped fish can be counted and either retained for use in the hatchery or released to spawn naturally.

Hatchery weirs are structures in streams designed to block the migration of adult fish but allow passage of water, juvenile fish, debris, and, in some cases, boats. Hatcheries often use weirs to collect broodstock and sort hatchery-origin fish from natural-origin fish. This capability allows managing the number of hatchery-origin fish that spawn in the natural environment or collecting the appropriate proportion of natural-origin broodstock to maintain an integrated hatchery program. Considerations associated with weirs are described in RIST (2009).

As shown in Table B-6, there are 34 hatchery locations in the project area 23 at state (WDFW) facilities, 9 at tribal facilities, and 2 at Federal (USFWS) facilities, where barriers potentially can affect fish species. Of the 34 barriers, 7 barriers are temporary and 27 barriers are permanent structures. One or more species of salmon and steelhead may be affected at each of these barriers.

2.1.4.6.1 Summary of Barriers at State Hatcheries

A total of 23 barriers at state hatchery facilities are located in watersheds where ESA-listed salmon and steelhead may be present (Table B-6). All non-listed salmon species may be also affected (Table B-6). Twenty of the barriers are permanent structures (water intake and/or weir) that can affect migration of natural-origin fish year round, whereas three barriers are temporary structures that operate seasonally. One facility (Elwha Channel) has a water intake structure owned and operated by a separate entity that supplies the hatchery with water, and a weir and trap located at the hatchery outlet that may incidentally affect migration of natural-origin Chinook salmon and steelhead.

In some cases, separate barriers exist downstream of water intakes so that, even if fish passage (e.g., via a fish ladder) were provided at water intakes, passage upstream would still be restricted. This is the case at the Minter Creek Hatchery, Kendall Creek Hatchery, and Soos Creek Hatchery. At Minter Creek Hatchery and Kendall Creek Hatchery, Chinook salmon are not passed upstream of the hatchery weirs or water intakes because there is no Chinook salmon spawning habitat upstream. At the Tokul Creek Hatchery, unmarked adult Chinook salmon are captured at the hatchery weir and transported upstream above that structure by truck so that they can spawn naturally.

Table B-6. Barriers associated with hatchery programs in Puget Sound.

Operator	Hatchery Facility (barrier)	Affected Stream	Barrier Type		Affected Fish Species								
			Temporary	Permanent	Chinook Salmon	Hood Canal Summer -run Chum Salmon	Steelhead	Bull Trout	Coho Salmon	Fall-run Chum Salmon	Pink Salmon	Sockeye Salmon	Cutthroat Trout
State WDFW [1]	Kendall Creek Hatchery (hatchery rack)	Kendall Creek		X	X [2]		X [2]	X	X	X	X		X
	Kendall Creek Hatchery (water intake)	Kendall Creek		X	X [2]		X [2]	X	X	X	X		X
	Samish Hatchery	Friday Creek		X	X [2]		X [2]		X	X			
	Samish Hatchery (weir/trap)	Samish River	X		X [2]		X [2]		X	X			
	Marblemount Hatchery (water intakes/ rack)	Cascade River and Clark Creek		X			X [2]	X	X	X	X		
	Marblemount Hatchery (water intake)	Jordan Creek	X		X		X [2]		X		X		
	Whitehorse Pond Hatchery	White. Slough		X			X [2]	X	X				X
	Wallace River Hatchery (hatchery rack)	May Creek	X [3]		X [2]		X [2]		X	X	X		X

Table B-6. Barriers associated with hatchery programs in Puget Sound, continued.

Operator	Hatchery Facility (barrier)	Affected Stream	Barrier Type		Affected Fish Species								
			Temporary	**Permanent**	**Chinook Salmon**	**Hood Canal Summer -run Chum Salmon**	**Steelhead**	**Bull Trout**	**Coho Salmon**	**Fall-run Chum Salmon**	**Pink Salmon**	**Sockeye Salmon**	**Cutthroat Trout**
	Wallace River Hatchery (weir/adult pond)	Wallace River		X [4]	X [2]		X [2]		X	X	X		X
	Reiter Ponds Hatchery	Hogarty Creek		X			X [2]						
	Tokul Creek Hatchery (water intake)	Tokul Creek		X	X [2]		X [2]		X		X		X
	Issaquah Hatchery (water intake)	Issaquah Creek		X	X [2]		X [2]		X			X	X
	Soos Creek Hatchery (water intake and weir)	Soos Creek		X	X [2]		X [2]		X	X			X
	Voights Creek Hatchery (water intake)	Voights Creek		X	X		X [2]		X	X	X		
	Minter Creek Hatchery (hatchery rack)	Minter Creek		X	X		X [2]		X	X			X

Table B-6. Barriers associated with hatchery programs in Puget Sound, continued.

Operator	Hatchery Facility (barrier)	Affected Stream	Barrier Type		Affected Fish Species								
			Temporary	Permanent	Chinook Salmon	Hood Canal Summer -run Chum Salmon	Steelhead	Bull Trout	Coho Salmon	Fall-run Chum Salmon	Pink Salmon	Sockeye Salmon	Cutthroat Trout
	Minter Creek Hatchery (water intake)	Minter Creek		X	X		X [2]		X	X			X
	Hupp Springs Hatchery (water intake)	NA		X	X		X [2]		X	X			
	Coulter Creek Hatchery (water intake)	Coulter Creek		X			X [2]		X	X			
	George Adams Hatchery (hatchery rack)	Purdy Creek tributary		X	X		X [2]		X	X			X
	Dungeness River Hatchery (water intake 1)	Dungeness River		X	X [2]		X [2]	X	X	X	X		X
	Dungeness River Hatchery (water intake 2)	Canyon Creek		X	X [2]		X [2]	X	X	X	X		X
	Hurd Creek Hatchery (water intake)	Hurd Creek		X			X [2]		X				

Table B-6. Barriers associated with hatchery programs in Puget Sound, continued.

Operator	Hatchery Facility (barrier)	Affected Stream	Barrier Type		Affected Fish Species								
			Temporary	**Permanent**	**Chinook Salmon**	**Hood Canal Summer-run Chum Salmon**	**Steelhead**	**Bull Trout**	**Coho Salmon**	**Fall-run Chum Salmon**	**Pink Salmon**	**Sockeye Salmon**	**Cutthroat Trout**
	Elwha Channel Hatchery (water intake and weir)	Elwha River		X	X [2]								
Tribal Lummi Indian Nation	Skookum Creek Hatchery (hatchery trap/outfall barrier)	Skookum Creek		X					X				X
Upper Skagit Indian Tribe	Upper Skagit Hatchery (water intake)	Red Creek		X					X				X
Stilla-guamish Tribe	Stilla-guamish North Fork Hatchery (water intake)	Johnson Creek		X					X				X
Muckle-shoot Tribe	Keta Creek Hatchery (weir)	Crisp Creek	X						X	X			X
Puyallup Indian Tribe	Diru Creek Hatchery (weir/trap)	Diru Creek		X					X	X			X

Table B-6. Barriers associated with hatchery programs in Puget Sound, continued.

Operator	Hatchery Facility (barrier)	Affected Stream	Barrier Type		Affected Fish Species								
			Temporary	Permanent	Chinook Salmon	Hood Canal Summer-run Chum Salmon	Steelhead	Bull Trout	Coho Salmon	Fall-run Chum Salmon	Pink Salmon	Sockeye Salmon	Cutthroat Trout
Nisqually Indian Tribe	Clear Creek Hatchery (two hatchery racks [5])	Clear Creek	X	X	X [2]				X	X			X
	Kalama Creek Hatchery (hatchery rack)	Kalama Creek	X		X [2]								X
	Nisqually River (floating weir)	Nisqually River	X		X [2]		X	X	X	X	X		X
Federal USFWS	Quilcene National Fish Hatchery (two barriers; hatchery weir and ladder) [5]	Big Quilcene River and Penney Creek		X		X	X (Big Quilcene only)		X	X			X

[1] Source: Barber et al. (1997).
[2] ESA-listed population affected by barrier.
[3] Rack removed no later than October 1 each year.
[4] Pickets removed in December each year.
[5] This entry includes two weirs.

A temporary seasonal weir is installed in the Wallace River each year to capture adult summer-run Chinook salmon broodstock for the Wallace River Hatchery program. The weir is installed in the early summer and removed no later than October 1. Chinook salmon spawning habitat exists above the weir. Although natural-origin Chinook salmon are passed upstream to seed the area, Chinook salmon access to this habitat is affected during the period when the weir is operating. A permanent weir is also used on May Creek at the Wallace River Hatchery, whose pickets are removed in December, allowing later returning listed (winter-run) steelhead to pass into upstream spawning areas.

In summary, hatchery barriers at some of the state hatcheries may affect listed Chinook salmon, steelhead, and bull trout, as well as other non-listed salmon species (Table B-6). There are 18 state hatcheries with barriers that may affect listed Chinook salmon, and 22 barriers that may affect listed steelhead, but listed Hood Canal summer-run chum salmon are not affected by any barriers (Table B-6). However, in general, these barriers are not likely to cause substantial effects because they are only operated seasonally to collect broodstock for hatchery operations, fish are passed above the barriers, and/or the barriers are located on tributaries that are small or do not form major spawning areas for the species.

Effects of state and tribal hatchery-related barriers on bull trout under existing conditions (and all alternatives) are summarized in Subsection 3.4.1, Methods for Determining Risks—Hatchery Facilities and Operation. There are seven bull trout core areas in which hatchery-related migration barriers occur. Bull trout core areas are described in EIS Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS. Ten hatchery structures may affect fish migration in bull trout core areas and an additional three hatchery structures occur outside bull trout core areas. Most hatchery-related migration barriers in Puget Sound occur in streams below headwater areas where bull trout predominate, but most hatchery-related barriers only operate seasonally to obtain broodstock for hatchery operations. Therefore, the overall risk of effects from migration barriers on bull trout is low (see Subsection 3.4.1, Methods for Determining Risks—Hatchery Facilities and Operation).

2.1.4.6.2 Summary of Barriers at Tribal Hatcheries

A total of 9 tribal facilities have fish migration barriers (5 permanent barriers and **4** temporary barriers). The majority of the fish affected by these barriers are not listed. All non-listed salmon species may be affected except sockeye salmon (Table B-6). A characteristic of these barriers is that the areas from which salmon and steelhead access is restricted are generally less than 1 mile. Thus, the extent of impacts from tribal barriers overall is not likely to affect overall migration movements for the species because the extent of the upstream spawning and rearing area that is affected is small.

Three tribal barriers have the potential to affect listed Chinook salmon, and one may affect listed steelhead and bull trout. All of these barriers are located in the Nisqually River. A new temporary floating weir is being tested in the lower mainstem of the Nisqually River to examine the feasibility of the structure, obtain data from trapped fish, manage the composition of hatchery-origin and natural-origin Chinook salmon spawning naturally, and obtain broodstock for hatchery programs (NMFS 2010a).

2.1.4.6.3 Summary of Barriers at Federal Hatcheries

There is only one Federal hatchery in the project area (the USFWS Quilcene National Fish Hatchery) (Table B-6). This hatchery is located along the Big Quilcene River. Listed Hood Canal summer-run chum salmon and steelhead are found in the Big Quilcene River. There is no listed Chinook salmon population, or any persistent naturally spawning by Chinook salmon in the Big Quilcene River watershed. The effects of the Quilcene National Fish Hatchery program (and associated facilities) on listed summer-run chum salmon were previously evaluated and authorized by NMFS under limit 5 of the ESA 4(d) rule for Hood Canal Summer-run Chum Salmon (NMFS 2002).

Potential effects on listed steelhead and non-listed species (coho salmon, fall-run chum salmon, and cutthroat trout) (Table B-6) occur due to the artificial barrier on the Big Quilcene River. This barrier is a small dam with an electrified grid that prevents upstream movements when it is operating to collect hatchery broodstock. However, the electric grid is turned off after the coho salmon migration is complete, and a ladder is opened to allow passage of any species, including listed steelhead, and non-listed fall-run chum salmon and cutthroat. Thus, effects on listed steelhead are likely not substantial.

A permanent artificial barrier at the mouth of Penny Creek, a tributary of the Big Quilcene River, prevents migration of all fish into the tributary, because the hatchery uses the creek as its water supply. Impacts of the restriction on listed steelhead and other species are likely not substantial, because Penny Creek is a relatively small tributary located below the spawning and rearing areas that predominate farther up in the Big Quilcene River system.

2.1.5 Harvest Management

The harvest of fish in Puget Sound is managed to support conservation standards that comply with the ESA for listed fish, which includes Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, steelhead, southern green sturgeon, and Puget Sound/Georgia Basin rockfish. Where ESA-listed fish co-mingle with non-listed hatchery-origin fish, harvest is constrained so that it does not impede recovery.

Harvest of fish in Puget Sound that may result in 'take' of a listed species, and associated actions to minimize the risks of adverse effects on those species, are presented in recent Puget Sound harvest management plans for Chinook salmon and steelhead (PSIT and WDFW 2010a, 2010b). As described in

EIS Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, the effects of those fisheries on listed Chinook salmon, summer-run chum salmon, and steelhead, as well as other listed species are disclosed in a separate EIS (NMFS 2004b, 2005a), and are evaluated in ESA section 7 biological opinions and 4(d) rule evaluations (e.g., NMFS 2005b, 2009, 2010b, 2011c).

From these reviews, NMFS determined that harvest actions, as described in the most recent Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a), would not jeopardize the Puget Sound Chinook salmon ESU (NMFS 2011d). Hood Canal summer-run chum salmon are primarily caught incidentally in fisheries directed at other species. Limits on harvest impacts for this species are established in WDFW and PNPTT (2000), and are designed to help rebuild its populations. The summer-run chum salmon harvest management plan was determined by NMFS to not jeopardize the summer-run chum salmon ESU (NMFS 2001).

Because harvest impacts were previously evaluated in NMFS (2004b, 2005a), and incorporated by reference in this EIS (EIS Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish), the effects of harvest on listed salmon and steelhead are not analyzed in detail in this EIS. However, the socioeconomic effects of harvest are reviewed in this EIS in Subsection 3.3, Socioeconomics, and evaluated by alternative in EIS Subsection 4.3, Socioeconomics. Harvest effects on fish other than salmon and steelhead are discussed in the applicable subsections in EIS Subsection 3.2, Fish.

2.2 Benefits

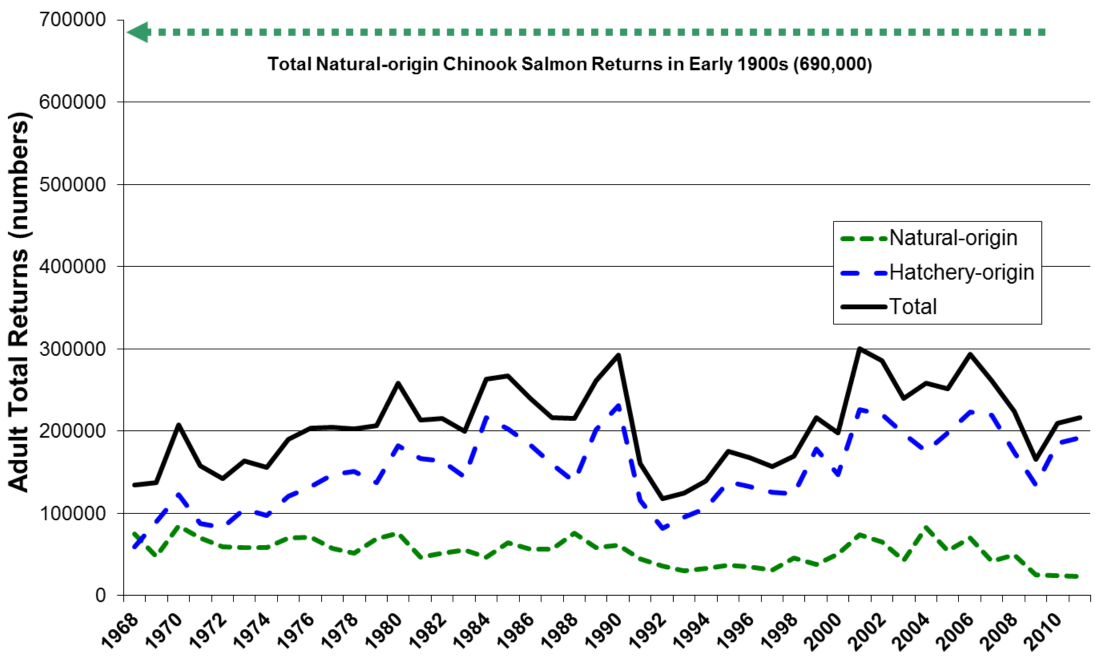
This subsection provides a general overview of benefits that hatchery programs provide to salmon and steelhead focusing on 1) hatchery-origin fish contribution to the total returns of fish (including fish available for harvest), 2) the contribution of hatchery-origin fish from certain hatchery programs to the viability of natural populations of salmon and steelhead (including the maintenance of genetic resources and reduction of extinction risk), and 3) contributions of marine-derived nutrients from hatchery-origin fish to the freshwater ecosystem.

2.2.1 Total Return

Total return is defined for the purposes of this EIS as the total number of returning adult hatchery-origin and natural-origin fish to Puget Sound, including fish that are harvested and fish that return to spawn. This is different from the definition of abundance that is applied to assess population viability (Subsection 2.2.2, Viability). In this subsection, the approaches used to describe total returns differ for species because the type and extent of information that is available varies considerably. For example, extensive information is available for salmon species (especially Chinook salmon), whereas less information is available for steelhead.

The total returns of salmon and steelhead species in Puget Sound are much lower than existed historically. For example, by 2002, the total returns of natural-origin and hatchery-origin Chinook salmon to Puget Sound were less than one-third of the 690,000 adult natural-origin fish estimated to have historically occurred in the early 1900s (Myers et al. 1998) (Figure B-1). This gap between historical and recent total returns is similar for other species. In another example, the historical returns of Puget Sound steelhead (409,200 to 682,000 fish) were likely at least an order of magnitude larger than current total estimates (Myers et al. 2014; see also Gayeski et al. 2011).

Hatchery-origin fish can provide a benefit by providing more fish for harvest, and under the appropriate conditions, for species conservation and recovery. This benefit helps compensate, in part, for loss and degradation of fish habitat and associated declines in natural productivity and the lower returns of natural-origin fish that have occurred over time. As shown in Table B-7, where information is available, adults from hatchery production contribute from 1 to 74 percent of the average total return (hatchery-origin and natural-origin) by species.



Sources: Estimated annual numbers of natural-origin and hatchery-origin Chinook salmon entering Puget Sound are from WDFW run reconstruction data, September 23, 2010. Estimated total natural-origin historic returns data are from Myers et al. (1998).

Figure B-1. Total annual adult returns of natural-origin and hatchery-origin Puget Sound Chinook salmon from 1968 to 2011, compared to estimated total historic returns.

Table B-7. Estimated average total return of adult salmon and steelhead and percentage of total adult return from hatchery production in Puget Sound.

Species	Average Total Return of Adults[1]	Average Return of Hatchery-origin Adults[1]	Average Percent of Total Adult Return that are Hatchery-origin Adults
Chinook salmon[2]	221,649	163,496	74 percent
Coho salmon[3]	960,006	447,285	47 percent
Chum salmon[4]	1,866,594	534,145	29 percent
Sockeye salmon[5]	337,767	101,330	30 percent
Pink salmon[6]	1,755,989	24,255	1 percent
Steelhead[7]	Unavailable	Unavailable	Unavailable

[1] Return is catch plus spawning escapement.
[2] Chinook salmon data for 2000-2004 are from Bruce Sanford, WDFW, e-mail to Tim Tynan, NMFS, June 21, 2005, regarding Chinook salmon run reconstruction.
[3] Coho salmon data for 1999-2003 are from Jeff Haymes, WDFW, e-mail to Tim Tynan, NMFS, July 2005, regarding coho salmon run reconstruction.
[4] Data for Puget Sound summer-run, fall-run, and winter-run chum salmon for 1998-2002 are from WDFW chum salmon website: http://wdfw.wa.gov/fishing/salmon/chum/pugetsound/data.html.
[5] Data on Cedar River and Baker River are from Kyle Adicks, WDFW, e-mail to Tim Tynan, NMFS, July 17, 2006, regarding estimated percent contribution of hatchery-origin sockeye salmon to the total Puget Sound return. Total adult return data from Baker Lake sockeye salmon trap counts and Ballard Locks fish counts for 2000-2004 accessed from the WDFW sockeye salmon website: http://wdfw.wa.gov/fishing/counts/sockeye/index.html.
[6] Puget Sound pink salmon data for 1989-2003 are from Kyle Adicks, WDFW, e-mail to Tim Tynan, NMFS, October 31, 2008, regarding pink salmon run reconstruction.
[7] Complete data for Puget Sound steelhead populations are unavailable, particularly for summer-run steelhead and most hatchery-origin populations that contribute to natural spawning.

Total return benefits are determined differently among species. For a discussion of the abundance benefits to ESA-listed species, in terms of population viability, refer to Subsection 2.2.2, Viability. Estimates of total returns are compared to standards that are intended to help measure the extent of benefits. For example, Chinook salmon total return benefits are associated with the extent that the estimated total number of hatchery-origin and natural-origin returns compares with Chinook salmon restoration spawner abundance targets. Restoration spawner abundance targets are the numbers of fish required for one spawner to produce one spawner in the subsequent generation (i.e., the population is replacing itself), and is consistent with the term "equilibrium abundance" used in Ford (2011). Insufficient information is available to use that same approach for other species. For steelhead, total return benefits are associated with the extent that the estimated total number of hatchery-origin and natural-origin returns compares with estimates derived using juvenile-to-adult steelhead survival rate goals (Fuss and Ashbrook 1995). Thus, the juvenile-to-adult survival rates in Table B-8 are used as standards to evaluate the contribution of hatchery programs for steelhead. These rates are based on assessments from fish marking programs and represent the potential contribution of well-operated hatchery programs to total returns from fisheries and escapement. In general, as total returns increase, benefits will also increase.

Table B-8. Juvenile-to-adult survival rate goals by species and life stage at release for hatchery-origin fish in Puget Sound.

Species	Life Stage at Release	Percent Juvenile-to-adult Survival Rate Goal[1]
Fall-run Chinook salmon[2]	Subyearling Yearling	1 5
Spring-run Chinook salmon[2]	Yearling	3 to 5
Coho salmon	Yearling	10
Chum salmon	Fed fry	0.5-1
Pink salmon	Fed fry	0.5-1
Sockeye salmon	Unfed fry	NA
Steelhead	Yearling	5

Source: Fuss and Ashbrook (1995).

[1] Juvenile-to-adult survival rate goals reflect total contributions to Puget Sound fisheries and escapement. Rates are goals based on expected adult return (Fuss and Ashbrook 1995).

[2] Chinook salmon are separated in the table by run timing primarily because survival rate goals differ by life stage at release. This is typically not the case for the other salmon and steelhead species.

2.2.2 Viability

Natural-origin salmon and steelhead populations are viable when they have a negligible risk of extinction due to factors such as small population size, local environmental variation from human activities, and genetic diversity changes over a 100-year timeframe (McElhany et al. 2000). Hatchery programs have benefits and risks on the viability of listed natural-origin populations, depending on the extent to which the programs contribute to the four VSP parameters that NMFS uses to assess population status and recovery (abundance, diversity, spatial structure, and productivity) (McElhany et al. 2000). The viability benefit associated with hatchery programs can contribute to the long-term health and evolutionary potential of fish species because the benefit helps foster resiliency of fish populations in the face of uncertain future environmental conditions.

As discussed in EIS Subsection 2.2.3, Guidelines for Each Artificial Production Strategy, there are two basic types of hatchery programs (integrated or isolated). Hatchery programs that are 1) reproductively connected (i.e., integrated) with a natural population (if one still exists), 2) promote natural selection over selection in the hatchery, and 3) contain genetic resources that represent the ecological and genetic diversity of a species, are then included in an ESU or DPS. When a hatchery program actively maintains distinctions or promotes differentiation between hatchery-origin fish and natural-origin fish, then NMFS refers to the program as isolated. Generally speaking, isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or a steelhead DPS.

Only integrated hatchery programs can benefit viability; isolated programs do not benefit viability. Use of integrated hatchery programs may accelerate recovery of a target population by increasing abundance in a shorter time period than may occur naturally (Waples 1996). Integrated programs whose primary management objective is conservation or recovery may be used to create genetic reserves to prevent the loss of unique traits due to natural or human-caused catastrophes, and may also be used to seed or reseed suitable, but vacant, habitat once the habitat factors limiting such uses have been addressed. The benefits of integrated programs for conservation or recovery must be weighed against the potential risks of reducing natural-origin production associated with removing eggs, juveniles, or adult fish from the natural environment for use as broodstock, altering the genetic integrity of the donor natural-origin fish population, and creating adverse ecological interactions among hatchery-origin and natural-origin juveniles.

The primary management objective of integrated hatchery programs can be harvest as well as conservation. Integrated programs whose primary management objective is harvest are designed to produce fish of the appropriate genetic composition to be compatible with the natural-origin salmon population in the watershed where the fish are propagated and released. The programs produce hatchery-origin fish that return in the largest numbers and highest quality possible for harvest in fisheries. These integrated harvest programs differ from isolated hatchery programs in that they incorporate natural-origin adult fish as broodstock, while limiting the proportion of hatchery-origin adults that spawn naturally, to increase the likelihood that the indigenous natural-origin spawning aggregation drives the genetic diversity of the salmon population in the natural environment (Mobrand et al. 2005).

The contributions of hatchery programs to the viability of listed natural-origin populations are consistent with and informed by the *Salmonid Hatchery Inventory and Effects Evaluation Report* (NMFS 2004a, 2006; Jones 2011), and NMFS' hatchery listing policy (70 Fed. Reg. 37204, June 28, 2005). That policy stipulates that hatchery-origin fish that are no more than moderately diverged from reference natural-origin populations can benefit the viability of listed ESUs or DPSs. NMFS reviews the status of ESA-listing decisions every 5 years, including the status of genetic resources in hatchery programs; the most recent update was completed in 2011 (Ford 2011).

Integrated hatchery programs may contribute to the viability of listed natural-origin populations in the context of NMFS' hatchery listing policy and in terms of VSP parameters (abundance, diversity, spatial structure, productivity) as follows:

- **Abundance** (number of individuals) contributes to viability when the number of listed hatchery-origin fish increases the number of natural-origin spawners. This use of abundance as specifically defined for its contribution to viability benefits is separate from total return benefits described in EIS Subsection 3.2.3.5, Benefits—Total Return (combined returns of hatchery-origin and natural-origin adult fish for either harvest and/or spawning).

- **Diversity** (e.g., variety of life histories, sizes, genetic differences) contributes to viability when hatchery operations (e.g., type, number, and manner of broodstock collection, mating, and rearing schemes) contain genetic resources important to the ESU or DPS.
- **Spatial structure** (distribution) contributes to viability when hatchery programs help fish bolster or re-establish natural production in habitat that was historically used for spawning and rearing.
- **Productivity** (change in population size or growth rate) is predominantly driven by habitat quality and quantity. Hatchery programs are unlikely to increase productivity except in situations where the small size of natural-origin populations is a predominant factor that limits population growth, and where fish extirpated from their historical habitat are successfully reintroduced (e.g., Chimacum Creek summer-run chum salmon, or Umbrella Creek [Lake Ozette] sockeye salmon).

Table B-9 summarizes the range of effects on population viability parameters from integrated and isolated hatchery programs.

2.2.3 Marine-derived Nutrients

During the time that anadromous salmon and steelhead live in marine environments, they consume food that contains nutrients that only occur in salt water (marine-derived nutrients). After spawning and dying in freshwater streams, the fish carcasses provide marine-derived nutrients as direct food sources for juvenile salmon, steelhead, and other fishes; aquatic invertebrates; and terrestrial animals. The nutrients increase primary and secondary production in streams (Wipfli et al. 1998; Gresh et al. 2000; Murota 2003; Quamme and Slaney 2002). As a result, these nutrients help support the growth and survival of stream-rearing juvenile salmon and steelhead (Hartman and Scrivener 1990; Johnston et al. 1990; Quinn and Peterson 1996; Bradford et al. 2000; Brakensiek 2002). NMFS (2004b) provides a comprehensive review of the scientific literature on this subject. Although all salmon and steelhead species may benefit to some extent from these carcasses, those that spawn relatively close to marine waters and those that have relatively short life histories in fresh water (i.e., chum salmon, pink salmon) may benefit less directly from marine-derived nutrients than species that spawn higher in stream systems and have longer freshwater life histories (e.g., coho salmon, steelhead).

Table B-9. Overview of the range in effects on viability parameters for natural-origin fish from integrated and isolated hatchery programs.

Viability Parameter	**Promote Genetic Diversity:** **Hatchery Broodstock Originate from the Local Population and are Included in the ESU or DPS** **(Integrated Programs)**	**Promote Differentiation:** **Hatchery Broodstock Originate from a Non-local Population or from Fish that are not Included in the Same ESU or DPS** **(Isolated Programs)**
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the small size of the natural-origin population is small, and in itself, is a predominant factor limiting population growth (i.e., productivity) (NMFS 2004a).	**Negligible to negative effect** This is dependent on differences between hatchery-origin fish and the local natural-origin population (i.e., the more distant the origin of the hatchery-origin fish the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural-origin populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural-origin populations. Broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** This is dependent on the differences between hatchery-origin fish and the local natural-origin population (i.e., the more distant the origin of the hatchery-origin fish the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance and productivity of the natural-origin populations in the ESU (70 FR 37204, June 28, 2005, at 37215).	**Negligible to negative effect** This is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect), handling, monitoring and research, and facility operation, maintenance, and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	**Negligible to negative effect** This is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect).

Source: NMFS (2012)

The total number and carcass biomass of hatchery-origin and natural-origin fish spawning naturally indicates the relative magnitude of marine-derived nutrient contributions. The total contribution of carcass biomass in the analysis area is about 23 million pounds (Table B-10). Chum salmon and pink salmon contribute the largest percentage of the biomass (80 percent combined), whereas coho salmon contribute 10 percent, and Chinook salmon contribute 5 percent. Chum salmon and pink salmon escapement is generally the least influenced by hatchery production carcass returns because carcasses of those species are predominantly of natural origin. The small steelhead escapement and biomass estimates (1 percent) reflects only natural-origin fish, because information on natural spawning of hatchery-origin steelhead is not available.

Table B-10. Average (2002–2006) total (hatchery-origin plus natural-origin) spawning escapement (numbers) and biomass (pounds) by species in Puget Sound.

	Chinook Salmon	Coho Salmon	Pink Salmon	Chum Salmon	Sockeye Salmon	Steelhead	Total
Escapement	71,381	398,882	1,791,749	952,294	169,166	16,011	3,399,483
(Percent)	(2)	(12)	(53)	(28)	(5)	(1)	(100)
Biomass[1]	1,070,709	2,393,292	7,166,998	11,427,525	1,014,997	96,066	23,169,586
(Percent)	(5)	(10)	(31)	(49)	(4)	(1)	(100)

Source: Will Beattie, NWIFC, email to Tim Tynan, NMFS, September 2, 2008, regarding carcass nutrient effects.
[1] Biomass is the average individual weight at return multiplied by escapement.

Hatchery production contributes marine-derived nutrients to freshwater systems through natural spawning of hatchery-origin fish and when hatchery programs place carcasses into streams. Table B-11 provides numbers of hatchery-origin salmon and steelhead carcasses distributed from hatcheries in Puget Sound watersheds. Most carcasses are from hatcheries producing coho salmon (44 percent), sockeye salmon (25 percent), and Chinook salmon (18 percent).

Table B-11. Numbers of salmon and steelhead carcasses distributed from WDFW hatcheries in Puget Sound watersheds.

Species	Hatchery Facility	Number of Carcasses [1]					
		2007	2008	2009	2010	2011	Average (percent of total)
Chum Salmon	Kendall Creek Hatchery		53	15			
	George Adams Hatchery		618				
	McKernan Hatchery	2,999	1,950	3,641	1,415	2,897	
	Minter Hatchery	150					
Total		**3,149**	**2,651**	**3,656**	**1,415**	**2,897**	**2,748 (10%)**
Chinook Salmon	Kendall Creek Hatchery		304	768	539	452	
	Samish Hatchery			13			
	Marblemount Hatchery	2,013	893	407	100	180	
	Tokul Creek Hatchery	17	9	36	4	69	
	Wallace River Hatchery			3			
	Issaquah Hatchery	210	298	239	128	414	
	Soos Creek Hatchery	1,533	896	2,069	542	313	
	Icy Creek Hatchery	13					
	Voights Creek Hatchery	565	1,152	1,016	988	972	
	Garrison Hatchery						
	Tumwater Falls Hatchery	77	261	136			
	Glenwood Springs Hatchery			37	787	2,243	
	Dungeness Hatchery		4				
	Elwha Hatchery	806	702	1,536	828	1,025	
Total		**5,234**	**4,519**	**6,260**	**3,916**	**5,668**	**5,119 (18%)**

Table B-11. Numbers of salmon and steelhead carcasses distributed from WDFW hatcheries in Puget Sound watersheds, continued.

Species	Hatchery Facility	Number of Carcasses [1]					
		2007	2008	2009	2010	2011	Average (percent of total)
Coho Salmon	Kendall Creek Hatchery		358	149	709	39	
	Baker Lake Hatchery				185	137	
	Marblemount Hatchery	8,040	3,896	5,512	754	640	
	Wallace River Hatchery	3,011	2,735	4,116	3,360	3,772	
	George Adams Hatchery						
	Issaquah Hatchery	297	186	120	452	161	
	Soos Creek Hatchery	1,944	1,306	2,192	194	202	
	Voights Creek Hatchery		63	2,161	1,209	50	
	Glenwood Springs Hatchery			23	54	149	
	Dungeness Hatchery	1,316	432	8,738	1,902	3,052	
Total		**14,608**	**8,976**	**23,011**	**8,819**	**8,202**	**12,723 (44%)**
Cutthroat	Eells Springs						
	Issaquah Hatchery			1			
Total				**1**			**0 (0%)**
Pink Salmon	Wallace River Hatchery			14			
	Soos Creek Hatchery	10		92			
	Voights Creek Hatchery	2		184		98	
	Dungeness Hatchery	205		314		203	
Total		**217**		**604**		**301**	**224 (1%)**
Steelhead	Kendall Creek Hatchery		9	25	108	117	
	Marblemount Hatchery	202	5	96	211	8	
	Whitehorse Pond	95	61			1	
	Tokul Creek Hatchery	244	234	265	149	106	
	Wallace River Hatchery			161			
	Reiter Ponds				4	451	
	Soos Creek Hatchery	139	278	89	288	193	
	Palmer Hatchery	141	74	109			
	Voights Creek Hatchery	67	37			9	
	Dungeness Hatchery	28	4	4	36	13	
Total		**916**	**702**	**749**	**796**	**898**	**812 (3%)**

Table B-11. Numbers of salmon and steelhead carcasses distributed from WDFW hatcheries in Puget Sound watersheds, continued.

		Number of Carcasses [1]					
Species	**Hatchery Facility**	**2007**	**2008**	**2009**	**2010**	**2011**	**Average (percent of total)**
Sockeye Salmon	Baker Lake Hatchery	2,598	2,865	4,824	3,742	1,307	
	Issaquah Hatchery	1	5			1	
	Cedar River Hatchery	2,121	2,084	3,106	6,818	6,643	
Total		4,720	4,954	7,930	10,560	7,951	7,223 (25%)
Total All Species		**28,844**	**21,772**	**42,211**	**25,506**	**25,917**	**28,850 (100%)**

Source: Catie Mains, pers. comm., WDFW, May 2, 2012.
[1] 2010 and 2011 data are preliminary.

Marine-derived nutrient contributions from salmon and steelhead to freshwater ecosystems were historically much larger than currently because the numbers of returning fish are now much less (Subsection 2.2.1, Total Return). Marine-derived nutrient benefits depend on a complex array of factors that include the distribution of salmon and steelhead carcasses, how long the carcasses are retained in the river before being removed by predators or moved downstream by floods, how quickly the carcasses decompose, and how the carcass nutrient content is retained and used within the ecosystem (Cederholm et al. 1999; Michael 1995; Bilby et al. 1996; Naiman et al. 2000). The relatively low salmon and steelhead spawning escapements in recent years (Gresh et al. 2000) likely exacerbate nutrient deficits in general, and may affect the recovery of natural-origin salmon and steelhead production in some streams. The hatchery-origin carcasses that are distributed within the Puget Sound streams each year (average 29,000) (Table B-11) help compensate for this decrease and contribute to primary and secondary production in freshwater streams.

3.0 Evaluation Methods and Criteria for Fish

This subsection describes the methods used for analysis of the affected environment and environmental consequences for fish contained in EIS Subsection 3.2, Fish, and EIS Subsection 4.2, Fish, respectively. The evaluation methods and criteria for listed Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, Puget Sound steelhead, and Washington Coastal-Puget Sound bull trout, non-listed salmon and trout, and other fish species are described in the subsections below.

3.1 Puget Sound Chinook Salmon

As described in EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, risk and benefit evaluations for Chinook salmon include competition, predation, genetics, and hatchery facilities and operations risks, and total return, viability, and marine-derived nutrients benefits. Risks and benefits are evaluated for each of the 22 natural-origin populations comprising the ESU, and at the ESU scale, except for marine-derived nutrients, which is evaluated only at the ESU scale.

3.1.1 Methods for Determining Risks—Competition and Predation

Competition and predation risks to natural-origin Chinook salmon from hatchery programs are evaluated for Chinook salmon hatcheries, coho salmon hatcheries, and steelhead hatcheries. Below are methods used to assess competition and predation risks in freshwater (watersheds and lakes) and marine areas.

3.1.1.1 Watersheds—Chinook Salmon and Coho Salmon Hatcheries

There are risks to natural-origin juvenile Chinook salmon from competition and predation with juveniles produced from Chinook salmon and coho salmon hatchery programs when the hatchery-origin and natural-origin fish of the same life stage co-occur.

Competition and predation risks to natural-origin Chinook salmon from Chinook salmon and coho salmon hatchery programs are assessed in watersheds containing recovery category 1 and recovery category 2 Chinook salmon populations (Table 2.2-1 in EIS Subsection 2.2.2, Hatchery Management Goal and Strategies). These watersheds are where indigenous Chinook populations occur, or where indigenous Chinook salmon populations have been extirpated and replaced by a localized, transplanted hatchery-origin stock, and where natural production is possible because suitable or productive habitat exists. The PCD Risk Model (Busack et al. 2005; Pearsons and Busack 2012) and analysis methods are described in Appendix D, PCD RISK 1 Assessment. The PCD Risk Model simulates the interaction between natural-origin and hatchery-origin salmon populations using input such as the following:

- Abundance of hatchery-origin and natural-origin anadromous salmon and steelhead juveniles
- Size (i.e., length) of hatchery-origin and natural-origin juveniles at the time hatchery-origin fish are released
- Freshwater residence time (days) of hatchery-origin fish after their release from the hatchery (a function of their release site and emigration speed)
- Extent (percent) of spatial and temporal overlap between hatchery-origin and natural-origin fish (a function of the length of the river where they co-exist)
- Freshwater survival rate of hatchery-origin fish as they emigrate seaward (daily decay rate)

- Habitat complexity approximated from application of the Ecosystem Diagnosis and Treatment Model (Lichatowich et al. 1995)
- Piscivory rate (for predation risk) determined from published diet studies, as an estimate of the likelihood that a natural-origin subyearling Chinook salmon would be consumed by a co-occurring Chinook salmon or coho salmon released from a hatchery

Competition and predation risks in fresh water from Chinook salmon and coho salmon hatchery programs to natural-origin Chinook salmon are qualitatively determined to be negligible, low, moderate, or high based on mortality rate index outputs from the PCD Risk Model (defined as the percent of the natural-origin Chinook salmon smolts that die as a consequence of competition or predation) (Table B-12). The risk levels assume that mortality rate indices greater than 5 percent are likely to have substantial adverse effects on Chinook salmon.

Table B-12. Criteria for assignment of competition and predation risk in fresh water to natural-origin Chinook salmon from hatchery-origin Chinook salmon and coho salmon.

Risk Level	**Criteria**
Negligible	Mortality rate index is less than or equal to 1 percent.
Low	Mortality rate index is greater than 1 percent but less than or equal to 5 percent.
Moderate	Mortality rate index is greater than 5 percent but less than or equal to 10 percent.
High	Mortality rate index is greater than 10 percent.

Multiple Chinook salmon populations are present in some watersheds (e.g., Nooksack, Skagit, Stillaguamish, and Snohomish River watersheds). In those watersheds, the PCD Risk Model output does not directly identify effects on individual natural-origin populations. In addition, the model simulates the effect of a hatchery release life stage (subyearling or yearling) on natural-origin Chinook salmon but not the effects of a combination of releases of both life stages. The effect of more than one hatchery program (e.g., a subyearling and a yearling Chinook salmon program, or a Chinook salmon program and a coho salmon yearling program) in a given system may be qualitatively assessed by examining the one-on-one simulations. However, because of the way the PCD Risk Model is structured, the model output (mortality rate indices based on percentages of natural-origin Chinook salmon that die as a consequence of predation or competition) cannot be accurately summed across programs. Where more than one hatchery program affects a Chinook salmon population, or where multiple populations exist in a watershed, the highest risk identified across programs is applied to that population. This approach is reasonable because it compensates for existing analytical constraints and limited available information. Rating the composite risks to individual natural-origin populations, according to highest risk ratings in an area where there may also be lower risk ratings, is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

3.1.1.2 Watersheds—Steelhead Hatcheries

The effects of steelhead hatchery programs on natural-origin Chinook salmon are not assessed with the PCD Risk Model because insufficient information on the life history of steelhead is available. Therefore, parameters for the model could not be accurately applied using inputs similar to those described for Chinook salmon and coho salmon hatcheries in Subsection 3.1.1.1, Watersheds—Chinook Salmon and Coho Salmon Hatcheries. For these reasons, competition and predation risks to natural-origin Chinook salmon posed by steelhead hatchery programs are assessed qualitatively.

Competition risks from steelhead hatchery programs to natural-origin Chinook salmon are qualitatively determined to be negligible, low, or moderate based on the timing of hatchery-origin steelhead releases and information on post-release residualism by hatchery-origin steelhead (Table B-13). Predation risks from steelhead hatchery programs to natural-origin Chinook salmon are qualitatively determined to be negligible, low, moderate, or high based primarily on the location and timing of hatchery-origin steelhead releases (Table B-14). Selection of parameters for competition and predation was based on literature reviews as summarized in Subsection 2.1.1, Competition, and Subsection 2.1.2, Predation, respectively, whereby release location and release timing would have the greatest potential to influence competition and predation once potential hatchery-origin competitors and predators are identified.

Table B-13. Criteria for assignment of competition risk to natural-origin Chinook salmon from hatchery-origin steelhead.

Risk Level	**Criteria**
Negligible	No hatchery-origin steelhead are released into the watershed.
Low	Hatchery-origin steelhead are released low in the watershed (up to RM 20), or steelhead are released after May 1, after the primary natural-origin juvenile Chinook salmon emigration period.
Moderate	Hatchery-origin steelhead are released low in the watershed (below RM 20), and steelhead are released before May 1, during the primary natural-origin juvenile Chinook salmon emigration period.
High	Hatchery-origin steelhead are released high in the watershed (above RM 20), and steelhead are released before May 1.

Table B-14. Criteria for assignment of predation risk to natural-origin Chinook salmon from hatchery-origin steelhead.

Risk Level	Criteria
Negligible	No hatchery-origin steelhead are released into the watershed.
Low	Hatchery-origin steelhead are released into the watershed after May 1, after the primary natural-origin juvenile Chinook salmon emigration period, and steelhead are released below RM 20.
Moderate	Hatchery-origin steelhead are released into the watershed before May 1, and steelhead are released below RM 20.
High	Hatchery-origin steelhead are released above RM 20.

3.1.1.3 Lakes

Competition and predation risks to natural-origin Chinook salmon populations exist from hatchery programs that produce Chinook salmon, coho salmon, and sockeye salmon for release into two lake systems—Lake Washington and Baker Lake—as described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population. The unique habitat available to Chinook salmon in these lake systems affects the potential for competition and predation in a manner that cannot be evaluated using the PCD Risk Model. Therefore, ecological risks are determined for the Chinook and coho salmon hatchery programs using a qualitative assessment.

Competition and predation risks to the Sammamish and Cedar Chinook salmon populations associated with the Cedar River Hatchery sockeye salmon program are assessed using biological baseline information and effects conclusions presented in the final Supplemental EIS for the Cedar River Sockeye Hatchery Project (Seattle Public Utilities 2005). Information on the effects of competition and predation to Chinook salmon from the Baker Lake sockeye program in the Skagit River watershed also relied on Seattle Public Utilities (2005).

3.1.1.4 Marine Areas

As described in EIS Subsection 3.2.5, Puget Sound Chinook Salmon ESU, Chinook salmon populations in the ESU rear throughout the marine waters of Puget Sound for varying periods of time, and would be exposed to competition and predation risks from hatchery-origin fish in those areas. Effects of competition and predation in marine areas are evaluated only on a Puget Sound-wide basis using inferences from the best available information. The risk of competition from hatchery-origin subyearling Chinook salmon production and the risk of predation from hatchery-origin yearling Chinook salmon releases are evaluated by alternative.

The PCD Risk Model addresses the risks of competition and predation to natural-origin Chinook salmon from the point of hatchery releases down to river-estuary confluences, but does not address risks in marine waters, including nearshore and pelagic environments (Appendix D, PCD RISK 1 Assessment). In marine areas, the risks of competition and predation under each alternative are evaluated in the context of hatchery-origin Chinook salmon production levels compared to the estimated baseline condition in Puget Sound marine areas, and the degree of spatial and temporal overlap between hatchery-origin and natural-origin Chinook salmon.

Competition risk to natural-origin Chinook salmon in marine areas under the alternatives is qualitatively determined to be negligible, low, moderate, or high, based on hatchery-origin subyearling Chinook salmon production levels compared to the estimated baseline condition in Puget Sound marine areas and the degree of spatial and temporal overlap between hatchery-origin and natural-origin Chinook salmon.

Predation risk to natural-origin Chinook salmon in marine areas under the alternatives is qualitatively determined to be negligible, low, moderate, or high, based on hatchery-origin yearling Chinook salmon production levels compared to the estimated baseline condition in Puget Sound marine areas and the degree of spatial and temporal overlap between hatchery-origin and natural-origin Chinook salmon.

3.1.2 Methods for Determining Risks—Genetics

This subsection identifies methods used to assess genetic risks of hatchery programs on listed Puget Sound Chinook salmon. The three categories of genetic risk described in Subsection 2.1.3, Genetics, that are evaluated are 1) loss of within-population diversity, 2) hatchery-induced selection (sometimes called domestication), and 3) loss of among-population diversity and outbreeding depression. These risks can contribute to a loss of fitness of natural-origin populations. Hatchery-induced selection risks to listed Puget Sound Chinook salmon are assessed for each population or watershed. Loss of within-population diversity and loss of among-population diversity/outbreeding depression are addressed to a lesser extent due to limitations in the availability of data.

3.1.2.1 Hatchery-induced Selection

Evaluation of hatchery-induced selection risk uses the AHA Model (Appendix E, Overview of the All-H Analyzer), and estimates gene flow and rates at which traits undergoing selection would change. Gene flow depends on the abundance of hatchery-origin and natural-origin spawners on the spawning grounds, their temporal and spatial overlap, and their mating success. When fish are brought into hatcheries for propagation, concerns exist that hatchery-induced selection may change a suite of traits away from the natural-origin optima for the population toward adaptation to the hatchery environment (Subsection 2.1.3.2, Hatchery-induced Selection).

For isolated Chinook salmon hatchery programs, hatchery-origin and natural-origin fish are managed to be distinct from each other, and thus no natural-origin fish are used as broodstock (EIS Subsection 2.2.2.1, Artificial Production Strategies). The genetic risks to recipient natural-origin Chinook salmon populations are related to the extent to which hatchery-origin adults reproduce, and mix with natural-origin fish on the spawning grounds. The metric used in this EIS as a surrogate for effects of hatchery-induced selection for isolated hatchery programs is the proportion of hatchery-origin fish spawning naturally (pHOS) (Appendix E, Overview of the All-H Analyzer). Use of the pHOS metric is a simplification, but the strength of using pHOS is that data on simple counts or estimates of the numbers of hatchery-origin and natural-origin spawners on the spawning grounds are more readily available. However, those numbers may not accurately represent the extent of actual spatial and temporal overlap, successful matings, and resultant gene flow. Successful matings are expected to be lower than the simple ratio of hatchery-origin to natural-origin spawner abundance. Hatchery-induced selection risks to natural-origin Chinook salmon from isolated hatchery Chinook salmon programs are qualitatively determined to be negligible, low, moderate, or high. These ratings are based on the HSRG's risk guideline of pHOS less than 5 percent for low-risk isolated programs (Mobrand et al. 2005) (Table B-15).

Table B-15. Criteria for assignment of genetic hatchery-induced selection risk to natural-origin Chinook salmon for isolated hatchery programs.

Risk Level	**Criteria**
Negligible	pHOS is less than 1 percent.
Low	pHOS is greater than or equal to 1 percent and less than 5 percent.
Moderate	pHOS is greater than or equal to 5 percent and less than 10 percent.
High	pHOS is greater than or equal to 10 percent.

Most hatchery programs for Puget Sound Chinook salmon are integrated with a natural population (EIS Subsection 2.2.2.1, Artificial Production Strategies). Integrated hatchery programs are intended to keep hatchery fish similar to the natural population, both genotypically and phenotypically. Genetic similarity can be achieved by continually mixing natural-origin adults into the hatchery broodstock, and by controlling the proportion of hatchery-origin adults among natural spawners. The metric used in this EIS to evaluate the risk that traits in natural-origin fish are optimal in the natural environment for integrated hatchery programs is the proportionate natural influence (PNI) (Appendix E, Overview of the All-H Analyzer). Where PNI values exceed 50 percent, it is hypothesized that the natural environment would drive adaptive change in the combined hatchery-origin and natural-origin population (HSRG et al. 2004). The premise is that traits in the combined population would remain similar to, or tend to change back toward characteristics that are more like a natural-origin population.

For this EIS, consistent with HSRG recommendations (HSRG et al. 2004), a PNI value of 0.67 or greater for long-term programs or 0.50 or greater for short-term programs present low risks for integrated hatchery programs that affect natural-origin Chinook salmon populations essential to the genetic diversity of the ESU. These PNI values conservatively emphasize the importance of natural-origin Chinook salmon as a driving influence on genetic risk and indicate relative hatchery-induced selection risks for the programs by alternative. The values serve as surrogate indicators for the other genetic risks associated with hatchery production that are not addressed at the population scale for the reasons previously mentioned.

Hatchery-induced selection risks to natural-origin Chinook salmon from integrated hatchery Chinook salmon programs are qualitatively determined to be negligible, low, moderate, or high (Table B-16), based on PNI thresholds associated with the HSRG's guidelines, duration of programs, and adherence to broodstock collection and mating BMPs.

Table B-16. Criteria for assignment of genetic hatchery-induced selection risk to natural-origin Chinook salmon for integrated hatchery programs.

Risk Level	**Criteria**
Negligible	No hatchery-origin Chinook salmon spawn naturally in the watershed.
Low	PNI is 0.5 or greater for short-term programs (less than 3 generations) and program adheres to BMPs for broodstock collection and mating, or PNI is 0.67 or greater for long-term programs (greater than 3 generations) and program adheres to BMPs for broodstock collection and mating.
Moderate	PNI is greater than 0.25 and less than 0.5 for short-term programs (less than 3 generations) and program adheres to BMPs for broodstock collection and mating, or PNI is greater than 0.35 and less than 0.67 for long-term programs (greater than 3 generations) and program adheres to BMPs for broodstock collection and mating.
High	PNI is 0.25 or less for short-term programs (less than 3 generations), or PNI is less than 0.35 for long-term programs (greater than 3 generations), or the program does not follow BMPs for broodstock collection and mating.

3.1.2.2 Loss of Among-population Diversity/Outbreeding Depression

Hatchery programs in Puget Sound historically used non-local Chinook salmon populations as hatchery broodstock to varying degrees. To the extent that returning non-local adults stray into natural spawning areas and interbreed with natural-origin, indigenous Chinook salmon, the resulting gene flow and outbreeding depression may cause a loss of fitness in the natural-origin progeny (Subsection 2.1.3.3, Loss of Among-Population Diversity and Outbreeding Depression). Where straying data for non-local hatchery-origin Chinook salmon are available, risk levels to natural-origin Chinook salmon populations are assigned using the pHOS-based criteria in Table B-15.

3.1.2.3 Loss of Within-population Diversity

Effects for this category of genetic risk are assessed qualitatively, using inferences based on available information. No quantitative analyses or modeling are used.

In summary, considering all categories, genetic risks to natural-origin Chinook salmon are assessed using results from AHA modeling and other complementary information, to the extent it is available. Model results emphasize hatchery-induced selection effects regarding the extent to which hatchery-origin fish reproduce, and commingle with natural-origin Chinook salmon on the spawning grounds (pHOS) for isolated hatchery programs, as well as the extent of natural influence (PNI) in integrated hatchery programs. Where available, information on other categories of genetic risk (i.e., loss of among-population diversity/outbreeding depression, or within-population diversity) complements the hatchery-induced selection risk evaluation information. As stated previously for competition and predation effects, where more than one hatchery program affects a Chinook salmon population, or where multiple populations exist in a watershed, the highest risk identified across programs is applied to that population or watershed. This approach is reasonable because it compensates for existing analytical constraints and limited available information. Rating the composite risks to individual natural-origin populations according to highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

3.1.3 Methods for Determining Risks—Hatchery Facilities and Operation

Hatchery programs require use of facilities and associated operations that can pose risks to natural-origin Chinook salmon. This subsection addresses a range of hatchery facilities and operation risks including barriers to fish migration and stream reach dewatering.

3.1.3.1 Hatchery Facilities and Operation

Hatchery facilities and operation risks to Puget Sound Chinook salmon populations are evaluated using two methods: 1) the HPV Tool, and 2) hatchery operator surveys in instances where the HPV Tool is not sufficiently informative. The HPV Tool was developed by the HSRG to assess operational effectiveness of hatcheries by evaluating the extent to which individual operations comply with BMPs (Appendix F, Hatchery Program Viewer [HPV] Analysis).

The HPV Tool relies on a series of 90 questions to develop compliance ratings. The HPV Tool provides information on eight operational phases used in this evaluation: broodstock choice, broodstock collection, adult holding, spawning, incubation, rearing, release, and facilities. Scores associated with each operational phase are categorized in terms of their relationship to viable salmon and steelhead population criteria for natural-origin fish (population abundance and productivity, population diversity, and spatial structure). Scores from the HPV Tool represent compliance ratings relating to BMPs that affect target natural-origin populations. The target populations for this analysis are those identified in the recovery plan for Puget Sound Chinook salmon listed under the ESA as shown in Table B-17 and Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population. The HPV Tool also highlights specific opportunities for changes that would benefit natural-origin fish and contribute to the identification of adaptive management mitigation measures. The results of the model for natural-origin Chinook salmon populations are described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population.

Fish disease risks include increases in the incidence and severity of endemic fish diseases, and the introduction of fish pathogens (Table B-5). All Chinook salmon hatchery programs are required to apply Fish Health Policy protocols adopted by WDFW and the Puget Sound tribes (NWIFC and WDFW 2006). These protocols, developed by state, tribal, and Federal agencies and based on the best available science, are deemed effective in controlling fish disease pathogen amplification and transfer risks; thus, disease introduction and transfer risks associated with Chinook salmon hatcheries are not evaluated.

3.1.3.2 Fish Migration Barriers

Results from hatchery operator surveys are used to evaluate the impact that permanent or seasonal barriers associated with Puget Sound tribal, state, and Federal salmon hatcheries might have on natural-origin Chinook salmon migrations (Subsection 2.1.4.6, Hatchery Barriers to Fish Migration). The effects of the migration barriers on Chinook salmon are described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population.

3.1.3.3 Stream Dewatering

Results from hatchery operator surveys are used to determine the extent to which water withdrawals associated with Puget Sound hatcheries result in dewatering of stream reaches adjacent to hatchery facilities (Subsection 2.1.4.5, Water Quantity and Quality). The effects of stream dewatering on Chinook salmon populations are described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population.

Hatchery facilities and operation risks associated with each hatchery program are determined to be negligible, low, moderate, or high depending on the compliance of the hatchery program with the HPV Tool BMPs, and the extent to which changes in the level of hatchery production differ from Alternative 1 (Table B-17). As stated previously, where more than one hatchery program affects a natural-origin Chinook salmon population, or where multiple populations exist in a watershed, the highest risk identified across programs is applied to that population or watershed. This approach is reasonable because it compensates for existing analytical constraints and limited available information. Rating the composite risks according to highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

Table B-17. Criteria for assignment of hatchery facilities and operation risks to natural-origin Chinook salmon.

Risk Level	Criteria
Negligible	Compliance for the hatchery program is moderate or high for all operational phases.
Low	Compliance for the hatchery program is low for one or more operational phases, or for the action alternatives (Alternatives 2 to 4), the fish production level is at least 15 percent smaller than Alternative 1.
Moderate	Compliance for the hatchery program is low for one or more operational phases, or for the action alternatives (Alternatives 2 to 4), the fish production level is the same as Alternative 1.
High	Compliance for the hatchery program is low for one or more operational phases, or for the action alternatives (Alternatives 2 to 4), the fish production level is 15 percent or more than Alternative 1.

3.1.4 Methods for Determining Benefits—Total Return

As described in Subsection 2.2.1, Total Return, hatchery-origin fish can provide a benefit by providing more fish for harvest and for conservation and recovery. For the purposes of the EIS, total return benefits (from hatchery and natural production) are evaluated at the population scale (and sometimes watershed scale) in terms of the relative contribution to the total return (combined hatchery-origin plus natural-origin contribution to fisheries and spawning escapement) and to the restoration spawner abundance level for each listed natural-origin population (Appendix C, Puget Sound Chinook Salmon Effects Analysis by

Population). For the purposes of the EIS, restoration spawner abundance levels are the equilibrium (replacement) abundance levels in Ford (2011).

Estimates of Puget Sound Chinook salmon hatchery-origin and natural-origin total returns involve combining contributions from Chinook salmon hatchery programs to fisheries and escapement, with run size estimates for natural-origin Chinook salmon populations. For each alternative, average hatchery-origin Chinook salmon run sizes are estimated for each hatchery program by multiplying juvenile production levels by the average contribution rates derived from coded-wire tag (CWT) recovery information for fisheries and escapement. Natural-origin Chinook salmon population run sizes are estimated by expanding average spawning escapement levels from 1999 to 2002 (NMFS 2005b) by the average percentage of total CWT recoveries in the spawning escapement for appropriate indicator stocks (CTC 2012). Run sizes for each hatchery program are summed with associated natural-origin run sizes to provide total return estimates for each of the 22 Puget Sound natural-origin Chinook salmon populations, and the estimates for each hatchery program are summed by alternative.

Total return benefits at the population scale are negligible, low, moderate, or high under the alternatives based on estimates of hatchery-origin plus natural-origin Chinook salmon run sizes for each program compared to restoration spawner abundance estimates (Table B-18). For the purposes of the EIS, the benefit levels assume that total returns greater than 20 percent of the restoration spawner abundance estimates are likely to have measureable and beneficial effects on total return numbers for Chinook salmon populations.

Table B-18. Criteria for assignment of total return benefits to Chinook salmon from Chinook salmon hatchery programs.

Benefit Level	**Criteria**
Negligible	No benefits are conferred by the program to the total return of Chinook salmon.
Low	Total run size of adult hatchery-origin Chinook salmon plus total run size of natural-origin Chinook salmon is less than 20 percent of the restoration spawner abundance estimate for the population.
Moderate	Total run size of adult hatchery-origin Chinook salmon plus run size of natural-origin Chinook salmon is 20 percent or greater but less than 50 percent of the restoration spawner abundance estimate for the population.
High	Total run size of adult hatchery-origin Chinook salmon plus run size of natural-origin Chinook salmon is greater than or equal to 50 percent of the restoration spawner abundance estimate for the population.

3.1.5 Methods for Determining Benefits—Viability

As described in Subsection 2.2.2, Viability, hatchery programs can benefit the viability of natural-origin Puget Sound Chinook salmon. Viability benefits from hatchery programs may only accrue from programs producing fish that are included in the listed ESU (Jones 2011). Hatchery programs that use fish not included in an ESU cannot benefit viability.

Benefits from listed hatchery programs to the viability of listed natural-origin populations are qualitatively evaluated in terms of the four VSP parameters (abundance, diversity, spatial structure, and productivity) NMFS uses to assess population status and recovery (McElhany et al. 2000). Abundance is benefited when naturally spawning listed hatchery-origin fish increase the number of natural-origin spawners. Diversity is benefited when BMPs are applied in hatchery operations (e.g., type, number and manner of broodstock collection, mating, and rearing schemes) to limit the likelihood that hatchery-origin fish would diverge from the natural population. Spatial structure is benefited when the listed hatchery-origin fish spawn naturally and successfully reproduce in available habitat that contribute to the distribution of the natural-origin population that was historically used for spawning. Productivity is predominantly driven by habitat quality and quantity, and is unlikely to benefit from listed hatchery programs, except in situations where the small size of the natural-origin population itself is a predominant factor that limits population growth.

Factors contributing to the assessment of viability benefits for the four VSP parameters include abundance and contribution of listed natural and hatchery-origin fish to natural-origin escapement, use of BMPs, distribution of hatchery-origin Chinook salmon into available historically used habitat, release levels, and population growth rate. Viability benefits to Chinook salmon at the population scale are based on a qualitative assessment of the extent to which each of the four VSP parameters for listed natural populations is benefited by listed hatchery programs as described in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population. Criteria for assessments of viability benefits to natural-origin Chinook salmon are found in Table B-19. The benefit levels assume that substantial (moderate or better) population viability benefits would occur when at least two viability parameters for Chinook salmon natural-origin populations are positively affected.

Table B-19. Criteria for assignment of viability benefits to natural-origin Chinook salmon from listed Chinook salmon hatchery programs.

Benefit Level	Criteria
Negligible	The hatchery program does not positively affect abundance, productivity, spatial structure, and diversity viability parameters for the natural-origin Chinook salmon population.
Low	The hatchery program positively affects one viability parameter.
Moderate	The hatchery program positively affects two or three viability parameters.
High	The hatchery program positively affects all four viability parameters.

3.1.6 Methods for Determining Benefits—Marine-derived Nutrients

After spawning, salmon die in streams and play an important role in the trophic dynamics of freshwater systems (Subsection 2.2.3, Marine-derived Nutrients). Nutrients that can only be obtained when fish feed in the ocean are brought into stream systems by salmon and steelhead and distributed naturally as carcasses when the spawners decompose. Hatchery production contributes marine-derived nutrients to freshwater systems via natural spawning of hatchery-origin fish and through carcass distribution programs of the hatchery operators. Because of the complexity and limited understanding of marine-derived nutrient dynamics (Subsection 2.2.3, Marine-derived Nutrients), along with uncertainties associated with natural-origin and hatchery-origin spawner escapements in Puget Sound waters, it is not possible to quantify effects for each alternative at the population scale. Therefore, nutrient benefits of Chinook salmon hatchery programs are evaluated only at the ESU scale.

This approach assigns levels of benefit based on the estimated percentage of hatchery-origin Chinook salmon carcasses in the context of hatchery production of all species, and the percentage change under the alternatives (Table B-20). It assumes that proportional differences in hatchery production among alternatives would lead to corresponding changes in carcasses and spawner biomass as contributions to marine-derived nutrient benefits. For the purposes of the EIS, the levels assume that marine-derived nutrient benefits to Chinook salmon from Chinook salmon hatchery programs would occur when the percent contributions of hatchery-origin Chinook salmon carcasses (compared to all species) are greater than 21 percent, and when estimates of percent increase in hatchery-origin Chinook carcasses compared to Alternative 1 are at least 26 percent. The specific percentages used in these criteria are based on a review of the range of carcass distribution percentages, and inspection of that data for natural break points for marine-derived nutrient benefit levels.

Table B-20. Criteria for assignment of marine-derived nutrient benefits from Chinook salmon hatchery programs.

Benefit Level	Criteria
Negligible	Under Alternative 1, hatchery-origin Chinook salmon carcasses comprise less than or equal to 10 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternatives 2 to 4), the increase in hatchery-origin Chinook salmon carcasses contributing to total spawner biomass is less than 10 percent compared to Alternative 1.
Low	Under Alternative 1, hatchery-origin Chinook salmon carcasses comprise more than 10 percent but less than or equal to 20 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternatives 2 to 4), the increase in hatchery-origin Chinook salmon carcasses ranges from 10 to 25 percent compared to Alternative 1.
Moderate	Under Alternative 1, hatchery-origin Chinook salmon carcasses comprise greater than 21 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternatives 2 to 4), increase in hatchery-origin Chinook salmon carcasses contributing to total spawner biomass ranges from 26 to 50 percent.
High	Under Alternative 1, hatchery-origin Chinook salmon carcasses comprise greater than 21 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternatives 2 to 4), increases in hatchery-origin Chinook salmon carcasses contributing to total spawner biomass are greater than 50 percent.

3.2 Hood Canal Summer-run Chum Salmon

As described in EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, evaluations for summer-run chum salmon are competition and predation risks. Competition and predation risks are evaluated for the two summer-run chum populations (Hood Canal and Strait of Juan de Fuca) and at the ESU scale. As described in EIS Subsection 3.2.6.4, Hatchery Program Risks (Summer-run Chum Salmon), and EIS Subsection 4.2.5, Hood Canal Summer-run Chum Salmon, because summer-run chum salmon hatchery programs are not evaluated in the EIS, genetic and hatchery facilities and operation risks, and benefits from total return, viability, and marine-derived nutrients are not evaluated.

3.2.1 Methods for Determining Risks—Competition

Competition risks associated with hatchery production are generally described in Subsection 2.1.1, Competition. As described in EIS Subsection 3.2.6.4.1, Risks—Competition (Summer-run Chum

Salmon), fish produced in hatcheries may compete with natural-origin summer-run chum salmon for food resources or habitat. Competition for food may occur in freshwater and nearshore marine areas during out-migration of juvenile summer-run chum salmon. Another effect considered in the EIS is adult competition between hatchery-origin salmon and steelhead and natural-origin summer-run chum salmon for spawning locations. The level of competition is assigned based on an evaluation of the extent to which hatchery-origin juvenile and adult fish would overlap spatially and temporally with summer-run chum salmon rearing, migration, and spawning areas.

3.2.1.1 Juveniles

Competitive interactions with summer-run chum salmon at the juvenile stage are qualitatively determined to be negligible, low, moderate, or high based primarily on the extent of overlap in space and time of hatchery-origin fish releases. These hatchery releases are compared to the freshwater and nearshore marine area out-migration timing for summer-run chum salmon using background information from NMFS (2002a) and WDFW and PNPTT (2000) (Table B-21). Food preferences of the species and release levels are also considered in assigning competition risk levels.

Table B-21. Criteria for assignment of juvenile competition risk to natural-origin summer-run chum salmon from hatchery-origin salmon and steelhead.

Risk Level	Criteria
Negligible	Hatchery-origin salmon or steelhead do not overlap in space and time with summer-run chum salmon.
Low	Hatchery-origin juveniles are released after the summer-run chum salmon fry out-migration period.
Moderate	Releases of hatchery-origin juveniles overlap out-migrating summer-run chum salmon fry in space and time.
High	Releases of hatchery-origin juveniles overlap out-migrating summer-run chum salmon fry in space and time, and the number of hatchery-origin fish released likely poses substantial competition risk.

3.2.1.2 Adults

Competitive interaction risks to summer-run chum salmon at the adult stage are qualitatively determined to be negligible, low, moderate, or high based primarily on the extent to which hatchery-origin adults may dig their redds where summer-run chum salmon eggs are already deposited (redd superimposition) (Table B-22).

Table B-22. Criteria for assignment of adult competition risk to natural-origin summer-run chum salmon from hatchery-origin salmon and steelhead (redd superimposition).

Risk Level	Criteria
Negligible	Hatchery-origin salmon or steelhead spawning does not overlap in space and time with summer-run chum salmon.
Low	Hatchery-origin adults spawn after summer-run chum salmon, and in areas that are not summer-run chum salmon spawning areas.
Moderate	Hatchery-origin adults spawn at the same time and in areas used by summer-run chum salmon.
High	Hatchery-origin adults spawn at the same time and in areas used by summer-run chum salmon, and the number of hatchery-origin fish released substantially increases the likelihood of overlap between hatchery-origin adults spawning at the same time and in areas used by summer-run chum salmon.

3.2.2 Methods for Determining Risks—Predation

Predation risks associated with hatchery production are described in Subsection 2.1.2, Predation. For summer-run chum salmon (EIS Subsection 3.2.6.4.2, Predation [Summer-run Chum Salmon]), fish produced in hatcheries may negatively affect natural-origin summer-run chum salmon as a result of predation by larger hatchery-origin salmon and steelhead. Risks of predation effects on summer-run chum salmon can be direct or indirect. Direct predation effects occur when summer-run chum salmon fry are eaten by fish that are of a size large enough to be able to consume the fry. Indirect predation effects occur when predators consume summer-run chum salmon while being attracted to concentrations of the more abundant hatchery-origin salmon with which summer-run chum salmon may be intermingled. Predation risks to summer-run chum salmon juveniles are qualitatively determined to be negligible, low, moderate, or high based primarily on the extent to which summer-run chum salmon fry overlap hatchery-origin releases that are of a large size compared to juvenile summer-run chum salmon during their freshwater and marine area migrations. Also considered is the extent to which hatchery-origin salmon released as fry attract predators at times and in areas where the summer-run chum fry are present (Table B-23).

Table B-23. Criteria for assignment of predation risk to natural-origin summer-run chum salmon juveniles from hatchery-origin salmon and steelhead.

Risk Level	Criteria
Negligible	Hatchery-origin salmon or steelhead do not overlap in space and time with summer-run chum salmon fry.
Low	Hatchery-origin fish do not prey on summer-run chum salmon fry because the released fish are no more than one-third larger than summer-run chum salmon fry, (e.g., fall-run chum salmon and pink salmon fry, and subyearling Chinook salmon), or Hatchery-origin fish are released after the summer-run chum salmon out-migration period.
Moderate	Releases of hatchery-origin juveniles overlap out-migrating summer-run chum salmon fry in space and time.
High	Releases of hatchery-origin juveniles overlap out-migrating summer-run chum salmon fry in space and time, and Hatchery-origin fish are released at a size large enough to consume summer-run chum salmon fry during the summer chum freshwater and marine out-migration period (direct predation), or Hatchery-origin fall-run chum salmon and pink salmon fry overlap spatially and temporally with out-migrating summer-run chum (indirect predation).

3.3 Puget Sound Steelhead

As described in EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, risk and benefit evaluations for steelhead include competition, genetics, and hatchery facilities and operations risks, and benefits from total return, viability, and marine-derived nutrients. These risks and benefits are evaluated for each of the 10 river basins where steelhead occur in Puget Sound, except for marine-derived nutrients, which is evaluated only at the scale of the steelhead DPS. Predation is not evaluated as a risk because natural-origin steelhead fry occur from June through October (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and no hatchery-origin yearlings are released during this period. In addition, the large size of natural-origin steelhead smolts and their propensity to move directly offshore once in marine waters helps juvenile steelhead avoid risks from predation (EIS Subsection 3.2.7.4.2, Risks—Predation [Steelhead]).

3.3.1 Methods for Determining Risks—Competition

Competition risks associated with hatchery production are described in Subsection 2.1.1, Competition. For natural-origin steelhead, competition risks from hatchery programs are most likely to occur from steelhead hatcheries, Chinook salmon hatcheries, and coho salmon hatcheries as described in EIS Subsection 3.2.7.4.1, Risks—Competition (Steelhead).

3.3.1.1 Steelhead Hatcheries

The HPV Coarse Filter Tool (adapted from Appendix F, Hatchery Program Viewer [HPV] Analysis) is used to evaluate effects on natural-origin steelhead from steelhead hatchery programs in terms of competition between juvenile hatchery-origin and natural-origin steelhead for food and space and between adult hatchery-origin and natural-origin steelhead for spawning sites and mates. Queries used by the tool in evaluating effects are:

1. Adults returning to the hatchery that are not needed for broodstock are not returned to the watershed to provide additional fishing opportunities, which may decrease competition between unharvested hatchery-origin adults and natural-origin adults on the spawning grounds.
2. Facilities exist to capture returning hatchery-origin adults at locations where juveniles from the program are released, decreasing the likelihood of competition between hatchery-origin and natural-origin spawners.
3. Juveniles are released in a physiological status consistent with smoltification, increasing the likelihood that they will out-migrate promptly and not remain and compete with natural-origin steelhead.
4. Juveniles are released at times and locations when competitive interactions for food and cover with natural-origin steelhead are minimized.
5. Juveniles are released off-station at locations with acclimation sites to increase smolt readiness to out-migrate promptly and minimize co-occurrence with natural-origin fish.

Competition risks from steelhead hatcheries are determined to be negligible, low, moderate, or high based on whether the HPV Coarse Filter Tool BMPs are met, and the extent to which changes in the level of hatchery production for Alternatives 2 to 4 differ from Alternative 1 (Table B-24). Major decreases or increases in production levels compared to Alternative 1 have more influence on risk ratings than minor increases or decreases.

Table B-24. Criteria for assignment of competition risk to natural-origin steelhead from hatchery-origin steelhead.

Risk Level	Criteria
Negligible	The hatchery program is in full compliance with the HPV Coarse Filter Tool BMPs.
Low	The hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, or For the action alternatives (Alternative 2 to 4), the fish production level is at least 15 percent smaller than Alternative 1.
Moderate	The hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, or For the action alternatives (Alternative 2 to 4), the fish production level is the same as Alternative 1.
High	The hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, or For the action alternatives (Alternative 2 to 4), the fish production level is 15 percent or more larger than Alternative 1.

3.3.1.2 Chinook Salmon and Coho Salmon Hatcheries

Natural-origin juvenile steelhead are exposed to competition risks from juveniles produced from Chinook salmon and coho salmon hatchery programs when hatchery-origin Chinook salmon and coho salmon are released at the same life stage (yearlings) and at the same time as when similar-sized natural-origin steelhead are present. Because insufficient data exist regarding juvenile natural-origin steelhead status, rearing behavior, and out-migration behavior, qualitative assessments are used to determine competition risks to natural-origin steelhead resulting from yearling Chinook and coho salmon hatchery production. Competition risks from Chinook salmon and coho salmon hatchery programs to natural-origin steelhead are qualitatively determined to be negligible, low, moderate, or high based on the likelihood and duration of competition with natural-origin steelhead, location of release, annual release sizes, and timing of releases relative to natural-origin steelhead rearing and out-migration (Table B-25).

Table B-25. Criteria for assignment of competition risk between natural-origin steelhead parr and smolts, and hatchery-origin yearling Chinook salmon and coho salmon.

Risk Level	Criteria
Negligible	No risks from the program on natural-origin steelhead parr and smolts.
Low	Hatchery-origin yearlings are released low in the watershed (below RM 20), or Total release numbers are less than 50,000 fish, or The hatchery-origin fish are not released during April-May—the primary natural-origin steelhead smolt emigration period.
Moderate	Hatchery-origin yearlings are released high in the watershed (above RM 20), and Total release numbers are 50,000 to 100,000 fish, and The hatchery-origin fish are released during April-May—the primary natural-origin steelhead smolt emigration period.
High	Hatchery-origin yearlings are released high in the watershed (above RM 20), and Total release numbers are greater than 100,000 fish, and The hatchery-origin fish are released during April-May—the primary natural-origin steelhead smolt emigration period.

3.3.2 Methods for Determining Risks—Genetics

Hatchery-induced selection and other genetic issues associated with hatchery production are described in Subsection 2.1.3, Genetics. In contrast to Chinook salmon, neither estimates of pHOS nor estimates of hatchery-origin steelhead spawning escapement are available for assessing introgression, hatchery-induced selection, and other genetic risks. This is because data quantifying the levels of straying and natural spawning by winter-run and summer-run hatchery-origin steelhead are generally not available (EIS Subsection 3.2.7.4.3, Risks—Genetics [Steelhead]).

As a result, in contrast to the modeling methods used to assess genetic risks for Chinook salmon, the HPV Coarse Filter Tool is used to evaluate genetic risks from hatchery-origin to natural-origin steelhead for each of the 10 river basins.

Isolated Hatchery Programs—Nineteen steelhead hatchery programs in the analysis area are operated as isolated programs that produce fish to meet harvest management objectives (EIS Subsection 2.2.2.1, Artificial Production Strategies). As described in EIS Subsection 3.2.7.4.3, Risks—Genetics (Steelhead), isolated steelhead hatchery programs use broodstock from unlisted out-of-DPS sources, and promote selection in the hatchery over selection in nature. Isolated hatchery programs are expected to pose risks to among-population diversity and fitness of natural-origin steelhead. The HPV Coarse Filter Tool is used to indirectly assess genetic risks by applying eight queries to programs where the broodstock originates outside of the indigenous steelhead genetic diversity unit (this includes all hatchery programs using Chambers Creek and Skamania steelhead stock in Puget Sound). This tool is also used in programs where the hatchery stock has been in artificial propagation for three or more generations (thus promoting selection in the hatchery over selection in nature).

Queries by the HPV Coarse Filter Tool for isolated steelhead hatchery programs are:

1. Has the gene flow from naturally spawning adults of hatchery-origin been quantitatively evaluated and found to be consistent with management objectives?
2. Did the broodstock for the program originate from the genetically appropriate local natural population within the watershed and has it been propagated in the hatchery for less than three generations?
3. Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?
4. Are hatchery-origin adults that return to traps removed from the watershed (i.e., not placed into the watershed to provide additional harvest opportunities)?
5. Do adequate adult capture facilities exist in every location where juveniles are released?
6. Are juvenile fish released on-station or, if released off-station, are the juveniles acclimated at the release site?
7. Are approximately 100 percent of the hatchery fish marked so that they can be distinguished from the natural population?
8. Is the proportion of natural spawners of hatchery-origin estimated for all natural populations with a reasonable probability of being impacted by releases from the program?

Integrated Conservation Hatchery Programs—Four steelhead hatchery programs in the analysis area are operated as integrated conservation programs (promoting selection in nature over selection in the hatchery) with the intent of supplementing natural-origin steelhead that are in low abundance (EIS Subsection 3.2.7.4.3, Risks—Genetics [**S**teelhead]). The HPV Coarse Filter Tool is used to evaluate genetic risks to natural-origin steelhead from gene flow by assessing the potential for genetic diversity loss and, for the purposes of this evaluation**,** other hatchery-related genetic risks from integrated programs.

Queries by the HPV Coarse Filter Tool for evaluating genetic risk for integrated conservation steelhead hatchery programs are:

1. Has the PNI in the watershed where the integrated hatchery steelhead program is located been evaluated and found to be consistent with management objectives?
2. Does the broodstock chosen represent natural-origin populations or populations that are adapted to the watersheds in which hatchery-origin fish would be released?
3. Have all populations within the watershed containing the target population been identified?
4. Are broodstock collected at a location and time such that only the target population would be collected?
5. Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?

Genetic risks from isolated and integrated steelhead hatcheries are determined to be negligible, low, moderate, or high based on whether the HPV Coarse Filter Tool BMPs are met, and the extent to which changes in the level of hatchery production for Alternatives 2 to 4 differ from Alternative 1 (Table B-26). Major decreases or increases in production levels compared from Alternative 1 have more influence on risk ratings than minor increases or decreases.

Table B-26. Criteria for assignment of genetic risk to natural-origin steelhead from hatchery-origin steelhead.

Risk Level	Criteria
Negligible	The hatchery program is in full compliance with HPV Coarse Filter Tool BMPs (applies to all alternatives).
Low	The hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs (applies to all alternatives), or For the action alternatives (Alternative 2 to 4), the fish production level is at least 15 percent smaller than Alternative 1.
Moderate	For the action alternatives (Alternative 2 to 4), the hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, and the fish production level is the same as Alternative 1.
High	For the action alternatives (Alternative 2 to 4), the hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, and the fish production level is 15 percent or more larger than Alternative 1.

3.3.3 Methods for Determining Risks—Hatchery Facilities and Operation

The HPV Coarse Filter Tool is used to assess risks of hatchery facilities and operation on natural-origin steelhead for each of the 10 river basins using criteria developed by HSRG (2004) as described in EIS Subsection 3.2.7.4.4, Risks—Hatchery Facilities and Operation. The HPV Coarse Filter Tool assesses whether facilities, such as water intake structures, meet current standards designed to prevent entrainment and injury of out-migrating natural-origin juvenile steelhead. Other factors include the placement and operation of hatchery structures that are potential barriers to natural-origin fish migration, and the locations of hatchery facilities that could be prone to flooding and loss of hatchery-origin steelhead production. The HPV Coarse Filter Tool is also used to identify steelhead hatchery programs by river basin that use out-of-basin-origin steelhead as broodstock or transfer steelhead smolts between river basins that create a risk of fish disease transfer. All steelhead hatchery programs are required to apply Fish Health Policy protocols (NWIFC and WDFW 2006), which are deemed adequate to minimize fish pathogen risk to natural-origin fish; thus, disease transfer risks associated with steelhead hatcheries are not analyzed. This risk category also includes the extent to which hatchery programs have performance standards and indicators in their hatchery management plans (PSTT and WDFW 2004) that address risks to natural-origin steelhead as part of an adaptive management framework.

Queries by the HPV Coarse Filter Tool for evaluating hatchery facilities and operation risk are:

1. Does hatchery intake screening comply with IHOT (1995), NMFS, or other agency facility standards?
2. Does the facility operate within the limitations established in its National Pollutant Discharge Elimination System (NPDES) permit and in compliance with state or federal regulations for discharge?
3. Does water usage at the facility comply with applicable permits?
4. Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?
5. Are hatchery structures located and operated in a manner that does not impede passage of natural-origin juveniles and adults?
6. Is staff notified of emergency situations at the facility through the use of alarms, auto dialer, and pagers?
7. Are program objectives defined?

8. Are performance measures established and monitored for PNI, fish health, survival within the hatchery, and smolt-to-adult survival rates?

9. Are hatchery programming and operational decisions based on an adaptive management plan?

Hatchery facilities and operation risks are determined to be negligible, low, moderate, or high based on whether the HPV Coarse Filter Tool BMPs are met, and the extent to which changes in the level of hatchery production differ between Alternative 1 and Alternative 2 (Table B-27).

Table B-27. Criteria for assignment of hatchery facilities and operation risks to natural-origin steelhead.

Risk Level	Criteria
Negligible	The hatchery program is in full compliance with HPV Coarse Filter Tool BMPs (applied to all alternatives).
Low	The hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs (applies to all alternatives), or The fish production level is at least 15 percent smaller than Alternative 1.
Moderate	Under the action alternatives (Alternative 2 to 4), the hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, or The fish production level is the same as Alternative 1.
High	Under the action alternatives (Alternative 2 to 4), the hatchery program is out of compliance with one or more HPV Coarse Filter Tool BMPs, or The fish production level is 15 percent or more larger than Alternative 1.

3.3.4 Methods for Determining Benefits—Total Return

The benefit of total return associated with hatchery production is described in Subsection 2.2.1, Total Return. Assessments of steelhead spawner total returns are complicated by high spring runoff during the spawning season, which precludes effective surveys in some large rivers and introduces high uncertainty in estimates for some years (EIS Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead). In addition, there is minimal information available on the contribution of hatchery-origin steelhead adults to natural spawning areas in nearly all cases.

Therefore, for the purposes of this analysis, the numbers of adults that would be produced under the alternatives for each of the 10 river basins are used to indicate the relative contributions of adult hatchery-origin steelhead available to fisheries and escapement (Appendix H, Steelhead Effects Analysis by

Basin). Estimates of the contribution of adult hatchery-origin steelhead are derived by applying recent year average smolt-to-adult return survival rates to the annual number of smolts that would be released under each alternative. For EIS purposes of comparing relative total return benefits across alternatives, a 1 percent survival rate goal is applied from the time the fish are released as yearling juveniles to return as adults. The goal associated with that survival rate is consistent with the generally low return rates for hatchery-origin Puget Sound steelhead in recent years, and recent declining abundance trends (EIS Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead). It is also the estimated adult return rate goal for hatchery-origin steelhead yearlings assumed in WDFW's HGMPs for hatchery-origin yearling steelhead (PSTT and WDFW 2004). Total return benefits under the alternatives are negligible, low, moderate, or high based on the extent to which returns of adult hatchery steelhead based on average smolt-to-adult return rates compare with the 1 percent survival rate goal (Table B-28).

Table B-28. Criteria for assignment of total return benefits from steelhead hatchery programs.

Benefit Level	Criteria
Negligible	No benefits are conferred by the program to steelhead adult total return.
Low	Returns of adult hatchery-origin steelhead are less than 50 percent of the adult return goal.
Moderate	Returns of adult hatchery-origin steelhead are greater than or equal to 50 percent but less than 75 percent of the adult return goal.
High	Returns of adult hatchery-origin steelhead are greater than or equal to 75 percent of the adult return goal.

3.3.5 Methods for Determining Benefits—Viability

The benefit to viability associated with hatchery production is described in Subsection 2.2.2, Viability. For steelhead, viability benefits to natural-origin fish would accrue from the four integrated steelhead conservation hatchery programs, but not from the isolated steelhead hatchery programs (EIS Subsection 3.2.7.4.7, Benefits—Viability [Steelhead]). Viability benefits from hatchery programs may only accrue from programs producing fish that are included as part of the listed DPS. Viability benefits from the four integrated conservation programs may accrue to natural-origin steelhead in terms of abundance, spatial structure, diversity, and productivity, which are the VSP parameters used by NMFS to assess the status of listed salmon and steelhead (McElhany et al. 2000). As described in Subsection 2.2.2, Viability, abundance is benefited when the number of naturally spawning listed hatchery-origin fish increases the number of natural-origin spawners. Diversity is benefited when the hatchery program contains genetic resources important to the DPS and when BMPs are applied in hatchery operations (e.g., type, number, and manner of broodstock collection, mating, and rearing schemes) to limit the likelihood that hatchery-origin fish would diverge from the natural population. Spatial structure is benefited when the program leads to hatchery-origin fish returning to and using available habitat that was historically used for spawning. Productivity is predominantly driven by habitat quality and quantity, and is unlikely to benefit from listed hatchery programs, except in situations where the small size of the natural-origin population itself is a predominant factor that limits population growth.

The integrated programs help to increase the number of fish naturally spawning, the locations where the fish spawn, and conserve genetic resources, although fitness could decrease for existing natural-origin stock (which is evaluated separately as a genetic risk [Subsection 4.2.3.3.1.2, Methods for Determining Effects—Genetics]). These expectations are consistent with the general approach and findings in NMFS (2004a, 2006) and Jones (2011), which assessed the extent to which fish from hatchery programs diverge from their natural-origin counterparts in watersheds where the hatchery-origin fish were released. Consistent with the availability of information, viability benefits to natural-origin steelhead at the river basin scale are assigned qualitatively based on the general assumption that the benefit level corresponds with the number of fish released from the integrated conservation hatchery programs; the larger the number of fish released, the greater the benefit. It is recognized that release number can also present genetic risks due to gene flow from hatchery-origin to natural-origin fish, but for the purposes of the EIS, that genetics risk is addressed separately. Table B-29 provides the criteria for assessments of viability benefits to natural-origin steelhead.

3.3.6 Methods for Determining Benefits—Marine-derived Nutrients

After spawning, all salmon and some steelhead die in streams and play an important role in the trophic dynamics of freshwater systems (Subsection 2.2.3, Marine-derived Nutrients). Nutrients that can only be obtained when fish feed in the ocean are brought into stream systems by salmon and steelhead and distributed naturally as carcasses from the spawners decompose. Hatchery production contributes marine-derived nutrients to freshwater systems via natural spawning of hatchery-origin fish and through carcass distribution programs conducted by the hatchery operators.

Table B-29. Criteria for assignment of viability benefits to natural-origin steelhead from integrated steelhead conservation hatchery programs.

Benefit Level	Criteria
Negligible	Hatchery program does not positively affect abundance, spatial structure, and diversity parameters for the natural-origin steelhead population.
Low	Hatchery program positively affects abundance, spatial structure, and diversity parameters, and Under the action alternatives (Alternative 2 to 4), integrated program production levels are at least 15 percent less than Alternative 1.
Moderate	Hatchery program positively affects abundance, spatial structure, and diversity parameters, and Under the action alternatives (Alternative 2 to 4), the integrated program production levels are the same as Alternative 1.
High	Hatchery program positively affects abundance, spatial structure, and diversity parameters, and Under the action alternatives (Alternative 2 to 4), integrated program production levels are 15 percent or more larger than Alternative 1.

Because of the complexity and limited understanding of marine-derived nutrient dynamics (Subsection 2.2.3, Marine-derived Nutrients), along with uncertainties associated with natural-origin and hatchery-origin steelhead spawner escapements in Puget Sound waters, it is not possible to determine effects for each alternative at the river basin scale. Therefore, nutrient benefits of hatchery programs are evaluated only at the DPS scale. The approach assigns levels of benefit based on the estimated percentage of hatchery-origin steelhead carcasses in the context of hatchery production of all species, and the percentage differences under the alternatives. It assumes that proportional differences in hatchery production among alternatives would lead to corresponding changes in carcasses and spawner biomass as contributions to marine-derived nutrient benefits (Table B-30).

Table B-30. Criteria for assignment of marine-derived nutrient benefits from steelhead hatchery programs.

Benefit Level	Criteria
Negligible	Under Alternative 1, hatchery-origin steelhead carcasses comprise less than or equal to 10 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternative 2 to 4), the change in hatchery-origin steelhead carcasses contributing to total spawner biomass is less than 10 percent compared to Alternative 1.
Low	Under Alternative 1, hatchery-origin steelhead carcasses comprise more than 10 percent and less than or equal to 20 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternative 2 to 4), the change in hatchery-origin steelhead carcasses ranges from 10 to 25 percent compared to Alternative 1.
Moderate	Under Alternative 1, hatchery-origin steelhead carcasses comprise greater than 21 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternative 2 to 4), changes in hatchery-origin steelhead carcasses contributing to total spawner biomass range from 26 to 50 percent.
High	Under Alternative 1, hatchery-origin steelhead carcasses comprise greater than 21 percent of the total number of hatchery-origin carcasses, or Under the action alternatives (Alternative 2 to 4), increases in hatchery-origin steelhead carcasses contributing to total spawner biomass are greater than 50 percent.

3.4 Washington Coastal-Puget Sound Bull Trout

As described in EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, the effects analyzed for bull trout consist of one risk and one benefit that are qualitatively reviewed. In the project area, bull trout are not artificially propagated and there are no hatchery programs that produce species that have the potential to interbreed and hybridize with bull trout (i.e., brook trout) or to contribute to bull trout total returns. Thus, genetics is not a risk and total return is not a benefit for bull trout. The risk and benefit evaluated were identified based on bull trout history traits (EIS Subsection 3.2.8.1, Life History of Bull Trout), and its distribution and abundance (EIS Subsection 3.2.8.2, Distribution and Abundance of Bull Trout) relative to hatchery program releases (Table 2.4-1 in EIS Subsection 2.2.4.2, Juvenile Fish Production Levels), within habitat occupied by bull trout in the project area. The risk is addressed by hatchery facility and at the DPS scale, and the benefit is evaluated at the DPS scale. The following subsections contain the reasoning used to evaluate risks and benefits in each category, followed by information showing the risk and benefit based on the reasoning used.

Hatchery-related risk and benefit levels are assigned in the context of other factors identified as limiting the survival and viability of bull trout in relevant Federal (USFWS 2004a, 2004b, 2008) and state agency

(WDFW 2004) status review documents. Thus, the assigned risk levels would be commensurate with the extent to which the hatchery-related risk contributes to overall risks faced by the species.

As described in EIS Subsection 3.2.8.2, Distribution and Abundance of Bull Trout, there is a scarcity of data available on the status of bull trout in Puget Sound. Thus, the analysis of risks and benefits is based on inferences from what is known about Puget Sound bull trout life history, geographic distribution, and ecological relationships with salmon and steelhead, as described in EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout) (Table B-31). Quantitative modeling is not used to evaluate risks and benefits. In contrast to salmon and steelhead, there are no detailed technical appendices.

Table B-31. Summary of evaluation methods used to determine effects on bull trout.

Effect	Evaluation Method
Risk	
Hatchery Facilities and Operation	Inferences based on the likelihood of impacts from hatchery-related barriers to migration of bull trout.
Benefit	
Viability	Inferences based on the likelihood of bull trout predation on salmon and steelhead in marine areas.

As described in EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout), bull trout mostly occur in cool waters that are generally upstream of salmon and steelhead hatcheries. Thus, competition between bull trout and hatchery-origin salmon and steelhead for food and space (particularly young bull trout that feed on similar prey species as salmon and steelhead) in fresh water is not likely because their distributions generally do not overlap. Adult bull trout, particularly migratory forms that occur in marine waters, are primarily piscivorous and feed on a variety of fish species, and are likely to compete with hatchery-origin fish. Thus, competition between bull trout and hatchery-origin salmon and steelhead is not evaluated further.

Similarly, data are not available indicating that newly released hatchery-origin salmon and steelhead prey upon bull trout or that bull trout are part of the diet of salmon or steelhead. Thus, predation by hatchery-origin salmon and steelhead on bull trout is not evaluated further.

Juvenile salmon and steelhead form part of the food base for bull trout in freshwater and marine areas (EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout]), and hatchery production may increase the bull trout food base, especially in marine areas. Marine areas are where juvenile hatchery-origin salmon and steelhead commingle with bull trout on their migration to the ocean. Thus, benefits to bull trout viability from salmon and steelhead hatchery programs are evaluated.

As described in EIS Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS, bull trout core areas are the closest approximation of biologically functioning units for the species, which may be comprised of one or more related populations. Core areas are identified in the draft bull trout recovery plan (USFWS 2004a, 2004b) and the most recent ESA status review (USFWS 2008).

3.4.1 Methods for Determining Risks—Hatchery Facilities and Operation

Hatchery facilities and operation risks occur at some hatchery facilities due to the presence or operation of structures that affect upstream and/or downstream migration of bull trout. As explained in EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout), weirs used to trap returning hatchery-origin salmon and steelhead, as well as hatchery water intakes, can affect bull trout migration. Such structures have the capability of contributing to bull trout habitat fragmentation, eliminating migratory corridors, and isolating bull trout populations. Available information is reviewed on hatchery-related structures that may affect bull trout that are associated with each hatchery program. Hatchery facilities and operation risks to bull trout from migration barriers associated with salmon and steelhead hatcheries are qualitatively determined to be negligible, low, moderate, or high based on whether the migration barriers are located in bull trout core areas, the potential or known use or observations of bull trout at or near the barriers, and in general, the likely effects of the barrier on bull trout viability or recovery (Table B-32).

There are seven bull trout core areas in which hatchery-related migration barriers are identified. These core areas are the Nooksack River, lower Skagit River, Snohomish and Skykomish Rivers (one core area), Puyallup River, Skokomish River, Dungeness River, and Elwha River (Table B-33).

Ten hatchery structures may affect fish migration in bull trout core areas and an additional three hatchery structures occur outside bull trout core areas. An overview of these structures and their risks to bull trout under the alternatives are provided in Table B-33.

As described in EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead (Bull Trout), differences in life histories and habitat preferences between bull trout and hatchery-origin salmon and steelhead limit the likelihood of impacts on bull trout. Most hatchery-related barriers operate seasonally for the purpose of obtaining broodstock for hatchery operations. Such structures are regularly monitored by hatchery personnel and, as bull trout are encountered, the fish are manually passed upstream or downstream from the weir as appropriate.

Table B-32. Criteria for assignment of hatchery facilities and operation risks to bull trout.

Risk Level	**Criteria**
Negligible	The hatchery structure is not located in a bull trout core area, or Bull trout have not been observed near where the hatchery structure is located, and The risk category of the core area is potential risk or low risk.[1]
Low	The hatchery structure is located in a bull trout core area, and The hatchery structure is a potential or known barrier to bull trout, and Bull trout have occasionally been observed at or near the hatchery structure, or Operation of the hatchery structure is unlikely to substantially impede upstream and downstream migration of bull trout.
Moderate	The hatchery structure is located in a bull trout core area, and The hatchery structure is a potential or known barrier to bull trout, and Bull trout have been observed at the hatchery structure, or Operation of the hatchery structure may substantially impede upstream and downstream migration of bull trout.
High	The hatchery structure is located in a bull trout core area, and The hatchery structure is a known barrier to bull trout, and Bull trout have been observed frequently using the area where the hatchery structure is located, and Operation of the hatchery structure blocks upstream and downstream migration of bull trout.

[1] Risk ratings from USFWS (2008).

Table B-33. Overview of hatchery-related bull trout migration barriers and risk levels under existing conditions and under all alternatives.

Hatchery Structure		Core Area and Its Risk Status[1]	Known or Potential Barrier and Bull Trout Observations	Characteristics of Operation[2]	Risk Level of Barrier under Existing Conditions and All Alternatives
Name	**Location**				
Structures in Bull Trout Core Areas					
Kendall Creek Hatchery Weir	Kendall Creek, North Fork Nooksack River	Nooksack River Potential Risk	Known Up to two bull trout observed some years	Temporary structure; manually operated seasonally for salmon broodstock collection	Low
Marblemount Hatchery Trap	Clark Creek, Cascade River	Lower Skagit River Low Risk	Known Few bull trout observed some years	Temporary structure; manually operated seasonally for salmon broodstock collection; otherwise passive	Low
Barnaby Slough Rearing Ponds Weir	Barnaby Slough, upper Skagit River	Lower Skagit River Low Risk	Potential	Temporary structure; manually operated seasonally for steelhead broodstock collection	Negligible
Wallace River Hatchery Weirs	Wallace River and May Creek, Skykomish River	Snohomish and Skykomish Rivers Potential Risk	Potential Bull trout observed in river near weir sites	Temporary structure; manually operated seasonally for salmon broodstock collection	Low
Tokul Creek Hatchery Weir	Tokul Creek, Snoqualmie River	Snohomish and Skykomish Rivers Potential Risk	Potential Bull trout observed below Snoqualmie Falls	Temporary structure; manually operated seasonally for steelhead broodstock collection	Negligible
Voights Creek Hatchery Weir and Trap	Voights Creek, Carbon River	Puyallup River At Risk	Known One juvenile bull trout observed in 1998	Temporary structure; passively operated seasonally for coho and Chinook salmon broodstock collection	Low

Table B-33. Overview of hatchery-related bull trout migration barriers and risk levels under existing conditions and under all alternatives, continued.

Hatchery Structure		Core Area and Its Risk Status[1]	Known or Potential Barrier and Bull Trout Observations	Characteristics of Operation[2]	Risk Level of Barrier under Existing Conditions and All Alternatives
Name	**Location**				
Buckley Diversion and Collection Trap	White River, Puyallup River	Puyallup River At 7Risk	Potential An average of 81 upstream migrant (range of 14 to 264) bull trout were passed upstream from 2003 to2013	Permanent structure; manually operated year round	Low
George Adams Hatchery Weir	Purdy Creek, Skokomish River	Skokomish River High Risk	Potential Several juvenile bull trout have been observed at the trap and in Purdy Creek	Temporary structure; manually operated seasonally for salmon broodstock collection	Low
Dungeness Hatchery Water Intake	Canyon Creek, Dungeness River	Dungeness River High Risk	Potential	Permanent structure; operated year round	Moderate
Elwha Channel Hatchery Weir	Side channel, lower Elwha River	Elwha River At Risk	Known Up to two bull trout from mainstem observed some years	Temporary structure; manually operated seasonally for salmon broodstock collection	Low
Structures Not in Bull Trout Core Areas					
Cedar River Weir	Lower Cedar River	NA (core area in Chester Morse Lake only)	Potential	Temporary structure; manually operated seasonally for sockeye salmon broodstock collection	Negligible
Clear and Kalama Creek Hatchery Weirs	Clear and Kalama Creeks, Nisqually River	NA	Potential One adult bull trout observed at the Clear Creek weir (late 1990s)	Temporary structures; manually operated seasonally for salmon broodstock collection	Negligible

Table B-33. Overview of hatchery-related bull trout migration barriers and risk levels under existing conditions and under all alternatives, continued.

Hatchery Structure		Core Area and Its Risk Status[1]	Known or Potential Barrier and Bull Trout Observations	Characteristics of Operation[2]	Risk Level of Barrier under Existing Conditions and All Alternatives
Name	Location				
Quilcene National Fish Hatchery Weir	Big Quilcene River	NA	Potential One report of bull trout juveniles in lower Big Quilcene River	Permanent structure; manually operated seasonally (electrified) when collecting salmon broodstock; passively operated bypass ladder allows passage rest of year, provided sufficient flow exists	Negligible

Sources: Information on bull trout observations at state facilities is from WDFW (2008), for tribal facilities USFWS (2004a, 2004b), and for the Federal facility Zajac (2002). Information for the Buckley Trap is from the U.S. Army Corps of Engineers http://www.nws.usace.army.mil/Missions/CivilWorks/LocksandDams/MudMountainDam/FishCounts.aspx.

[1] Core areas and risk status ratings are from USFWS (2008). Risk ratings are high risk, at risk, potential risk, and low risk.

[2] Manual passage involves handling and placement of fish upstream or downstream. Passive passage occurs in situations where fish ladders or other bypass facilities exist that allow migration without active handling by people.

3.4.2 Methods for Determining Benefits—Viability

Bull trout eat juvenile salmon and steelhead (EIS Subsection 3.2.8.3, Relationship with Salmon and Steelhead [Bull Trout]) as part of their diet in freshwater and marine areas. Salmon and steelhead hatchery programs can benefit bull trout by increasing the food base available to rearing and migrating bull trout. This benefit is expected to be greatest for bull trout in marine waters because that is where juvenile hatchery-origin salmon and steelhead commingle with bull trout on their migration to the ocean. The evaluation of viability benefits in the EIS draws primarily from the assessment by USFWS of the occurrence and behavior of bull trout in Puget Sound marine areas (USFWS 2004a, 2004b). Benefits from salmon and steelhead hatchery programs to bull trout viability—at the project area scale—were qualitatively determined to be negligible, low, moderate, or high considering the extent to which hatchery programs would be expected to affect bull trout viability in marine areas (Table B-34).

Table B-34. Criteria for assignment of viability benefits for bull trout in marine areas.

Risk Level	Criteria
Negligible	Hatchery programs do not positively affect viability of the bull trout DPS in the project area.
Low	Hatchery programs positively affect viability parameters, and In the context of all factors affecting the viability, hatchery programs would not be expected to increase the viability of the bull trout DPS in the project area.
Moderate	Hatchery programs positively affect viability parameters, and In the context of all factors affecting viability, hatchery programs may be expected to increase the viability of the bull trout DPS in the project area.
High	Hatchery programs positively affect viability parameters, and In the context of all factors affecting viability, hatchery programs would be expected to substantially increase the viability of the bull trout DPS in the project area.

3.4.3 Determining Overall Risks and Benefits

One risk and one benefit for bull trout are evaluated in this EIS. The hatchery facilities and operation risk from migration barriers is based on information compiled from evaluations of 13 individual hatchery program facilities. Applicable migration barriers are assigned a numeric score (Table B-35) for summing at the project area scale. Individual scores are summed and divided by the total number of hatchery-related bull trout migration barriers evaluated, resulting in a mean score representing the risk at the project area scale. For the purposes of this analysis, mean values with fractions less than 0.5 are rounded down, and the assigned risk level reflects the lower number. Fractions greater than or equal to 0.5 are rounded up, and the assigned risk level reflects the higher number. Viability benefits are evaluated only at the project area scale, and a single benefit rating is identified.

Table B-35. Numeric scoring of risk levels.

Risk Level	Score
Negligible	0
Low	1
Moderate	2
High	3

3.5 Non-listed Salmon

Evaluation of the affected environment (EIS Subsection 3.2, Fish) and analysis of alternatives (EIS Subsection 4.2, Fish) were conducted by reviewing the following four species or species groups of non-listed salmon in the project area:

- Puget Sound/Strait of Georgia Coho Salmon ESU
- Puget Sound/Strait of Georgia Chum Salmon ESU
- Odd-year and Even-year Pink Salmon ESUs
- Sockeye salmon

As described in EIS Subsection 3.2.1, Introduction, EIS Subsection 4.2.1, Introduction, and EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, based on the data available for non-listed salmon, evaluations are qualitative and rely on inferences from available information for each species based on their relationship with salmon and steelhead. Thus, no modeling was conducted to evaluate the risks and benefits of hatchery-origin fish on non-listed salmon. Background information including life history, distribution, and abundance of the natural-origin species, and the non-listed salmon species' relationship with other species of salmon and steelhead were used to evaluate risks and benefits from hatchery-origin salmon and steelhead. Evaluated risks are competition, predation, genetic, and hatchery facilities and operation impacts on natural-origin non-listed salmon in fresh water and nearshore marine environments. Also evaluated are total return, viability, and marine-derived nutrient benefits, depending on the non-listed salmon species' relationship with other species of salmon and steelhead. Risks and benefits are qualitatively evaluated at the project area scale for each species. Criteria applied to evaluate risks to non-listed salmon for hatchery facilities and operation and benefits from marine-derived nutrients follow the criteria for listed Chinook salmon described in Table B-17 and Table B-20, respectively. For other risks and benefits, the evaluation was based on inferences from available information.

3.6 Other Fish Species

Evaluation of the affected environment (EIS Subsection 3.2, Fish) and analysis of alternatives (EIS Subsection 4.2, Fish) were conducted by reviewing the following six groups of other fish species that occur in the project area:

- Rainbow trout
- Coastal cutthroat trout
- Sturgeon and lamprey
- Forage fish
- Groundfish
- Resident freshwater fish

As described in EIS Subsection 3.2.1, Introduction, EIS Subsection 4.2.1, Introduction, and EIS Subsection 4.2.3, Overall Methods for Analyzing Effects, similar to non-listed salmon, evaluations for these fish species are qualitative and rely on inferences from available information for each species group based on their relationship with salmon and steelhead. No modeling was conducted to evaluate the risks and benefits of hatchery-origin fish on these fish species. Background information, including life history, distribution, abundance of these species, and the other species' relationship to salmon and steelhead, were used to evaluate risks and benefits from hatchery-origin salmon and steelhead. Evaluated risks are competition, predation, and incidental harvest (bycatch) effects on the other fish species in freshwater and nearshore marine environments, depending on relationships between the other fish species with salmon and steelhead. The potential beneficial contribution of hatchery-origin fish to the prey base of the other fish species is also reviewed. The risks and contribution of hatchery-origin fish to the other fish species prey base are qualitatively evaluated at the project area scale.

4.0 References

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Appendix C

Puget Sound Chinook Salmon Effects Analysis

by Population

For a list of acronyms used in this appendix, see Acronyms and Abbreviations in EIS

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1.0 Introduction

This appendix identifies hatchery program risks and benefits for the Puget Sound Chinook Salmon ESU at the Chinook salmon population scale. Puget Sound watersheds may support one or more listed Chinook salmon population. The 13 Puget Sound watersheds for which impacts on Chinook salmon are evaluated are shown in Table C-1. Within these watersheds are 22 natural-origin Chinook salmon populations that constitute the ESU as delineated by NMFS (Ruckelshaus et al. 2006) and described in EIS Subsection 3.2.5.2, Distribution and Abundance of Natural-origin Chinook Salmon.

Table C-1. Watersheds, listed natural-origin populations, and associated hatchery programs that constitute the Puget Sound Chinook salmon ESU.

Watershed	Natural-origin Population	Associated Hatchery Program
Nooksack River	North Fork Nooksack spring-run	Kendall Creek
	South Fork Nooksack spring-run	Skookum Creek [1]
Skagit River	Lower Skagit fall-run	Marblemount
	Upper Skagit summer-run	Marblemount
	Cascade spring-run	Marblemount
	Suiattle spring-run	None
	Lower Sauk summer-run	None
	Upper Sauk spring-run	None
Stillaguamish River	North Fork Stillaguamish summer-run	Harvey Creek/Whitehorse Springs
	South Fork and mainstem Stillaguamish fall-run	Harvey Creek[1]
Snohomish River	Skykomish summer/fall-run	Wallace River, Bernie Kai-Kai Gobin Tulalip Bay
	Snoqualmie summer/fall-run	None
Lake Washington	Sammamish fall-run	Issaquah
	Cedar fall-run	None
Green River	Green fall-run	Soos Creek, Icy Creek, Keta Creek
Puyallup River	Puyallup fall-run	Voights Creek and Clarks Creek
White River	White spring-run	White River, Puyallup White River Acclimation Sites, Hupp Springs
Nisqually River	Nisqually fall-run	Clear Creek and Kalama Creek
Skokomish River	Skokomish fall-run	George Adams, Rick’s Pond
Hamma Hamma River, Duckabush River, Dosewallips River	Mid-Hood Canal fall-run	Hamma Hamma
Dungeness River	Dungeness spring-run	Dungeness/Hurd Creek
Elwha River	Elwha summer/fall-run	Elwha Channel/Morse Creek

[1] New program that warrants consideration for listing as part of the ESU (NMFS 2011a).

Source: NMFS (2011a); Ruckelshaus et al. (2006).

This appendix evaluates hatchery-related risks and benefits for the 22 Chinook salmon populations by alternative. Alternative 1 (No Action) also represents baseline conditions. The baseline conditions described in this appendix are summarized and reported in EIS Subsection 3.2.5, Puget Sound Chinook Salmon ESU. Potential mitigation measures are identified for hatchery programs that have the potential to pose risks to natural-origin Chinook salmon.

2.0 Chinook Salmon Populations

For context, below are brief summaries of information on the distribution and life history of the 22 recovery category 1 and 2 Chinook salmon natural-origin populations in the Puget Sound Chinook Salmon ESU (Table C-1). Details on population recovery categories are found in EIS Subsection 2.2.2, Hatchery Management Goals and Strategies. Briefly, watersheds with recovery category 1 populations still contain indigenous populations, whereas watersheds with recovery category 2 populations no longer contain indigenous populations (indigenous populations have been extirpated and supplanted by transferred hatchery-origin stocks), but natural production is possible because suitable habitat is available. More detailed information is presented in Ruckelshaus et al. (2006) and in Ford (2011).

2.1 Nooksack Chinook Salmon Populations

Two natural-origin spring-run Chinook salmon populations exist in the Nooksack River basin—North Fork Nooksack and South Fork Nooksack—that are genetically distinct from all other Puget Sound populations (Marshall et al. 1995). Peak spawning for the North Fork Nooksack population occurs in early September, about 2 weeks earlier than for the South Fork Nooksack population (Barclay 1980, 1981). Consequently, North Fork Nooksack fry emerge from the gravel earlier (Wunderlich et al. 1982), but fry are present in both forks from early February through early May. Most fish leave for marine waters as juvenile subyearlings, but yearling smolts constitute about 29 percent of seaward migrating juveniles for the North Fork Nooksack population. Yearling migrants produce approximately 35 percent of the adults returning to the South Fork Nooksack population (Lummi Indian Nation 2006).

Hatchery supplementation using the indigenous stock began in 1981 in the North Fork (Kendall Creek), and has a current production objective of releasing 800,000 hatchery-origin subyearling Chinook salmon annually. The South Fork Nooksack supplementation program based at Skookum Creek Hatchery operated from 1980 to 1996. An artificial propagation effort was reinitiated in 2006 beginning as a captive broodstock effort. Degraded floodplain and channel structure processes, and dysfunctional sediment-routing leading to degraded stream channel structure and instability are the most important factors affecting survival and productivity for the two Chinook salmon populations in the Nooksack River watershed (NMFS 2006a).

2.2 Skagit River Basin Chinook Salmon Populations

The Skagit River basin supports three natural-origin spring-run Chinook salmon populations (Cascade, Upper Sauk, and Suiattle), two natural-origin summer-run Chinook salmon populations (Upper Skagit and Lower Sauk), and one natural-origin fall-run Chinook salmon population (Lower Skagit) (Ruckelshaus et al. 2006). Chinook salmon spawn and/or rear in many tributary and mainstem river areas, as well as in side channels and the complex tidal delta channels in the Skagit River system. Hatchery production currently consists of relatively small-scale, indicator stock programs that release subyearling and yearling hatchery-origin spring-run Chinook salmon and subyearling summer-run and fall-run Chinook salmon through programs based at WDFW's Marblemount Hatchery (WDFW and PSTT 2004). The current major limiting factors and threats to the recovery of populations of Chinook salmon in the Skagit River basin are insufficient juvenile rearing conditions and capacity in the Skagit Bay estuary, the Skagit River delta and flood-plain, and the lower Skagit River; insufficient adult spawning capacity; excessive mortality during incubation; and insufficient juvenile rearing conditions and capacity in mainstem and tributary habitats (NMFS 2006a). Other important limiting factors are routing of sediment, loss of mature riparian forest, and degraded water quality. Along with degraded floodplain and channel structure, these latter factors adversely affect adult spawning, egg/fry incubation, and juvenile rearing capacity and conditions in the tributary, mainstem river, estuarine, and nearshore areas that are used by Chinook salmon (NMFS 2006a).

2.3 Stillaguamish Chinook Salmon Populations

The Stillaguamish River basin supports a natural-origin summer-run Chinook salmon population in the North Fork, and a natural-origin fall-run Chinook salmon population in the South Fork and lower mainstem (Ruckelshaus et al. 2006). Degraded habitat conditions have severely reduced the productivity of both populations (Pess et al. 2001). Much of the basin is within the Mount Baker-Snoqualmie National Forest. Extensive timber harvest and catastrophic slope failures have substantially reduced Chinook salmon production in the Stillaguamish River basin. Escapement to the South Fork is considerably lower than the restoration spawner abundance (EIS Table 3.2-9). The Harvey Creek Hatchery/Whitehorse Pond program supplements natural-origin escapement to the North Fork. Releases of coded-wire tagged juvenile hatchery-origin fish from this program provide indicator stock data for fisheries management. Degraded floodplain and channel structure, dysfunctional sediment-routing, and loss of mature riparian forests have destabilized, simplified, and destroyed the habitats required for migration, spawning, and rearing (i.e., off-channel areas, mainstem river areas, and tributaries) (NMFS 2006a). Degraded conditions and loss of lower river and estuarine areas for the rearing of ocean-migrating Chinook salmon is also a main factor limiting recovery of Chinook salmon populations in the Stillaguamish River basin.

2.4 Snohomish Chinook Salmon Populations

There are two natural-origin summer/fall-run Chinook salmon populations in the Snohomish River basin (Ruckelshaus et al. 2006). The Skykomish population spawns in the Snohomish River mainstem; the Skykomish, Wallace, Sultan, and Pilchuck Rivers; and Bridal Veil Creek. The Snoqualmie population spawns in the Snoqualmie, Tolt, and Raging Rivers, and Tokul Creek. The hatchery-origin summer-run Chinook salmon produced through the Wallace River and Tulalip hatchery programs are derived from native Skykomish River broodstock. There are no hatchery programs in the watershed that propagate Snoqualmie Chinook salmon. Hatchery-origin Green River-origin fall-run Chinook salmon were previously produced by hatcheries in the basin; thus, naturally-spawning returns of this hatchery stock have likely interbred with native stocks. Degraded rearing habitat in lower river and estuarine areas is a primary limiting factor to recovery of the Snohomish River Chinook salmon populations (i.e., degraded conditions and loss of important habitats for the rearing of ocean-type Chinook). In addition, degraded floodplain and channel structure processes, dysfunctional sediment-routing, and loss of mature riparian forests have resulted in destabilized, simplified, and destroyed tributary, off-channel, mainstem river, estuarine, and nearshore areas required for migration, spawning, and rearing (NMFS 2006a).

2.5 Lake Washington Basin Chinook Salmon Populations

Two fall-run Chinook salmon populations occur in the Lake Washington basin—the Cedar population in the Cedar River and the Sammamish population in the northern tributaries to the Sammamish River, including Issaquah, Big Bear, and Cottage Lake Creeks. Chinook salmon spawn in the Cedar River up to Landsburg Dam (RM 22), and since 2004, some adults have been transported above the dam to spawn naturally in the upper watershed. The hatchery-origin population produced at the WDFW Issaquah Hatchery was derived using transplanted Green River-origin broodstock. It is unknown whether the Sammamish River tributaries historically supported a self-sustaining natural-origin Chinook salmon population (Ruckelshaus et al. 2006), such as occurs in the Cedar River (Marshall et al. 1995). Returns from the Issaquah Hatchery contribute substantially to natural spawning in both populations. Lack of an adequate estuary for the rearing of out-migrating Chinook salmon fry is a primary factor limiting recovery of the Sammamish Chinook salmon population. Access to the ocean for all Lake Washington salmon requires passage through the Lake Washington Ship Canal and Hiram Chittendon Locks, which further impede survival. In addition, degraded floodplain and channel structure and water quality (in particular, high water temperature) create inadequate conditions for Chinook salmon in the lake and its tributaries for migration, spawning, and rearing. Hydrologic alterations relating to urban development in the surrounding watersheds are also a limiting factor (NMFS 2006).

2.6 Green Chinook Salmon Population

Natural-origin fall-run Chinook salmon spawn in the Green River mainstem up to RM 61, where a diversion dam and Howard Hanson Dam block all fish passage, and in two tributaries (Newaukum and Soos Creeks). The hatchery-origin fish propagated through programs at Soos, Icy, and Keta Creek hatcheries are derived from the native populations and are included in the ESU. Hatchery adult returns contribute substantially to natural spawning (EIS Table 3.2-9). Habitat in the Green River mainstem, and particularly in the lower Duwamish River, has been degraded by urban and industrial development, related water quality problems, and substantial channel modification, which has affected natural-origin productivity. Lack of adequate estuarine conditions for the rearing of ocean-migrating Chinook salmon is a primary limiting factor to recovery of the Green River population. Degradation of floodplain channel structure processes, hydrologic processes, and large woody debris and riparian vegetation processes have adversely affected watershed conditions for migration, spawning, and rearing (NMFS 2006).

2.7 Puyallup Chinook Salmon Population

Natural-origin fall-run Chinook salmon spawn in the Puyallup River mainstem, and in several tributaries throughout the basin, including South Prairie and Wilkeson Creeks, and the Carbon River. Hatchery-origin fish are produced at the Voight’s Creek and Clark Creek facilities. As a recovery category 2 population, Puyallup Chinook salmon are genetically similar to the Green River population, in part because of the implementation of hatchery programs in the basin since 1917 using Green River broodstock. The natural-origin component of the fall-run Chinook salmon population is currently indistinguishable from natural spawners of hatchery origin. Salmon access to the upper watershed was blocked at RM 41.7 following construction of Electron Dam in 1903. Fish passage was restored one hundred years later in 2003. Natural productivity is considered to be low, limited by extensive channel modifications and suburban, agricultural, and industrial development in the lower Puyallup River mainstem and Commencement Bay (NMFS 2006). Estuarine habitat loss and degradation, and degraded floodplain and channel structure are the primary factors limiting recovery of the Puyallup fall-run population. Hydropower operation in the upper Puyallup River is also a substantial factor limiting survival and productivity of the population. Degraded riparian forests and degraded water quality are also major limiting factors affecting the population.

2.8 White Chinook Salmon Population

A natural-origin spring-run Chinook salmon population exists in the White (formerly Stuck) River, a Puyallup River tributary. This is the only remaining natural-origin spring-run Chinook salmon population in southern Puget Sound (the others have been extirpated), and consequently represents a unique component to the diversity of the ESU. Spawning occurs in the lower White River, below the diversion dam at Buckley, and returning adults are transported above Mud Mountain Dam to spawn naturally in the upper basin. Hatchery-origin fish of White River spring-run stock are produced at White River Hatchery and in three acclimation ponds in the upper river, and at Hupp Springs, a satellite facility in Carr Inlet. These hatchery programs maintained the population after the escapement of natural-origin Chinook salmon declined to a very low level in the 1970s. Structural modifications to Mud Mountain Dam have improved smolt survival, but land use practices in the upper watershed and habitat degradation in the lower White River and lower Puyallup River limit productivity of natural-origin Chinook salmon. Primary factors limiting White River Chinook salmon population recovery are inadequate conditions for adult migration and spawning, insufficient conditions for juvenile rearing and migration, mortalities associated with fish passage facilities, and insufficient capacity and condition of estuarine areas (NMFS 2006). Hydropower impacts and hydrologic alterations are important factors limiting recovery of the population to a viable status. Degraded riparian forests, floodplain and channel structure, and estuarine habitat conditions are also major limiting factors affecting the population.

2.9 Nisqually Chinook Salmon Population

The Nisqually River supports a natural-origin fall-run Chinook salmon population, which spawns in the mainstem up to about RM 40 and in the Mashel River. Hatchery-origin Chinook salmon production occurs at the Clear Creek and Kalama Creek facilities. Chinook salmon returning to the Nisqually River are genetically similar to the Green River fall-run population because of the mid-last century extirpation of the spring-run population native to the Nisqually River and the use of Green River stock when the Nisqually hatchery programs were initiated. The natural-origin population was extirpated as a result of a migration blockage at the Centralia diversion dam (RM 26), hydroelectric dam operations in the upper river, a catastrophic spill of copper ore from a railroad trestle failure, other habitat degradation, and over-harvest. Hatchery-origin adults currently contribute about half of the total natural spawning escapement. Estuarine habitat loss and degradation, hydropower impacts, and hydrologic alterations are the three primary limiting factors to recovery of the population to a viable status (NMFS 2006). Degraded floodplain, channel structure, and nearshore and marine habitats are also major limiting factors affecting the population. Restoration efforts in the Nisqually River estuary have recently been implemented that should substantially reduce the loss and degradation of habitat in that area.

2.10 Skokomish Chinook Salmon Population

The Skokomish River supports a natural-origin fall-run Chinook salmon population that spawns in the North Fork up to RM 17, where passage is blocked by a hydroelectric dam, and in the South Fork up to RM 5. Hatchery-origin fall-run Chinook salmon are produced at the George Adams and Rick's Pond facilities. The Chinook salmon produced through both programs are genetically indistinguishable from natural-origin fish in the watershed, which are the result of fish transplanted from the Green River that have become localized to the Skokomish watershed. Hydroelectric operations in the North Fork, and land use practices and flood control structures in the South Fork have caused severe sedimentation in the lower river floodplain that limits the productivity of natural-origin Chinook salmon. Hatchery-origin returns contribute substantially to natural spawning. Hydropower impacts, over harvest, and sediment-routing-disruption are the primary factors limiting recovery of the Skokomish fall-run population (NMFS 2006). Access to spawning areas, condition of spawning habitat, and the quality of habitat for egg incubation are all adversely affected by these two factors. Degraded floodplain and channel structure processes, estuarine habitat loss and degradation, and degraded riparian forests are also significant factors limiting survival and productivity of the population.

2.11 Mid-Hood Canal Chinook Salmon Population

The Mid-Hood Canal fall-run population comprises natural-origin Chinook salmon production in the Hamma Hamma, Dosewallips, and Duckabush Rivers. There is some uncertainty about the historical or current capacity of these watersheds to support self-sustaining natural-origin Chinook salmon populations (Ruckelshaus et al. 2006), though the accessible reaches of the Dosewallips River appear to contain sufficient habitat. There has been substantial modification and degradation of habitat in the deltas of all three rivers, and spawning escapement is low (EIS Table 3.2-9). The Chinook salmon produced through the single hatchery program on the Hamma Hamma River are genetically indistinguishable from natural-origin fish in the watershed, which are the result of fish transplanted from the Green River that have become localized to the Hama Hamma watershed. The contribution of hatchery-origin adults to natural spawning is not well understood. Hatchery production at the Hamma Hamma Hatchery facility currently uses Hamma Hamma Chinook salmon for broodstock and additional broodstock from the George Adams Hatchery (Skokomish River). Degradation of estuaries needed for the rearing of ocean-migrating Chinook salmon fry is the predominant limiting factor to recovery of the Mid-Hood Canal fall-run Chinook salmon population (NMFS 2006). Degraded riparian forests, dysfunctional floodplain and channel structure, and nearshore and marine habitat loss and degradation are also significant factors limiting survival and productivity of the population.

2.12 Dungeness Chinook Salmon Population

The Dungeness River supports a natural-origin population of spring-run Chinook salmon that spawn in the mainstem up to about RM 19, and in the Greywolf River up to RM 5. Freshwater entry timing is elongated, perhaps extending from spring through September, although most enter the river by early August. Using the natural-origin Dungeness stock, WDFW initiated a captive-brood hatchery supplementation program at the Hurd Creek Hatchery following a severe decline in escapement in the 1980s. The original captive-brood program was terminated after 2001, but a conventional supplementation program at the Dungeness Hatchery continues to operate. Natural spawning escapement has subsequently improved, though most of the returns are still of hatchery origin (EIS Table 3.2-9). Hydrologic alterations resulting in adult migration delay and blocked access to spawning areas, lack of sufficient spawning habitat capacity, and decreased survival of eggs and juvenile fish in the watershed are the major factors limiting recovery of Dungeness Chinook salmon (NMFS 2006). In addition, degraded floodplain and channel structure, disrupted sediment routing, water quality (high water temperatures), and degraded riparian forests have adversely affected Chinook salmon survival and productivity in freshwater, estuary, and nearshore marine areas.

2.13 Elwha Chinook Salmon Population

The Elwha Chinook salmon population has been at very low abundance for decades and is further threatened in the short-term, by conditions resulting from ongoing removal of the Elwha and Glines Canyon Dams. The dams restricted Chinook salmon natural spawning to the lower 5 miles of the river from 1913 through 2011. When removal of the dams is completed, 70 miles of near-pristine habitat in Olympic National Park will be available to the population. Adult Chinook salmon currently enter the river from early June through September. Productivity of natural-origin Chinook salmon has been severely limited by the lack of suitable spawning and rearing habitat, and degraded conditions in the estuary (NMFS 2006). Restoration of a properly functioning estuary is also essential for recovery of the population. Fish produced by the Elwha Channel Hatchery program represent the genetic resources of the Elwha Chinook salmon population (WDFW 2012), and are being used to secure the population during dam removal and habitat recovery.

3.0 Methods

Methods used to analyze effects on the Puget Sound Chinook Salmon ESU and its component populations, and how population effects are compiled for the ESU as a whole, are provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and EIS Subsection 4.2.3.2, Methods for Analysis (Chinook Salmon).

3.1 Population Analysis

The PCD Risk Model (Appendix D, PCD RISK 1 Assessment) is used to evaluate competition and predation risks from hatchery-origin Chinook salmon and coho salmon on natural-origin Chinook salmon in fresh water, the AHA Model (Appendix E, Overview of the All H Analyzer) is used to evaluate genetic risks, and the HPV Tool (Appendix F, Hatchery Program Viewer [HPV] Analysis) is used to evaluate hatchery facilities and operation risks. Evaluations are complemented by other qualitative assessments (e.g., location, timing, and magnitude of releases from hatchery programs). Methods for evaluation of abundance benefits are based on qualitative assessment of total adult run size in the context of adult escapement goals. Methods for evaluation of viability benefits to natural-origin populations are based on qualitative assessment of the extent to which programs contribute to the four viable salmonid population (VSP) parameters: abundance, productivity, diversity and distribution (McElhany et al. 2000). This population evaluation focuses on risks and benefits within freshwater rivers and streams where salmon and steelhead adults spawn, and juveniles rear and eventually out-migrate to marine waters. Risks and benefits in marine waters are evaluated qualitatively at the marine area or ESU scale, and inferences are qualitatively applied to some populations.

Results are organized by Chinook salmon population and watershed, as appropriate, and risks for species are evaluated for the following:

- Chinook salmon hatchery programs – evaluation consists of competition, predation, genetics, and hatchery facilities and operation risks
- Coho salmon hatchery programs – evaluation consists of competition and predation risks
- Steelhead hatchery programs – evaluation consists of competition and predation risks

Risks not evaluated for natural-origin Chinook salmon populations or watersheds include:

- Competition from releases of hatchery-origin fish younger than subyearlings
- Most hatchery-origin fish releases in salt water with some exceptions as noted by Chinook salmon population reviewed. Marine area effects are considered at the ESU-wide scale

- Competition and predation from Chinook salmon and coho salmon hatchery programs in watersheds that do not have indigenous Chinook salmon populations (recovery category 3 Chinook salmon populations)

For an explanation as to why these risks are not evaluated, see EIS Subsection 3.2.5.4, Hatchery Program Risks and Benefits.

Benefits from Chinook salmon hatchery programs to total return and viability are evaluated and organized similarly to appendices for other listed fish species. Viability is evaluated for all integrated conservation programs and those few isolated programs producing fish that are listed under the ESA. Thus, viability would not appear as a benefit to Chinook salmon populations or watersheds from most Chinook salmon isolated hatchery programs.

Benefits from hatchery programs contributing marine-derived nutrients are not evaluated at the population scale because of insufficient information at that scale. Instead, benefits are evaluated at the ESU scale. Thus, refer to EIS Subsection 3.2.5.4.9, Benefits – Marine-derived Nutrients (Chinook Salmon) and Subsection 4.2.4.14, Benefits – Marine-derived Nutrients (Chinook Salmon) for evaluation of this benefit for Chinook salmon.

Multiple Chinook salmon populations are present in some watersheds (e.g., Nooksack, Skagit, Stillaguamish, and Snohomish River watersheds). Because of data limitations and the way analytical tools operate (e.g., PCD Risk Model), the effects of a hatchery release life stage (subyearling or yearling) on natural-origin Chinook salmon are simulated, but the effects of a combination of releases of both life stages are not simulated. The effect of more than one hatchery program (e.g., a subyearling and a yearling Chinook salmon program, or a Chinook salmon program and a coho salmon yearling program), cannot be accurately summed across programs. In circumstances where more than one population exists in a watershed, or where more than one hatchery program affects a population in a watershed, the aggregate effect of the programs on the population is rated the same as the highest rating of the programs in the watershed. Conversely, if the effect of the programs was either negligible or low, the aggregate effect is rated low. In other words, where more than one hatchery program affects a Chinook salmon population, or where multiple populations exist in a watershed, the highest risk identified across programs is applied to the population being evaluated. This approach is reasonable because it compensates for existing analytical constraints and uses information that is available. Rating the composite risks to individual natural-origin populations according to highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

Detail on hatchery programs and releases in Puget Sound are included in Appendix A, Puget Sound Hatchery Programs and Facilities.

3.2 ESU Analysis

Results from this appendix for individual Chinook salmon populations are summarized for the Puget Sound Chinook Salmon ESU in EIS Subsection 4.2.4, Puget Sound Chinook Salmon ESU. Risks and benefits for each Chinook salmon population are assigned a numeric score, and sums of scores for each of the 22 populations are divided by the respective number of hatchery programs. The resulting mean then represents the risk or benefit level for the ESU as a whole (EIS Subsection 4.2.4.2, Determining Overall Risks and Benefits).

3.3 Mitigation Measures and Adaptive Management

As described in EIS Subsection 4.1.1, Mitigation Measures and Adaptive Management, and EIS Subsection 4.2.4.16, Mitigation Measures and Adaptive Management, potential mitigation measures are identified for the action alternatives to address risks associated with hatchery programs. Mitigation measures in the EIS include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). For reference throughout this Chinook salmon appendix, Table C-2 identifies potential mitigation measures associated with risk ratings.Some mitigation measures may apply to more than one impact to natural-origin Chinook salmon. As described in EIS Subsection 4.2.4.16, Mitigation Measures and Adaptive Management (Chinook Salmon), mitigation measures may help reduce risks, but may also reduce benefits. In addition, mitigation measures may affect other resources. For example, a reduction in a hatchery program may affect prey resources for other fish and wildlife, tribal fishing rights, and water quality, among other resource values.

Table C-2. Potential mitigation measures associated with impacts to natural-origin Chinook salmon by risk category.

Risk Category	Impact	Potential Mitigation Measures	
		Number	**Description**
Competition	Hatchery-origin Chinook salmon, coho salmon, and/or steelhead are released high in the watershed (above RM 20)	C1	Monitor post-release out-migration behavior and diet of hatchery-origin Chinook salmon, coho salmon, and/or steelhead to determine the extent of the risks from the hatchery program. If competition is determined to be a substantial risk factor, truck hatchery-origin smolts to a downstream acclimation site for release near the mouth of the river
	Hatchery-origin Chinook salmon, coho salmon, and/or steelhead are released during the primary natural-origin Chinook salmon out-migration period (before May 1)	C2	Delay release of hatchery-origin Chinook salmon, coho salmon, and/or steelhead until after the majority of natural-origin Chinook salmon smolts have emigrated
	Low number of natural-origin Chinook smolts relative to number of Chinook salmon hatchery-origin releases	C3	Reduce program size
	Release of hatchery-origin Chinook salmon occurs in waters where they comingle and compete with natural-origin Chinook salmon in lower freshwater and delta areas and in nearshore marine areas	C4	Modify time and/or locations of release
	Size of hatchery-origin Chinook salmon and coho yearlings at release relative to natural-origin fish	C5	Alter timing of release such that the size of fish released would decrease the potential for competition
Predation	Hatchery-origin Chinook salmon, coho salmon, and/or steelhead are released high in the watershed (above RM 20)	P1	Monitor post-release out-migration behavior and diet of hatchery-origin fish to determine the extent of the risks from the hatchery program. If predation is determined to be a substantial risk factor, truck hatchery-origin smolts to a downstream acclimation site for release near the mouth of the river
	Hatchery-origin Chinook salmon, coho salmon, and/or steelhead are released during the primary natural-origin Chinook salmon out-migration period (before May 1)	P2	Monitor releases to assess predation risk. If impact is present, delay release of hatchery-origin salmon until after the majority of natural-origin Chinook salmon smolts have emigrated

Table C-2. Potential mitigation measures associated with impacts to natural-origin Chinook salmon by risk category, continued.

Risk Category	Impact	Potential Mitigation Measures	
		Number	**Description**
	Low number of natural-origin Chinook smolts relative to number of Chinook salmon hatchery-origin releases	P3	Reduce program size
	Release of hatchery-origin Chinook salmon occurs in waters where they would comingle and compete with natural-origin Chinook salmon in lower freshwater and delta areas and in nearshore marine areas	P4	Modify time and/or locations of release
	Size of hatchery-origin fish at release relative to the size of natural-origin Chinook salmon	P5	Alter timing of release such that the release size of fish would decrease the potential for predation
	Large number of hatchery-origin fish released	P6	Reduce program size
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations	G1	Develop program that incorporates local natural-origin fish as broodstock
	Hatchery-origin adult Chinook salmon stray and interbreed with natural-origin adult Chinook salmon	G2	Acclimate juveniles away from areas used by natural-origin Chinook salmon spawners or release fish on station to avoid hatchery-origin fish straying and interbreeding, and focus harvest of hatchery-origin fish in specific area, monitor stray rates, and make program changes as needed to decrease the number of strays into areas used by natural-origin spawners, establish and manage hatchery-origin and natural-origin adult returns to achieve spawning proportion goals
	Large proportion of hatchery-origin Chinook salmon spawn naturally compared to small numbers of natural-origin Chinook salmon that would be used as broodstock	G3	Develop plan to reduce pHOS
Hatchery Facilities and Operation	Water temperature profile differs from the natural profile during adult holding	H1	Change the hatchery temperature profile to be more representative of the natural temperature profile.

Table C-2. Potential mitigation measures associated with impacts to natural-origin Chinook salmon by risk category, continued.

Risk Category	Impact	Potential Mitigation Measures	
		Number	Description
	Water temperature profile differs from the natural profile during incubation.	H2	Change the hatchery temperature profile to be more representative of the natural temperature profile and avoid non-random culling of eggs. Separate eggs to control pathogen amplification.
	Releasing hatchery-origin fish of a size, behavior, growth rate, and physiological status that would result in competition and predation to natural-origin fish	H3	Change the release size, behavior, growth rate, and physiological status of hatchery-origin fish to decrease the potential for competition and predation to natural-origin fish
	Pond site is in remote area with no electrical service, relies on gravity flows, and lacks security	H4	Develop plan to provide service and improve security, or change site
	Yearling release strategy is different from the natural life history of Chinook salmon resulting in a potential for divergence from the natural-origin Chinook salmon population	H5	Change to subyearling release strategy
	Facility water intake does not meet current standards	H6	Upgrade intakes, when feasible, to current standards
	Facility is not sited to minimize risk of catastrophic fish loss from flooding	H7	Develop flood risk management protocols and minimize exposure by restricting use during flood season or discontinue program

4.0 Population Results

Provided in this subsection are risks and benefits to natural-origin Chinook salmon populations, beginning with those in the northeastern part of the ESU (Nooksack River population), then progressing southerly and then northwesterly to the Elwha River population.

4.1 North Fork Nooksack Chinook Salmon

4.1.1 Introduction

As shown in Table C-1, two natural-origin Chinook salmon populations are found in the Nooksack River watershed: North Fork Nooksack spring-run and South Fork Nooksack spring-run. The populations are federally listed as threatened under the ESA. These two populations are evaluated separately in the subsections below; however, several of the hatcheries within the Nooksack River watershed can affect both natural-origin populations as explained within the two subsections. This subsection discusses the North Fork Nooksack Chinook salmon population, whereas Subsection 4.2, South Fork Nooksack Chinook Salmon, discusses the latter population.

As described in Subsection 2.1, Nooksack Chinook Salmon Populations, the North Fork Nooksack River supports a unique spring-run Chinook salmon population. Hatchery supplementation using the indigenous stock began in the North Fork of the Nooksack River at Kendall Creek, and has a current production objective of releasing 750,000 hatchery-origin subyearling Chinook salmon annually.

The following rivers, streams, and bays are found within the Nooksack River watershed and support hatchery-origin fish that could affect natural-origin North Fork Nooksack Chinook salmon:

- Nooksack River (mainstem, North Fork, Middle Fork, and South Fork)
- Kendall Creek (a Nooksack River tributary)
- Skookum Creek (a South Fork Nooksack River tributary)
- Samish River
- Lummi Bay

Five Chinook salmon hatchery programs, two coho salmon hatchery programs, and one steelhead hatchery program implemented at four hatcheries have the potential to impact the North Fork Chinook salmon population (Table C-3 and Table C-4), and are evaluated in this subsection.

Table C-3. Hatchery programs and categories of effects evaluated for North Fork Nooksack Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling	√	√	√	√	√	√
	Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling	√[1]	√[1]	√[2]			
	Samish Hatchery isolated fall-run Chinook salmon subyearling	√[1]	√[1]	√[2]			

Table C-3. Hatchery programs and categories of effects evaluated for North Fork Nooksack Chinook salmon, continued.

Species	Hatchery and Program	Risk				Benefit	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
	Samish Hatchery isolated fall-run Chinook salmon yearling	√[1]	√[1]	√[2]			
Coho salmon	Kendall Creek Hatchery coho salmon yearling	√	√				
	Skookum Creek Hatchery coho salmon yearling	√	√				
Steelhead	Kendall Creek Hatchery isolated winter-run steelhead yearling	√	√				

[1] These hatchery programs are evaluated as a single Chinook salmon group for competition and predation risks.
[2] These hatchery programs are evaluated as a single Chinook salmon group for genetic risks.

Table C-4. Hatchery salmon and steelhead production evaluated for North Fork Nooksack Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon[1]	Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling	750,000	750,000	0	750,000	0
	Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling	2,000,000	1,500,000	25	2,000,000	0
	Samish Hatchery isolated fall-run Chinook salmon subyearling	4,000,000	4,000,000	0	4,000,000	0
	Samish Hatchery isolated fall-run Chinook salmon yearling	100,000	100,000	0	100,000	0
	Total subyearlings	6,750,000	6,250,000	7	6,750,000	0
	Total yearlings	100,000	100,000	0	100,000	0

Table C-3. Hatchery programs and categories of effects evaluated for North Fork Nooksack Chinook salmon, continued.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
	TOTAL	6,850,000	6,350,000	7	6,850,000	0
Coho Salmon	Kendall Creek Hatchery coho salmon yearling	300,000	150,000	50	300,000	0
	Skookum Creek Hatchery coho salmon yearling	1,000,000	500,000	50	2,000,000	100
	TOTAL	1,300,000	650,000	50	2,300,000	76
Steelhead	Kendall Creek Hatchery isolated winter-run steelhead yearling	150,000	75,000	50	150,000	0
All	TOTAL	8,300,000	7,045,000	15	9,300,000	13

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.1.2 Methods

In conducting the analysis for the North Fork Nooksack Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** Hatchery programs that release Chinook salmon in rivers and streams and saltwater bays are evaluated. Marine releases are evaluated as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish. One hatchery program (Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling) is evaluated for all risks and benefits. Other Chinook salmon hatchery programs that have a potential to impact natural-origin North Fork Nooksack Chinook salmon include the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs. These hatchery programs release fish into marine areas or are associated with recovery category 3 populations (which do not have indigenous Chinook salmon populations). Thus, they are evaluated as a group for competition and predation risks. In addition, genetic risks for these hatchery programs are evaluated as a group along with the Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling program because they have the potential for genetic interaction with North Fork Nooksack Chinook salmon upon return as adults.
- **Coho Salmon:** Hatchery programs that release coho salmon in bays are not evaluated at the population scale, but are evaluated at the ESU scale. Such releases include Lummi Bay Hatchery

isolated coho yearling and Squalicum Harbor net pen isolated coho yearling programs. Two hatchery programs (Kendall Creek Hatchery coho salmon yearling and Skookum Creek Hatchery coho salmon yearling programs) are each evaluated for competition and predation risks to natural-origin North Fork Nooksack Chinook salmon.

- **Steelhead:** One hatchery program (Kendall Creek Hatchery isolated winter-run steelhead yearling) is evaluated for competition and predation risks. The Whatcom Creek Hatchery isolated winter-run steelhead yearling program is not evaluated because releases from the program occur in the Samish River watershed, which is a recovery category 3 watershed for Chinook salmon.

4.1.3 Results

Results for North Fork Nooksack Chinook salmon analyses are summarized in Table C-5. The action alternatives would include use of an adaptive management approach, but the results in Table C-5 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for the population are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-5 is explained in the subsequent subsections for this population.

Table C-5. Summary of hatchery-related risks and benefits for North Fork Nooksack Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	High	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Moderate	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.1.3.1 Risks

4.1.3.1.1 Competition

Competition risks for the North Fork Nooksack Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Nooksack River watershed are summarized in Table C-6. Under all alternatives, the Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling program would result in a high competition risk because the subyearlings produced through this program are released high in the watershed during the natural-origin Chinook salmon rearing and out-migration periods. The hatchery-origin fish release results in potential elevated spatial and temporal overlap between the hatchery-origin fish and natural-origin Chinook salmon juvenile fish. In addition, the low number of natural-origin juvenile fish at current abundance levels relative to hatchery-origin subyearling abundance increases the likelihood for negative competitive interactions.

The Kendall Creek Hatchery isolated winter-run steelhead yearling program would release steelhead after May 1 and would have a low competition effect as shown in Table C-6.

The overall risk of competition to North Fork Nooksack Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-6).

Table C-6. North Fork Nooksack Chinook salmon competition risk by alternative.

	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
Hatchery Program Risk				
Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling	12.0	High	Same as Alternative 1	Same as Alternative 1
Other Chinook Salmon Hatcheries - Impacts to natural-origin juvenile Chinook salmon attributable to competition with all races of Chinook salmon released from hatcheries within or adjacent to the Nooksack River watershed (Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	High	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery coho salmon yearling	0.3 (0.2 for Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Skookum Creek Hatchery coho salmon yearling	0.8 (0.7 for Alternative 3, 0.6 for Alternative 4)	Negligible	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1] From the PCD Risk Model. If only one index percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Regarding competition from other Chinook salmon hatchery programs, hatchery-origin Chinook salmon released from the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and the Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs would pose high competition risks to natural-origin Chinook salmon from the North Fork Nooksack population. This is because hatchery-origin summer/fall-run Chinook salmon from the Lummi Bay Hatchery would be released in Lummi Bay and the lower Nooksack River where they may intermingle and compete with natural-origin Chinook salmon in Nooksack River lower river freshwater and delta areas. Hatchery-origin Chinook salmon from the Samish Hatchery may also compete with co-occurring natural-origin North Fork Nooksack Chinook salmon juvenile out-migrants in nearshore marine areas adjacent to the river mouth.

4.1.3.1.2 Predation

Predation risks to the North Fork Nooksack Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Nooksack River watershed are summarized in Table C-7. Other than steelhead, the risk levels from predation from releases by Chinook salmon hatcheries are the same as competition and the reasoning is the same as explained above under Subsection 4.1.3.1.1, Competition. The coho salmon hatcheries (Kendall Creek Hatchery coho salmon yearling and Skookum Creek Hatchery coho salmon yearling programs) have a high rating because the hatcheries would release larger yearling fish during a substantial portion of the out-migration period for the smaller natural-origin juvenile Chinook salmon (coho salmon are typically released from April to June; natural-origin Chinook smolts typically out-migrate from March to June, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). In comparison, the steelhead hatchery program would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). However, the Kendall Creek Hatchery isolated winter-run steelhead yearling program would release fish in the North Fork Nooksack River at RM 46, resulting in a high predation risk to natural-origin Chinook salmon (Table C-7). The overall risk of predation to North Fork Nooksack Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-7).

Table C-7. North Fork Nooksack Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling	15.7	High	Same as Alternative 1	Same as Alternative 1
Other Chinook Salmon Hatcheries -Impacts on natural-origin juvenile Chinook salmon attributable to predation by hatchery-origin Chinook salmon released from hatcheries within the Nooksack River watershed (Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	High	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery coho salmon yearling	42.4 (30 for Alternative 3)	High	Same as Alternative 1	Same as Alternative 1
Skookum Creek Hatchery coho salmon yearling	59.0 (51 for Alternative 3, 64.4 for Alternative 4)	High	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		**High**	**Same as Alternative 1**	**Same as Alternative 1**

[1] From the PCD Risk Model. If only one index percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.1.3.1.3 Genetics

Assessments of genetic risks to the North Fork Nooksack Chinook salmon population are based primarily on PNI estimates from the AHA Model for each alternative (Table C-8). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-8. North Fork Nooksack Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling	0.12	High	Same as Alternative 1	Same as Alternative 1
Other Chinook Salmon Hatcheries- Genetic introgression risk from straying hatchery-origin fall-run Chinook salmon, including loss of among-population diversity (Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling, Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs, and Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling programs)	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		**High**	**Same as Alternative 1**	**Same as Alternative 1**

[1] From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

The hatchery-induced selection risk for the Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling program under Alternative 1 and Alternative 2 is high because the PNI is less than 0.35 under all alternatives (Table C-8) (Appendix E, Overview of the All H Analyzer). No natural-origin Chinook salmon would be incorporated as broodstock in the hatchery program. Additionally, more than 75 percent of fish spawning in natural spawning areas are first generation hatchery-origin Chinook salmon originating from the Kendall Creek Hatchery program. Consequently, the hatchery may drive the evolution of the integrated population, which increases the assigned risk of hatchery-induced selection. There would be no changes in broodstock collection methods or fish production levels across alternatives; thus, genetic risks would be the same for all alternatives.

Fall-run Chinook salmon were released from Kendall Creek Hatchery through 1996, potentially creating a localized natural-origin fall-run Chinook salmon run that spawns in the North Fork Nooksack River. Stray, first generation, hatchery-origin fall-run Chinook salmon originating from the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling programs also contribute to natural spawning in the North Fork Nooksack River. Localized natural-origin and stray hatchery-origin fall-run Chinook salmon may interbreed with natural-origin spring-run North Fork Nooksack Chinook salmon to some degree.

Hatchery-origin releases from the Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling program were initiated in 2011. Hatchery-origin adults resulting from the program may eventually stray into the North Fork Nooksack River and interbreed with North Fork Nooksack Chinook salmon, potentially to the detriment of among-population diversity.

4.1.3.1.4 Hatchery Facilities and Operation

As described in Subsection 2.1, Nooksack Chinook Salmon Populations, the Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling program rears and releases hatchery-origin subyearling fish that are considered part of the North Fork Nooksack Chinook salmon population. Broodstock are collected from hatchery-origin adult returns to the hatchery and no natural-origin fish are incorporated for spawning. Hatchery fish would continue to be reared and released from the hatchery and from sites located in the upper North Fork Nooksack River. Hatchery facility conditions and operational practices for the program would remain the same under all alternatives, and results for the program using the HPV Tool are shown in Table C-9.

Table C-9. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for North Fork Nooksack Chinook salmon.

Hatcheries - Kendall Creek Hatchery integrated spring-run Chinook salmon subyearlings (facility and release locations: North Fork Nooksack River [RM 46], confluence with Deadhorse Creek [RM 63.5], and RM 65.1)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	Low	High	
Spawning	High	Moderate	
Incubation	Moderate	High	
Rearing	Moderate	High	
Release	High	Moderate	
Facilities	NA	Moderate	
			Moderate

[1] Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

The overall risk of hatchery facilities and operation impacts to the listed North Fork Chinook salmon population is moderate. The HPV Tool assigned a low compliance rating in the adult holding phase for the subyearling release program because of a water temperature profile that differs significantly from the natural profile during adult holding, which may have a detrimental effect on reproductive performance of the fish in the natural environment.

4.1.3.2 Benefits

4.1.3.2.1 Total Return

Table C-10 compares effects of the alternatives on the total return of adult hatchery-origin fish produced by the Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average North Fork Nooksack Chinook salmon natural run size (including fisheries and escapement). The return size of hatchery-origin fish produced under each alternative plus the recent year average natural-origin return is contrasted with the restoration spawner abundance estimate for the population and considered as total return.

Table C-10. Estimated total return contributions for North Fork Nooksack Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	5,025	5,025	5,025
Average natural-origin return	311	311	311
Projected average total return	5,336	5,336	5,336
Restoration spawner abundance [1]	16,400	16,400	16,400
Projected average total return as a percent of restoration spawner abundance	33	33	33

Source: Chinook returns are from Tynan (2008).

[1] Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement are moderate for all alternatives because the combined total return is between 20 and 50 percent (33 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-10). Subyearling release levels remain the same under all alternatives (Table C-4). Fish produced through the program would continue to be harvested incidentally in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canada (Georgia Strait sport fishery and West Coast Vancouver Island troll and sport fisheries [CTC 2012]). Contributions of these fish to U.S. fisheries are low because Washington fisheries are managed to reduce incidental harvests of this stock (through time and area closures and selective fishing practices), consistent with the stock recovery intent of the program producing the fish. A minor number of these hatchery-origin fish (less than 30 fish) would continue to be targeted each year in a Lummi and Nooksack tribal ceremonial and subsistence fishery in the Nooksack River mainstem. Adult Chinook salmon returns to the Nooksack River watershed resulting from hatchery production under all alternatives would contribute substantially to the current critically depressed total return of North Fork Nooksack adults escaping to spawn naturally, and to Kendall Creek Hatchery as broodstock to sustain the program.

4.1.3.2.2 Viability

Viability benefits to the North Fork Nooksack Chinook salmon population from the Kendall Creek Hatchery integrated spring Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Kendall Creek Hatchery integrated spring-run Chinook salmon program would benefit the abundance, diversity, and spatial structure of the North Fork Nooksack Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of North Fork Nooksack Chinook salmon. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the North Fork Nooksack population of 1,666 fish. This average included surplus hatchery-origin adults planted back into the natural environment from Kendall Creek Hatchery. The estimated mean number of natural-origin spawners for this period is 276 fish. The remainder of the fish spawning naturally (1,390 fish or 83 percent of the mean spawning escapement) were Kendall Creek hatchery-origin spring-run Chinook salmon.

Diversity – The hatchery program would benefit diversity. BMPs used by the Kendall Creek Hatchery program would continue to maintain the genetic diversity of the propagated population, thus increasing the likelihood that within-population genetic diversity of the natural-origin population would be conserved over time. Measures include collection of large numbers of broodstock (e.g., mean number of effective breeders = 4,330 from 1997 to 2001), random collection of broodstock over the breadth of the return, and using a factorial mating scheme during spawning (WDFW 2005a) to ensure the diversity of spawners is represented.

Spatial Structure – The hatchery program would benefit spatial structure. Releases of fish from the hatchery would be into acclimation areas located in upper North Fork and Middle Fork Nooksack River tributaries. Spawners would be distributed into areas where natural-origin fish were historically present (WDFW 2005a), thus benefiting spatial structure of the population.

Productivity – The benefit of the hatchery program to productivity is unknown. However, the low numbers of natural-origin spawners discussed above suggests that productivity in the existing natural habitat continues to be poor and that contributions of naturally spawning hatchery-origin fish are not leading to improved productivity. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) North Fork Nooksack population of 0.61. This short-term lambda value is the lowest of all populations of Puget Sound Chinook salmon evaluated by Ford (2011). A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite North Fork Nooksack naturally spawning population is not replacing itself in the short term, despite decades of high contributions of hatchery-origin spawners through straying. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be moderate.

4.1.3.3 Summary – North Fork Nooksack Chinook Salmon

Table C-5 summarizes the risks and benefits for all alternatives pertinent to the North Fork Nooksack Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight salmon hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from moderate to high, with competition, predation, and genetics being high, and hatcheries facilities and operation being moderate. Risks are unchanged under Alternative 3 and Alternative 4. Benefits are moderate for both total return and viability under all alternatives.

4.1.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). The mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits.

However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Competition. The following site-specific mitigation measure would help to decrease competition risks to the North Fork Nooksack Chinook salmon population.

- Release all Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling fish on-station rather than releasing half of the production into the lower Nooksack River near Kwina Slough. This measure would reduce competition risks to rearing and emigrating natural-origin Chinook salmon juveniles in the lower Nooksack River.

Predation. The following site-specific mitigation measure would help to decrease predation risks to the North Fork Nooksack Chinook salmon population.

- Truck hatchery-origin fish from Kendall Creek Hatchery coho salmon yearling program, Kendall Creek Hatchery isolated winter-run steelhead yearling program, and Skookum Creek Hatchery coho salmon yearling program downstream for release near the Nooksack River mouth to reduce interactions with natural-origin juvenile Chinook salmon rearing and migrating in the North Fork, South Fork, and mainstem Nooksack Rivers. This measure may also increase the proportion of hatchery-origin fish surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate seaward.

Genetics. The following mitigation measures would help to decrease genetic risks to the North Fork Nooksack Chinook salmon population.

- Release all Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearlings on-station rather than releasing half of the production into the lower Nooksack River near Kwina Slough. This measure may reduce straying and genetic introgression risks posed by hatchery-origin fall-run Chinook salmon spawning in areas used by early timed natural-origin Chinook salmon.

- Develop a lower Nooksack River acclimation site for hatchery fish produced through the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling program to increase homing fidelity, to create a segregated harvest area where adult hatchery-origin returns could be subjected to higher harvest rates, and to reduce the potential for straying of hatchery-origin spawners in natural production areas.

Provided in Table C-11 is a summary of potential mitigation measures for the North Fork Nooksack Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, genetic, and hatchery facilities and operation risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-5).

Table C-11. Potential mitigation measures for the North Fork Nooksack Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Predation	Apply Mitigation Measures P1 and P2.
Genetics	Apply Mitigation Measures G1 and G2.
Hatchery facilities and operation	Apply Mitigation Measure H1.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above Chinook salmon, coho salmon, and steelhead hatchery program mitigation measures consistent with an adaptive management approach would likely help reduce the risks of competition, predation, and genetic impacts of the programs on the natural-origin North Fork Nooksack Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the North Fork Nooksack River natural-origin Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). Under the NMFS delisting criteria, as one of only two populations in the North East (or Strait of Georgia) Major Population Group, recovery of the natural-origin North Fork Nooksack Chinook salmon population to a low extinction risk status is required for ESU viability and delisting.

4.2 South Fork Nooksack Chinook Salmon

4.2.1 Introduction

As shown in Table C-1, the Nooksack River supports the natural-origin South Fork Nooksack Chinook salmon population. The population is federally listed under the ESA. As described in Subsection 2.1, Nooksack Chinook Salmon Populations, the South Fork Nooksack supplementation program at the Skookum Creek Hatchery operated from 1980 to 1996. The program has been reinitiated by the hatchery operato, and is undergoing changes in broodstock management that will be analyzed for the final EIS.

The following rivers, streams, and bays are found within the Nooksack River watershed and support hatchery-origin fish that could affect natural-origin South Fork Nooksack Chinook salmon:

- Nooksack River (mainstem, North Fork, Middle Fork, and South Fork)
- Kendall Creek (a Nooksack River tributary)
- Skookum Creek (a South Fork Nooksack River tributary)
- Whatcom Creek (an independent stream that flows from Lake Whatcom to Bellingham Bay)
- Samish River
- Lummi Bay

Five Chinook salmon hatchery programs, two coho salmon hatchery programs, and two steelhead hatchery programs implemented at five hatcheries have the potential to impact the South Fork Nooksack spring-run Chinook salmon population (Table C-12 and Table C-13), and are reviewed in this subsection.

Table C-12. Hatchery programs and categories of effects evaluated for South Fork Nooksack Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	**Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling**	√	√			√	√
	Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling			√[2]			
	Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling	√[1]	√[1]	√[2]			
	Samish Hatchery isolated fall-run Chinook salmon subyearling	√[1]	√[1]	√[2]			
	Samish Hatchery isolated fall-run Chinook salmon yearling	√[1]	√[1]	√[2]			
Coho salmon	Kendall Creek Hatchery coho salmon	√	√				
	Skookum Creek Hatchery coho	√	√				

Table C-12. Hatchery programs and categories of effects evaluated for South Fork Nooksack Chinook salmon, continued.

Species	**Hatchery and Program**	**Risk**				**Benefit**	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
	salmon yearling						
Steelhead	Kendall Creek Hatchery isolated winter-run steelhead yearling	√	√				
	Whatcom Creek Hatchery isolated winter-run steelhead yearling	√	√				

[1] These hatchery programs are evaluated as a single Chinook salmon group for competition and predation risks.
[2] These hatchery programs are evaluated as a single Chinook salmon group for genetic risk.

Table C-13. Hatchery salmon and steelhead production evaluated for South Fork Nooksack Chinook salmon.

Species	**Hatchery and Program**[1]	**Release Number for Alternatives 1 and 2**	**Alternative 3**		**Alternative 4**	
			Release Number	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon	Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling	200,000	200,000	0	200,000	0
	Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling	2,000,000	1,500,000	25	2,000,000	0
	Samish Hatchery isolated fall-run Chinook salmon subyearling	4,000,000	4,000,000	0	4,000,000	0
	Samish Hatchery isolated fall-run Chinook salmon yearling	100,000	100,000	0	100,000	0
	Total subyearlings	6,200,000	5,700,000	8	6,200,000	0
	Total yearlings	100,000	100,000	0	100,000	0
	TOTAL	6,300,000	5,800,000	8	6,300,000	0
Coho Salmon	Kendall Creek Hatchery coho salmon yearling	300,000	150,000	50	300,000	0
	Skookum Creek Hatchery coho salmon yearling	1,000,000	500,000	50	2,000,000	100
	TOTAL	1,300,000	650,000	50	2,300,000	76
Steelhead	Kendall Creek Hatchery	150,000	75,000	50	150,000	0

Table C-13. Hatchery salmon and steelhead production evaluated for South Fork Nooksack Chinook salmon, continued.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
	isolated winter-run steelhead yearling					
	Whatcom Creek Hatchery isolated winter-run steelhead yearling	40,000	40,000	0	45,000	12
	TOTAL	190,000	115,000	37	195,000	3
All	TOTAL	8,540,000	7,315,000	14	10,345,000	21

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.2.2 Methods

In conducting the analysis for the South Fork Nooksack Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** Hatchery programs that release hatchery-origin Chinook salmon in rivers, streams, and saltwater bays are evaluated. One hatchery program (Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling) is evaluated for competition, predation, and genetic risks, and total return and viability benefits. Other Chinook salmon hatchery programs that have a potential to impact natural-origin South Fork Nooksack Chinook salmon include the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs. These hatchery programs are evaluated together as a group for competition and predation risks because fish are released into marine waters where they comingle. Other Chinook salmon hatchery programs evaluated for genetic risk are Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling, Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling, and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs. The recent captive broodstock component of the Skookum Hatchery program is not evaluated because it pertains to captive broodstock efforts which do not involve spawning, rearing, and releases of fish.
- **Coho Salmon:** Hatchery programs that release coho salmon directly into adjacent marine waters are not evaluated, which includes the Lummi Bay Hatchery isolated coho yearling and Squalicum Harbor net pen isolated coho yearling programs. Two hatchery programs (Kendall Creek

Hatchery coho salmon yearling and Skookum Creek Hatchery coho salmon yearling programs) are each evaluated for competition and predation risks to natural-origin South Fork Nooksack Chinook salmon.

- **Steelhead:** Two hatchery programs (Kendall Creek Hatchery isolated winter-run steelhead yearling and Whatcom Creek Hatchery isolated winter-run steelhead yearling) are each evaluated for competition and predation risks to natural-origin South Fork Nooksack Chinook salmon.

4.2.3 Results

Results for the South Fork Nooksack Chinook salmon population are summarized in Table C-14. The action alternatives would include use of an adaptive management approach, but the results in Table C-14 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for the assignment of risks in Table C-14 is explained in the subsequent subsections for this population.

Table C-14. Summary of hatchery-related risks and benefits for the South Fork Nooksack Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	High	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	NA	NA	NA
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.2.3.1 Risks

4.2.3.1.1 Competition

Competition risks to the South Fork Nooksack Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the South Fork Nooksack River watershed are summarized in Table C-15. The Skookum Creek Hatchery program propagating South Fork Nooksack Chinook salmon stock is new and designed to preserve and rebuild the critically depressed natural-origin South Fork Nooksack Chinook salmon population. The first releases of fish from the Skookum Creek Hatchery program occurred in 2011. Risks and benefits are assigned based on implementation of the program as described in the HGMP (Lummi Indian Nation 2006).

The competition risks to the natural-origin South Fork Nooksack Chinook salmon population posed by hatchery-origin salmon and steelhead production in the Nooksack River watershed are generally the same as assigned for the North Fork Nooksack Chinook salmon population (Subsection 4.1.3.1.1, Competition [North Fork Nooksack]). Both of the natural spawning populations are at similar very low abundance levels, and share many of the same habitat conditions and limiting factors in the watershed. The hatchery-origin fish competition risk to South Fork Nooksack Chinook salmon is moderate because the Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling program would release hatchery-origin South Fork Nooksack fish during the natural-origin Chinook salmon rearing and out-migration periods, leading to a high degree of spatial and temporal overlap between the hatchery-origin fish and natural-origin Chinook salmon juveniles. In addition, the very low number of natural-origin juvenile out-migrants relative to planned hatchery smolt production may result in an increased likelihood of negative interaction and competition and predation effects for the natural-origin Chinook salmon population.

Hatchery-origin fall-run Chinook salmon released from the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs also pose a high competition risk to natural-origin Chinook salmon from the South Fork Nooksack population. This is because Lummi Bay Hatchery isolated summer/fall-run Chinook salmon are released in Lummi Bay and the lower Nooksack River where they may intermingle and compete with natural-origin Chinook salmon in Nooksack River lower river freshwater and delta areas. Hatchery-origin Chinook salmon from the Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs may also compete with co-occurring natural-origin South Fork Nooksack Chinook salmon juvenile out-migrants in nearshore marine areas adjacent to the river mouth.

The two steelhead programs (Kendall Creek Hatchery isolated winter-run steelhead yearling and Whatcom Creek Hatchery isolated winter-run steelhead yearling) release steelhead after May 1 and would have a low competition effect as shown in Table C-15.

The overall risk of competition to South North Fork Nooksack Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-15).

Table C-15. South Fork Nooksack Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling	6.4	Moderate	Same as Alternative 1	Same as Alternative 1
Other Chinook Salmon Hatcheries - Impacts to natural-origin juvenile Chinook salmon attributable to competition with all races of Chinook salmon released from hatcheries within or adjacent to the Nooksack River watershed (includes Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling, Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	High	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery coho salmon yearling	0.3 (0.2 for Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Skookum Creek Hatchery coho salmon yearling	0.6 (0.7 for Alternative 3, 0.8 for Alternative 4)	Low	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Whatcom Creek Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		**High**	**Same as Alternative 1**	**Same as Alternative 1**

[1] From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.2.3.1.2 Predation

Predation risks to the South Fork Nooksack Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Nooksack River watershed are summarized in Table C-16. Other than steelhead, the risk levels from predation by Chinook salmon hatchery programs are the same as competition and the reasoning is the same as explained above under Subsection 4.2.3.1.1, Competition (South Fork Nooksack Chinook Salmon). The coho salmon hatcheries (Kendall Creek Hatchery coho salmon yearling and Skookum Creek Hatchery coho salmon yearling programs) have a high rating because the hatcheries would release the larger yearling fish during the primary out-migration period for the smaller natural-origin juvenile Chinook salmon (coho salmon are typically released from April to June; natural-origin Chinook salmon smolts typically out-migrate from March to June, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). In comparison, the two steelhead hatchery programs release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). However, the Kendall Creek Hatchery isolated winter-run steelhead yearling program releases fish in the North Fork Nooksack River at RM 46, which results in a high predation risk to natural-origin Chinook salmon in the Nooksack River basin. The Whatcom Creek Hatchery isolated winter-run steelhead yearling program releases fish in the Samish River at RM 10.5 and Whatcom Creek at RM 0.5 after May 1, which results in a low predation risk (Table C-7). The overall risk of predation to South Fork Nooksack Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-16).

Table C-16. South Fork Nooksack Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling	13.9	High	Same as Alternative 1	Same as Alternative 1
Other Chinook Salmon Hatcheries - Impacts to natural-origin juvenile Chinook salmon attributable to predation with all races of Chinook salmon released from hatcheries within or adjacent to the Nooksack River watershed (includes Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling, Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	High	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery coho salmon yearling	42.4 (30 for Alternative 3)	High	Same as Alternative 1	Same as Alternative 1
Skookum Creek Hatchery coho salmon yearling	59.0 (51 for Alternative 3, 64.4 for Alternative 4)	Moderate	Same as Alternative 1	Same as Alternative 1
Kendall Creek Hatchery isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Whatcom Creek Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		**High**	**Same as Alternative 1**	**Same as Alternative 1**

[1] From PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.2.3.1.3 Genetics

Assessments of genetic risks to the South Fork Nooksack Chinook salmon population using the AHA Model are not available because insufficient information was available at the time of modeling. Risk levels are assigned (Table C-17) as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, using inferences based on the best available information.

Table C-17. South Fork Nooksack Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Skookum Creek Hatchery integrated spring-run Chinook salmon subyearlings	NA	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Genetic introgression risk from straying hatchery-origin Chinook salmon, including loss of among-population diversity (includes Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling, Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Overall Risk		Unknown, but likely High	Same as Alternative 1	Same as Alternative 1

[1] From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

The assumed level of hatchery-induced selection risk for Alternative 1 is unknown but likely high because, although only natural-origin Chinook salmon would be incorporated as broodstock in the Skookum Creek Hatchery spring-run Chinook salmon program, nearly all resultant adult fish that would be present on the spawning grounds would be first generation hatchery-origin Chinook salmon. The hatchery program would drive the evolution of the integrated population (at least for the first 10 years of the program), increasing hatchery-induced selection risks. There would be no changes in broodstock collection methods or hatchery fish production levels across the alternatives; thus, risks would be the same for all alternatives.

Hatchery-origin adult Chinook salmon from the Kendall Creek Hatchery integrated spring-run Chinook salmon subyearling program, and localized hatchery-origin and Green River lineage fall-run Chinook salmon originating from the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling and Samish Hatchery isolated fall-run Chinook salmon subyearling and yearling programs, have been shown to stray into the South Fork Nooksack River in substantial numbers (Lummi Indian Nation, unpublished data, 2010). For example, in many recent years, Chinook salmon adults that are not natural to the South Fork Nooksack River have accounted for 75 percent of the total annual spawning population. However, genetic data indicate that a distinct natural-origin South Fork Nooksack Chinook salmon population continues to persist in the watershed despite the presence of strays from outside the South Fork Nooksack River. Effects on the genetic diversity of the South Fork Chinook salmon population are unknown, although it is likely that straying and spawning by these other Chinook salmon stocks pose a high genetic introgression risk to the natural-origin population (Table C-17).

4.2.3.1.4 Hatchery Facilities and Operation

Data necessary to analyze hatchery facilities and operation risks using the HPV Tool are not available for the Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling program. The program is undergoing changes in broodstock management that will be analyzed for the Final EIS. It is anticipated that this program would continue to use BMPs to guide hatchery operations in the propagation of this stock.

4.2.3.2 Benefits

4.2.3.2.1 Total Return

Table C-18 compares effects of the alternatives on the total return of adult hatchery-origin fish that may be produced by the Skookum Creek Hatchery integrated spring-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average South Fork Nooksack Chinook salmon natural return size. The abundance of hatchery-origin fish produced under each alternative plus the recent year average natural-origin return is contrasted with the restoration spawner abundance estimate for the population.

Table C-18. Estimated total return contributions for South Fork Nooksack Chinook salmon.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Average hatchery-origin return	1,340	1,340	1,340
Average natural-origin return	79	79	79
Projected average total return	1,261	1,261	1,261
Restoration spawner abundance[1]	9,100	9,100	9,100
Projected average total return as a percent of restoration spawner abundance	14	14	14

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Projected total return benefits to fisheries and escapement are low for all alternatives, because the combined total return is less than 20 percent (14 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-18). Subyearling release levels (Table C-13), and total return benefits to fisheries and escapement would remain the same under all alternatives (Table C-18). As mentioned above for the North Fork Nooksack, hatchery-origin adult fish would continue to be harvested incidentally in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canada (Georgia Strait sport fishery and West Coast Vancouver Island troll and sport fisheries) (CTC 2012). Contributions of these fish to U.S. fisheries would be low because Washington fisheries are managed to reduce incidental harvests of the South Fork Nooksack River stock (through time and area closures, and selective fishing practices), consistent with the stock preservation and recovery intent of the program producing the fish. Adult Chinook salmon returns to the Nooksack River watershed resulting from hatchery production under all alternatives would contribute substantially to the returns of South Fork Nooksack adults escaping to spawn naturally, which are currently at critically depressed levels.

4.2.3.2.2 Viability

Viability benefits to the South Fork Nooksack Chinook salmon population from the Skookum Creek Hatchery integrated spring-run Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program have been identified for consideration for listing as part of the Puget Sound Chinook Salmon ESU (NMFS 2011).

Under Alternative 1 and Alternative 2, the Skookum Creek Hatchery integrated spring-run Chinook salmon program would benefit the abundance, diversity, and spatial structure of the South Fork Nooksack Chinook salmon population. Thus, the viability benefit of the program to the South Fork Nooksack Chinook salmon population is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of South Fork Nooksack Chinook salmon. The natural-origin South Fork Nooksack Chinook salmon population is small. Production levels would be consistent with analyses reflected in Ford (2011), although recent analyses indicate that the proportion of naturally spawning fish that are part of the population is substantially smaller than assumed in the NMFS status review (Lummi Indian Nation unpublished data 2010). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the South Fork Nooksack population of 388 fish. The estimated mean number of natural-origin spawners for this period is 244 fish. The remainder of the fish spawning naturally (144 fish, or 37 percent of the mean spawning escapement) includes stray natural-origin and hatchery-origin North Fork Nooksack Chinook salmon, stray hatchery-origin fall-run Chinook salmon, and localized natural-origin fall-run Chinook salmon.

Diversity – The hatchery program would benefit diversity. BMPs used by the Skookum Creek Hatchery program would maintain the diversity of the hatchery-origin population, thus increasing the likelihood that within-population genetic diversity of the natural-origin population would be conserved over time. Measures include collection of adult broodstock randomly over the breadth of the natural-origin spawner return period, and collection and rearing of juveniles from the South Fork Nooksack River. DNA analyses would be used to verify the origin of each fish collected and only those identified to be of South Fork Nooksack origin would be used by the program. In addition, a large number of broodstock (e.g., mean number of effective breeders = 480), and a factorial mating scheme (Lummi Indian Nation 2006) would be used to ensure the diversity of spawners are represented.

Spatial Structure – The hatchery program would be expected to benefit spatial structure as increased numbers of naturally spawning hatchery-origin adults disperse into available but underutilized spawning areas in the South Fork Nooksack River.

Productivity – The benefits of the program to productivity are uncertain. Ford (2011) reported a short-term (1995 through 2009) median population growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) South Fork Nooksack population of 0.94. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 indicates a population that is growing. In this case, the composite South Fork Nooksack naturally spawning population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be moderate.

4.2.3.3 Summary – South Fork Nooksack Chinook Salmon

Table C-14 summarizes the risks and benefits for all alternatives pertinent to the South Fork Nooksack Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the nine hatchery programs evaluated for the South Fork Nooksack River population, risks to natural-origin Chinook salmon under all alternatives are high for competition and predation and likely high for genetics. Hatchery facilities and operation risks are not evaluated because of the limits of recent data available for the Skookum Hatchery integrated spring-run Chinook program.

Total return and viability benefits from the hatchery programs for the South Fork Nooksack River population would range from low for total return to moderate for viability under all alternatives.

4.2.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to reduce low risks or increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Competition. The following site-specific measure would help to decrease competition risks to the South Fork Nooksack Chinook salmon population.

- Release all Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearlings on-station rather than releasing half of the production in Kwina Slough. This measure would reduce competition risks to natural-origin Chinook salmon juveniles in the lower Nooksack River.

Predation. The following site-specific measure would help to decrease predation risks to the South Fork Nooksack Chinook salmon population.

- Truck Kendall Creek Hatchery coho salmon yearlings and Skookum Creek Hatchery coho salmon yearlings downstream for release near the Nooksack River mouth to reduce interactions with natural-origin juvenile South Fork Nooksack Chinook salmon rearing and migrating in the South Fork Nooksack River and mainstem Nooksack River. This measure may also increase the proportion of hatchery fish surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from upriver areas seaward.

Genetics. The following site-specific measures would help to decrease genetic risks to the South Fork Nooksack Chinook salmon population.

- Release all Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearlings on-station rather than releasing half of the production in Kwina Slough. This measure would reduce genetic introgression risks posed by hatchery-origin fall-run Chinook salmon spawning in areas used by early-timed natural-origin Chinook salmon.
- Develop a lower Nooksack River acclimation site for the Lummi Bay Hatchery isolated summer/fall-run Chinook salmon subyearling program to increase homing fidelity, to provide a site where adult hatchery-origin fall-run Chinook salmon returns could be subjected to higher harvest rates, and to reduce the number of hatchery-origin spawners straying into natural production areas.
- Monitor stray rates and make program changes as needed to decrease the number of strays breeding in the South Fork Nooksack River watershed.

Provided in Table C-19 is a summary of potential mitigation measures for the South Fork Nooksack Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, and genetic risks, which are rated as high (competition and predation) and likely high (genetics) risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-14).

Table C-19. Potential mitigation measures for hatchery programs affecting the South Fork Nooksack Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C2, C3, and C4.
Predation	Apply Mitigation Measures P1, P2, P3, and P4.
Genetics	Apply Mitigation Measures G1 and G2.

[1] Refer to Table C-2 for a description of each mitigation measure.

Competition, predation, and genetic risks to the South Fork Nooksack Chinook salmon population would likely be reduced relative to the current situation if the above mitigation measures were implemented. The survival of natural-origin South Fork Nooksack Chinook salmon to the ocean rearing life stage would be improved by applying hatchery management measures that would create spatial and temporal separation between hatchery-origin and natural-origin fish. The genetic diversity and productivity of natural-origin Chinook salmon populations in the watershed would benefit from the application of mitigation measures that would reduce straying and introgression risks posed by non-native hatchery-origin fall-run Chinook salmon adults. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would also be based on the assigned value of the South Fork Nooksack population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). Under the NMFS delisting criteria, as one of only two populations in the North East Major Population Group, recovery of the South Fork Nooksack Chinook salmon population to a low extinction risk status is required for ESU viability and delisting.

4.3 Skagit River Chinook Salmon Populations

4.3.1 Introduction

As shown in Table C-1, and described in Subsection 2.2, Skagit River Chinook Salmon Populations, the Skagit River watershed supports three natural-origin spring-run Chinook salmon populations (in the Cascade River, Upper Sauk River, and Suiattle River), two natural-origin summer-run Chinook salmon populations (in the Upper Skagit River and Lower Sauk River), and one natural-origin fall-run Chinook salmon population (in the Lower Skagit River). All populations are federally listed as threatened under the ESA. Hatchery production currently consists of four relatively small-scale indicator stock programs that release yearling and subyearling hatchery-origin spring-run Chinook salmon and subyearling summer-run and fall-run Chinook salmon through programs based at the Marblemount Hatchery (Table C-20 and A-20). All six Skagit River Chinook salmon populations are evaluated together in this subsection because hatchery-related competition, predation, and genetic effects would be similar among the six populations.

The following rivers are found within the Skagit River watershed and support hatchery-origin fish that could affect natural-origin Chinook salmon: Cascade River and Baker River, which are both tributaries to the Skagit River.

Four Chinook salmon hatchery programs, two coho salmon hatchery programs, two steelhead hatchery programs, and one sockeye hatchery program from three hatcheries have the potential to impact the natural-origin Skagit River Chinook salmon populations (Table C-20 and Table C-21) and are reviewed in this subsection.

Table C-20. Hatchery programs and categories of effects evaluated for Skagit River Chinook salmon populations.

Species	Hatchery and Program	Risk				Benefit	
		Competition	Predation	Genetics	Facilities and Operation	Total Return	Viability
Chinook salmon	Marblemount Hatchery integrated fall-run Chinook salmon subyearling	√	√	√	√	√	√
	Marblemount Hatchery integrated summer-run Chinook salmon subyearling	√	√	√	√	√	√
	Marblemount Hatchery isolated spring-run Chinook salmon subyearling	√	√	√	√	√[1]	√[1]
	Marblemount Hatchery isolated spring-run Chinook salmon yearling	√	√	√	√	√[1]	√[1]
Coho salmon	Marblemount Hatchery isolated coho salmon yearling	√	√				
	Baker Lake Hatchery isolated coho salmon yearling	√	√				
Steelhead	Marblemount Hatchery isolated winter-run steelhead yearling	√	√				
	Barnaby Slough Hatchery isolated winter-run steelhead yearling	√	√				

Table C-20. Hatchery programs and categories of effects evaluated for Skagit River Chinook salmon populations, continued.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Facilities and Operation**	**Total Return**	**Viability**
Sockeye	Baker Lake integrated summer-run sockeye (fry, subyearling, yearling)	√	√				

[1]Evauated together as a group for total abundance and viability benefits.

Table C-21. Hatchery salmon and steelhead production evaluated for Skagit River Chinook salmon.

			Alternative 3		Alternative 4	
Species	**Hatchery and Program[1]**	**Release Number for Alternatives 1 and 2**	**Release Number**	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon	Marblemount Hatchery integrated fall-run Chinook salmon subyearling	222,000	222,000	0	222,000	0
	Marblemount Hatchery integrated summer-run Chinook salmon subyearling	200,000	200,000	0	200,000	0
	Marblemount Hatchery isolated spring-run Chinook salmon subyearling	250,000	250,000	0	250,000	0
	Marblemount Hatchery isolated spring-run Chinook salmon yearling	150,000	150,000	0	150,000	0
	Total Sub-yearling	672,000	672,000	0	672,000	0
	Total Yearling	150,000	150,000	0	150,000	0
	TOTAL	822,000	822,000	0	822,000	0
Coho Salmon	Marblemount Hatchery isolated coho salmon yearling	250,000	125,000	50	250,000	0
	Baker Lake isolated coho salmon yearling	60,000	30,000	50	60,000	0
	TOTAL	310,000	155,000	50	310,000	0

Table C-21. Hatchery salmon and steelhead production evaluated for Skagit Chinook salmon, continued.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Steelhead	Marblemount Hatchery isolated winter-run steelhead yearling	334,000	167,000	50	364,000	9
	Barnaby Slough Hatchery isolated winter-run steelhead yearling	200,000	100,000	50	200,000	0
	TOTAL	534,000	267,000	50	564,000	6
Sockeye	Baker Lake integrated summer-run sockeye (fry, subyearling, yearling)	1,125,000	1,125,000	0	1,125,000	0
All	TOTAL	2,791,000	2,369,000	15	2,821,000	1

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.3.2 Methods

In evaluating effects for the Skagit River Chinook salmon populations, the following analyses are applied.

4.3.2.1 Chinook Salmon

4.3.2.1.1 Competition and Predation

Competition and predation risks from Chinook salmon hatchery-origin programs within the Skagit River watershed are assumed to have the same effect on all six natural-origin Chinook salmon populations in the Skagit River watershed. Four Chinook salmon hatchery programs (Marblemount Hatchery integrated fall-run Chinook salmon subyearling, Marblemount Hatchery integrated summer-run Chinook salmon subyearling, and Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs) are evaluated for competition and predation risks.

4.3.2.1.2 Genetics

The Marblemount Hatchery integrated fall-run Chinook salmon subyearling and Marblemount Hatchery integrated summer-run Chinook salmon yearling programs are evaluated for the genetic risks to all six Skagit River Chinook salmon populations. In addition, the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs are evaluated for most Chinook salmon populations in the Skagit River watershed, except for the Lower Sauk and Upper Sauk Chinook salmon populations, because of their remoteness from the hatchery locations. Genetic effects for these subyearling and yearling programs are inseparable (one PNI value is derived for hatchery fish—subyearling and yearling origin—from the two programs that use the same source stock).

4.3.2.1.3 Hatchery Facilities and Operation

This risk is not analyzed for the Lower Sauk or Upper Sauk natural-origin Chinook salmon populations because of their remoteness from hatchery locations. This risk is analyzed for:

- **Lower Skagit Chinook Salmon Population**. Effects to this population are from the Marblemount Hatchery integrated fall-run Chinook salmon subyearling program.
- **Upper Skagit Chinook Salmon Population**. Effects to this population are from the Marblemount Hatchery integrated summer-run Chinook salmon subyearling program.
- **Cascade River and Suiattle Chinook Salmon Populations**. Effects to these populations are from the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs.

4.3.2.1.4 Total Return and Viability

The Suiattle River, Lower Sauk River, and Upper Sauk River natural-origin Chinook salmon populations are not evaluated for total return and viability, because hatchery programs would not benefit these populations. These benefits are analyzed for:

- **Lower Skagit Chinook Salmon Population**. Effects to this population are from the Marblemount Hatchery integrated fall-run Chinook salmon subyearling program.
- **Upper Skagit Chinook Salmon Population**. Effects to this population are from the Marblemount Hatchery integrated summer-run Chinook salmon subyearling program.
- **Cascade Chinook Salmon Population**. Effects to this population are from the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs, which are evaluated together for this benefit.

4.3.2.2 Coho Salmon

Hatchery programs that release coho salmon hatchery-origin fish in bays are not evaluated, which includes the Oak Harbor net pen isolated coho yearling program. The Marblemount Hatchery isolated coho salmon yearling and Baker Lake isolated coho salmon yearling programs are evaluated for competition and predation effects.

4.3.2.3 Steelhead

The Marblemount Hatchery isolated winter-run steelhead yearling and Barnaby Slough Hatchery isolated winter-run steelhead yearling programs are evaluated for competition and predation effects.

4.3.2.4 Sockeye

The Baker Lake integrated summer-run sockeye program is evaluated for competition and predation. The program produces fry, subyearling, and yearling releases.

4.3.3 Results

Results for the Skagit River Chinook salmon populations are summarized in Tables A-21 to A-26. The action alternatives would use an adaptive management approach, but the results in Tables A-21 to A-26 do not assume any particular application of adaptive management measures. Potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-22 to C-26 is explained in the subsequent subsections for these populations.

Table C-22. Summary of hatchery-related risks and benefits for the Lower Skagit Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Moderate	Same as Alternative 1	Same as Alternative 1
Viability	Negligible	Same as Alternative 1	Same as Alternative 1

Table C-23. Summary of hatchery-related risks and benefits for the Upper Skagit Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Negligible	Same as Alternative 1	Same as Alternative 1

Table C-24. Summary of hatchery-related risks and benefits for the Cascade Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative
Predation	High	Same as Alternative 1	Same as Alternative
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Negligible	Same as Alternative 1	Same as Alternative 1

Table C-25. Summary of hatchery-related risks and benefits for the Lower Sauk Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	NA	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

Table C-26. Summary of hatchery-related risks and benefits for the Upper Sauk Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	NA	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

Table C-27. Summary of hatchery-related risks and benefits for the Suiattle Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

4.3.3.1 Risks

4.3.3.1.1 Competition

Competition risks to the Skagit River Chinook salmon populations from Chinook salmon, coho salmon, sockeye salmon, and steelheadhatchery programs under the four alternatives in the Skagit River watershed are summarized in Table C-28. Risks of competition effects to natural-origin Chinook salmon resulting from hatchery salmon and steelhead production in the Skagit River watershed are negligible to low under all alternatives.

Sockeye Salmon. The unlisted Baker River Sockeye Salmon ESU exists in the Baker River watershed. Unlike other Chinook salmon populations, assessments of competition risks to natural-origin Chinook salmon associated with the Baker Lake Hatchery sockeye salmon program are evaluated by applying a combination of existing information, theory, and expert opinion to assess how Chinook salmon survival would be affected by a total release level of 1,125,000 sockeye salmon fry, subyearlings, and yearlings under the alternatives. The hatchery releases and resulting adult returns would present risks to the natural-origin Skagit River Chinook salmon populations in the following ways:

- competition for food resources during the juvenile life history stages
- competition for spawning sites between hatchery-origin sockeye salmon and natural-origin Chinook salmon
- superimposition of hatchery-origin sockeye redds on pre-existing natural-origin Chinook salmon redds

The number of hatchery-origin fry released (Table C-28) would be the same under all alternatives; thus, competition risks would be the same for all alternatives.

The overall competition risk from the sockeye salmon program to Chinook salmon is low under all alternatives (Table C-28) for the reasons described below. In general, biological, ecological, and behavioral differences between species limit the risk of competitive interactions effects (Seattle Public Utilities 2005). Food resource competition risks to Skagit River Chinook salmon juveniles from Baker Lake Hatchery sockeye salmon releases would be low because of differences in size, associated habitat, and diet preferences between the two species.

Similar to findings elsewhere (Seattle Public Utilities 2005), the risk of competition effects from hatchery-origin sockeye salmon to natural-origin Skagit River Chinook salmon spawners is low. This is primarily because the locations of releases of sockeye salmon under the program are in Baker Lake beach areas, and thus returning adults would home to the Baker River and lake. In addition, when the two species co-occur Chinook salmon tend to spawn in deeper and faster water than sockeye salmon, and can actively select such sites when sockeye salmon are more numerous than in years when sockeye are less numerous.

The risk that hatchery-origin sockeye salmon from the program will impact natural-origin Skagit River Chinook salmon by redd superimposition is low. This is primarily because, as mentioned above, returning hatchery-origin adult sockeye salmon would be expected to home to the Baker River and lake because of the locations at which they had been acclimated and released. However, for sockeye salmon that return to the Skagit River, redd superimposition may occur when gravels into which eggs have already been deposited are used by fish spawning later in the same place. However, even if sockeye salmon did superimpose their redds on Chinook salmon, the likelihood of significant mortality to the Chinook salmon eggs would be inconsequential. This is because the larger Chinook salmon deposit their eggs deeper and into larger gravels than the smaller sockeye salmon adults (Seattle Public Utilities 2005).

The overall risk of competition to the six natural-origin Chinook salmon populations is low for all alternatives (Table C-28).

Table C-28. Skagit River Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Marblemount Hatchery integrated fall-run Chinook salmon subyearling	0.8	Negligible	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery integrated summer-run Chinook salmon subyearling	1.0	Low	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated spring-run Chinook salmon subyearling	1.2	Low	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated spring-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated coho salmon yearling	0.1 (0 for Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Baker Lake Hatchery isolated coho salmon yearling	0 (0 for Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Barnaby Slough Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Baker Lake integrated summer-run sockeye (fry, subyearling, yearling)	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1] From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.3.3.1.2 Predation

Predation risks to the Skagit River Chinook salmon populations from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Skagit River watershed are summarized in Table C-29. Predation risks range from negligible to high.

Table C-29. Skagit River Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Marblemount Hatchery integrated fall-run Chinook salmon subyearling	0.1	Negligible	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery integrated summer-run Chinook salmon subyearling	1.0	Negligible	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated spring-run Chinook salmon subyearling	1.1	Low	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated spring-run Chinook salmon yearling	6.0	Moderate	Same as Alternative 1	Same as Alternative 1
Marblemount Hatchery isolated coho salmon yearling	5.8 (2.8 under Alternative 3)	Moderate	Low	Same as Alternative 1
Baker Lake Hatchery isolated coho salmon yearling	1.0 (0.5 under Alternative 3)	Low	Negligible	Same as Alternative 1
Marblemount Hatchery isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Barnaby Slough Hatchery isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Baker Lake integrated summer-run sockeye (fry, subyearling, yearling)	NA	Negligible	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1] From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

There is a moderate risk of predation from Marblemount Hatchery spring-run Chinook salmon yearlings across all alternatives because of the large size of the yearlings at the time of their release (average length of 6.1 inches fork length) (EIS Table 3.2-4) relative to smaller, natural-origin juvenile Chinook salmon life stages that would be encountered (average length of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4), and the up-river location of the hatchery release site (RM 78.5). There is a moderate risk of predation effects from Marblemount Hatchery coho salmon yearlings under Alternative 1, Alternative 2, and Alternative 4 because of the number of fish that would be released (250,000) combined with the relatively large average individual size of the hatchery-origin yearlings (length 5.5 inches fork length) (EIS Table 3.2-4) compared to their natural-origin Chinook salmon counterparts, which would have an average length of 2.1 to 2.7 inches fork length at the time the hatchery-origin coho salmon were released (Seiler et al. 2002). Under Alternative 3, the number of coho salmon released would be to 125,000; thus, the risk of predation effects would decrease to low. The two steelhead hatchery programs would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Chinook Salmon. The Marblemount Hatchery isolated winter-run steelhead yearling program would release fish in the Cascade River, a tributary to the Skagit River at RM 78.5, which results in a high risk to natural-origin Chinook salmon (Table C-29). The Barnaby Slough Hatchery isolated winter-run steelhead yearling program would release fish in the Skagit River at RM 70.2, which also results in a high risk to natural-origin Chinook salmon (Table C-29).

Sockeye Salmon. The overall predation risk from the Baker Lake Hatchery integrated summer-run sockeye salmon program to natural-origin Chinook salmon is negligible under all alternatives (Table C-29). Releases of sockeye salmon from the program would not be expected to present a direct or indirect predation risk to natural-origin Skagit River Chinook. This is because sockeye salmon subyearlings (1,000,000 fry and 120,000 fingerlings) released by the hatchery program would initially be of too small a size to be predators of co-occurring natural-origin Chinook salmon fry during out-migration from the Baker and Skagit Rivers. Although a relatively small number (5,000) of yearling sockeye salmon would be released under the alternatives, the risk of predation to natural-origin Chinook salmon is inconsequential. Sockeye salmon feed on plankton (planktivorous), not fish (piscivorous), which makes direct predation on natural-origin Chinook salmon by hatchery-origin juvenile sockeye salmon during their freshwater rearing in Baker Lake highly unlikely. In addition, juvenile Chinook salmon and sockeye salmon tend to rapidly segregate into different habitats during their lake rearing phases, further reducing the likelihood that the hatchery program would increase risks of predation effects on Chinook salmon. For example, in Lake Washington, the other major lake system in Puget Sound containing sockeye salmon and Chinook salmon, Chinook salmon fry rear in shallow nearshore areas from February through early May (Tabor et al. 1998), while sockeye salmon fry migrate rapidly into open water habitat with only a small fraction of the migrants overlapping briefly with juvenile Chinook salmon in nearshore areas.

The overall risk of predation to Skagit River Chinook salmon populations associated with all Skagit River watershed hatchery programs is high under all alternatives (Table C-29).

4.3.3.1.3 Genetics

Assessments of genetic risks to the six Chinook salmon populations in the Skagit River watershed are based on the AHA Model for each alternative (Table C-30). Risk levels are primarily assigned using the qualitative criteria applied to PNI estimates for integrated programs and pHOS estimates for isolated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-30. Skagit River Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Marblemount Hatchery integrated fall-run Chinook salmon subyearling	0.84	Low	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from Marblemount Hatchery integrated summer-run Chinook salmon subyearling	0.93	Low	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from Marblemount Hatchery isolated spring-run Chinook salmon[2]	2%	Low	Same as Alternative 1	Same as Alternative 1
Introgression risk posed by strays from the out-of-watershed hatcheries	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1] From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

[2] Includes the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and Marblemount Hatchery isolated spring-run Chinook salmon yearling programs, which are evaluated for most Skagit River watershed Chinook salmon populations except for the Lower Sauk and Upper Sauk Chinook salmon populations, because of their remoteness from the hatchery locations. Genetic effects for these two subyearling and yearling programs are inseparable (a single pHOS value is derived for hatchery fish (subyearling and yearling origin) returning to the river from the two programs based on the same stock).

The genetic risks associated with Marblemount Hatchery summer-run and fall-run Chinook salmon programs are low under Alternative 1 and Alternative 2 because both programs would incorporate a high proportion of natural-origin recruits as broodstock, and because the small number of fish released would result in a return of a low proportion of hatchery-origin fish of the total return on the spawning grounds. AHA Model estimates a PNI of 0.93 for the Marblemount Hatchery summer-run program and 0.84 for the fall-run program (Table C-30) (Appendix E, Overview of the All H Analyzer).

The Marblemount Hatchery spring-run Chinook salmon programs would be operated as isolated programs. Available data indicates that the contribution of stray hatchery-origin adult fish from the programs to natural spawning areas would not be substantial. The estimate of pHOS is 2 percent for the Marblemount Hatchery isolated spring-run program (Table C-30) (Appendix E, Overview of the All-H Analyzer). Thus, the genetic risk to natural-origin Chinook salmon populations in the Skagit River associated with the Marblemount Hatchery spring-run Chinook salmon program is low. Broodstock collection methods and release levels would be the same for all alternatives. Thus, the overall genetic risk to all Chinook salmon populations in the Skagit River watershed is low under all alternatives (Table C-30).

4.3.3.1.4 Hatchery Facilities and Operation

There are four hatchery programs in the Skagit River watershed that are evaluated for their adherence to hatchery facilities and operation BMPs. All four programs are based at the Marblemount Hatchery (subyearling and yearling spring-run Chinook salmon, subyearling summer-run Chinook salmon, and fall-run Chinook salmon), but only two of the programs would release fish at that location. Hatchery facilities and operation for the programs would not affect the Lower Sauk and Upper Sauk Chinook salmon populations because hatchery programs are not proposed for those populations, and the hatchery programs would be separated by distance from the natural-origin populations.

Lower Skagit Chinook Salmon Population. The Marblemount Hatchery fall-run Chinook salmon program would rear and release hatchery-origin subyearling fish originating from the Lower Skagit Chinook salmon population. Adults used as broodstock would be collected using gill nets from the mainstem river. Spawning and incubation would occur at Marblemount Hatchery. After transfer, hatchery-origin fish would be reared to subyearling size at a pond in the lower Baker River, near the location where the broodstock were collected. Hatchery facility conditions and operational practices for the program would remain the same across all alternatives. Evaluation results for the program using the HPV Tool are shown in Table C-31.

Because most operational phases are within compliance, the overall risk of hatchery facilities and operation impacts to the listed Lower Skagit Chinook salmon population is moderate (Table C-31). However, Marblemount Hatchery is in high compliance with nearly all operational phases.

The HPV Tool identified a low compliance score in the adult holding operational phase for the subyearling release program. This low compliance score in the adult holding phase is primarily because of a different water temperature profile in the hatchery than found under natural conditions. This may cause differential selection pressures for traits of adult maturation and gamete development.

Table C-31. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Lower Skagit Chinook salmon.

Hatchery - Marblemount Hatchery integrated fall-run Chinook salmon subyearlings (facility and release locations: Clarks Creek, tributary to the Cascade River [RM 78]; Baker River [RM 1] trap/pond, tributary to on the lower Skagit River [RM 56.5]).			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Brood Stock Choice	High	High	
Brood Stock Collection	High	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Upper Skagit Chinook Salmon Population. The Marblemount Hatchery program would rear and release subyearling fish originating from natural-origin Upper Skagit summer-run Chinook salmon adults collected from the Skagit River. Hatchery fish would be reared and released from a pond located in the upper Skagit River watershed. Hatchery facility conditions and operational practices for the program would remain the same across all alternatives. Evaluation results for the program using the HPV Tool are shown in Table C-27.

Because most operational phases are within compliance, the overall risk of hatchery facilities and operation impacts to the listed Upper Skagit Chinook salmon population is moderate (Table C-32). However, Marblemount Hatchery is in high compliance with nearly all operational phases. The HPV Tool identified a low compliance score in the adult holding operational phase for the subyearling Chinook salmon release program because the hatchery temperature profile during adult holding differs significantly from the natural profile. This may cause differential selection pressures for traits of adult maturation and gamete development.

Table C-32. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Upper Skagit Chinook salmon.

Hatchery - Marblemount Hatchery integrated summer-run Chinook salmon subyearling (facility and release location: Clarks Creek->Cascade River; upper Skagit River).			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Brood Stock Choice	High	High	
Brood Stock Collection	Moderate	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Cascade and Suiattle Chinook Salmon Populations. Two isolated hatchery programs at Marblemount Hatchery would rear and release fish that are part of the Cascade spring-run Chinook salmon population (a subyearling release program and a yearling release program). Both programs would rely on collection of adult returns to the hatchery for broodstock. Each program is evaluated independently using the HPV Tool (Table C-33 and Table C-34). These programs would affect both the Cascade and Suiattle Chinook salmon populations.

The overall risk of hatchery facilities and operation impacts to the listed Cascade and Suiattle Chinook salmon populations is moderate for the subyearling program. The HPV Tool found this program would be in moderate or high compliance for five of the seven operational phases evaluated. It would be in low compliance for the adult holding and incubation operational phases for the subyearling program.

Table C-33. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Cascade and Suiattle Chinook salmon subyearlings.

Hatchery - Marblemount Hatchery isolated spring-run Chinook salmon subyearling program (facility and release location: Clarks Creek->Cascade River ->Skagit River).			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Brood Stock Choice	High	High	
Brood Stock Collection	Medium	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	Low	High	
Rearing	High	High	
Release	Medium	Medium	
Facilities	NA	High	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Table C-34. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Cascade and Suiattle Chinook salmon yearlings.

Hatchery - Marblemount Hatchery isolated spring-run Chinook salmon yearling program (facility and release location: Clarks Creek->Cascade River ->Skagit River)			
	Compliance Results		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Brood Stock Choice	High	High	
Brood Stock Collection	High	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	Low	High	
Rearing	High	High	
Release	Low	Low	
Facilities	NA	High	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

For the adult holding phase, low compliance was because of the temperature profile during adult holding differing substantially from the natural profile. For the incubation phase, low compliance was due to the temperature profiles not being similar (spring-run/well water) to the natural environment during incubation contributing to differences in emergence timing. Because of the potential for Bacterial Kidney Disease (BKD), eggs would be kept separate until the level of BKD was determined. Individual egg lots may be destroyed if high levels of BKD were found. This non-random culling may result in a loss of genetic diversity, as those traits present in the culled progeny would no longer be represented.

Holding adult fish in warmer spring water may accelerate adult maturation and gamete development relative to what would occur in the natural environment, thus potentially leading to hatchery-induced selection for traits in the hatchery. However, this possibility is balanced to some extent with the decreased likelihood that fish disease pathogens would be transmitted during adult holding when well water is used. Avoiding non-random culling of eggs would require decreasing the level of BKD at the facility. To avoid major BKD outbreaks each egg lot would be separated to control pathogen amplification in the hatchery environment.

For the yearling program (Table C-34), the overall risk of hatchery facilities and operation impacts to the listed Cascade and Suiattle Chinook salmon populations is moderate based on a range of low to high compliance results. Although the yearling program at Marblemount Hatchery is in moderate or high compliance for most operational phases evaluated, three low compliance ratings were assigned. The HPV Tool identified low compliance ratings in the adult holding, incubation, and release operational phases for the yearling release program. Reasons for the low ratings for yearlings are as described above for the Marblemount Hatchery subyearling program, which for yearlings would also employ low compliance operational practices to avoid the spread of BKD. The release operational phase for the yearling program also had a low compliance rating. Releasing fish dissimilar to natural-origin fish in size, behavior, growth rate, and physiological status may affect performance and increase competition and predation impacts.

The previous findings regarding holding adult fish and incubating eggs in spring-run water applies for this population. Avoiding non-random culling of eggs would require decreasing the level of BKD at the facility. To avoid major BKD outbreaks, separating each egg would minimize or prevent the occurrence of BKD.

Yearling Chinook salmon releases, because of their larger size (average length of 6.1 inches fork length) (Table 3.2-4) when compared with natural-origin con-specifics (average length of 1.6 to 4.7 inches fork length, dependent on life stage) (Table 32.4) that may be encountered during out-migration, pose elevated predation risks. Releasing yearling fish from the Marblemount Hatchery may alter program performance (by increasing hatchery-origin fish survival), but may increase the risk of competition and predation impacts. This program would release actively migrating smolts that would be expected to move rapidly out of fresh water where predation risks may be greatest (generally within 1 to 2 weeks post-release). By emigrating rapidly, the risk of deleterious competition and predation interactions with other salmon and steelhead in the freshwater migration corridor would be substantially reduced. Yearlings survive to return as adults at higher rates compared to subyearlings. Thus, fewer fish would be released to meet adult production objectives compared to subyearling releases.

4.3.3.2 Benefits

4.3.3.2.1 Total Return

Lower Skagit Chinook Salmon. Table C-35 compares effects of the alternatives on the total return of adult hatchery-origin fall-run Chinook salmon produced by the Marblemount Hatchery integrated fall-run Chinook salmon subyearling program. The estimated total contribution of fish to fisheries and escapement under each alternative is compared with the recent year average Lower Skagit Chinook salmon natural run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin return is contrasted with the restoration spawner abundance estimate for the population.

Table C-35. Estimated total return contributions for Lower Skagit Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	289	289	289
Average natural-origin return	6,319	6,319	6,319
Projected average total return	6,608	6,608	6,608
Restoration spawner abundance[1]	15,800	15,800	15,800
Projected average total return as a percent of restoration spawner abundance	42	42	42

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement are moderate for all alternatives, because the combined total run size is between 20 and 50 percent (42 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-35). Subyearling release levels (Table C-21) and adult total return benefits to fisheries and escapement would remain the same under all alternatives (Table C-35). Adult fish produced through the program would continue to be harvested with natural-origin Lower Skagit Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canadian Georgia Strait sport and troll fisheries, West Coast Vancouver Island troll fisheries, and other Canadian sport fisheries (assuming Skagit summer-run Chinook salmon catch distributions [CTC 2012]). The hatchery program would be expected to remain an indicator stock program, with relatively small annual hatchery production levels.

Upper Skagit Chinook Salmon. Table C-36 compares effects of the alternatives on the total return of adult hatchery-origin summer-run Chinook salmon produced by the Marblemount Hatchery integrated summer-run Chinook salmon subyearling program. The estimated total contribution of fish to fisheries and escapement under each alternative is compared with the recent year average Upper Skagit summer-run Chinook salmon natural run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-36. Estimated total return contributions for Upper Skagit Chinook salmon.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Average hatchery-origin return	940	940	940
Average natural-origin return	29,286	29,286	29,286
Projected average total return	30,226	30,226	30,226
Restoration spawner abundance[1]	26,000	26,000	26,000
Projected average total return as a percent of restoration spawner abundance	116	116	116

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total returnbenefits to fisheries and escapement are high for all alternatives, because the combined total run size is greater than 50 percent (116 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-36). Annual hatchery production levels are the same for all alternatives (Table C-21), and total return benefits to fisheries and escapement remain the same under all alternatives (Table C-36). Adult fish produced through the hatchery program would continue to be harvested with natural-origin Upper Skagit Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canadian Georgia Strait sport and troll fisheries, West Coast Vancouver Island troll fisheries, and other Canadian sport fisheries (CTC 2012). Most hatchery-origin Upper Skagit Chinook salmon produced each year would continue to escape harvest and spawn naturally in the Skagit

River. The hatchery program would be expected to remain an indicator stock program, with relatively small annual release levels, fishery contributions, and escapement under all alternatives.

Cascade Chinook Salmon. Table C-37 compares effects of the alternatives on the total return of adult hatchery-origin Chinook salmon produced by the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs. The estimated total contribution of fish to fisheries and escapement under each alternative is compared with the recent year average Cascade spring-run Chinook salmon natural run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-37. Estimated total return contributions for Cascade Chinook salmon.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Average hatchery-origin return	2,630	2,630	2,630
Average natural-origin return	522	522	522
Projected average total return	3,152	3,152	3,152
Restoration spawner abundance[1]	1,200	1,200	1,200
Projected average total return as a percent of restoration spawner abundance	263	263	263

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement are high for all alternatives, because the combined total run size is greater than 50 percent (263 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-37). Annual hatchery production levels are the same for all alternatives (Table C-21), and total return benefits to fisheries and escapement also remain the same under all alternatives (Table C-37). Adult fish produced through the hatchery program would continue to be harvested with natural-origin Cascade Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canadian Georgia Strait sport and troll fisheries, West Coast Vancouver Island troll fisheries, and other Canadian sport fisheries (CTC 2012). Over 50 percent of the total number (hatchery-origin plus natural-origin) of Cascade Chinook salmon produced each year would be expected to escape harvest and spawn naturally. Hatchery-origin Chinook salmon contributions to these fisheries would continue to be substantial relative to natural contribution levels under all alternatives. Few of the hatchery-origin spring-run Chinook salmon escape to spawn naturally. Under all alternatives, the total return (composed of mainly hatchery-origin fish) would greatly exceed the estimated equilibrium spawner abundance level (Table C-37).

4.3.3.2.2 Viability

Lower Skagit Chinook Salmon. Viability benefits to the Lower Skagit Chinook salmon population from the Marblemount Hatchery integrated fall-run Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Marblemount Hatchery integrated fall-run Chinook salmon program would provide negligible benefits to the viability of the Lower Skagit Chinook salmon population for the reasons described below.

Abundance – The hatchery program would have a negligible benefit to the abundance of Lower Skagit Chinook salmon. The program is modest in size. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Lower Skagit population of 2,163 fish. The estimated mean number of natural-origin spawners for this period is 2,067 fish. The remainder of the fish spawning naturally (96 fish, or only 4 percent of the mean spawning escapement) were of hatchery origin.

Diversity – The hatchery program would have a negligible benefit to diversity. BMPs would continue to be used to maintain the diversity of the hatchery population. Broodstock (up to 160 adults each year) would be collected from the run at large in the lower Skagit River.

Spatial Structure – The hatchery program would have a negligible benefit on spatial structure. Hatchery-origin fish would be released from an acclimation pond at RM 1.0 on the Baker River, adjacent to the major spawning area for the donor fall-run Chinook salmon population. Adult fish produced through the program would return to natal natural spawning areas for the population and not to novel habitat near the Marblemount Hatchery.

Productivity – The hatchery program would be expected to have a negligible effect on productivitybecause of the small size of the program, the subyearling life history release strategy, and use of only natural-origin fish as broodstock. Ford (2011) reported a short-term (1995 to 2009) median growth rate (lambda) for the composite (hatchery-origin and mainly natural-origin Chinook salmon) naturally spawning Lower Skagit population of 1.04. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population whose size is increasing. In this case, lambda indicates the population in the short term is at least replacing itself, and increasing modestly. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be negligible.

Upper Skagit Chinook Salmon. Viability benefits to the Upper Skagit Chinook salmon population from the Marblemount Hatchery integrated summer-run Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook population.

Under Alternative 1 and Alternative 2, the Marblemount Hatchery integrated summer-run Chinook salmon program would provide negligible benefits to the viability of the Upper Skagit Chinook salmon population for the reasons described below.

Abundance – The hatchery program would have a negligible benefit to the abundance of Upper Skagit Chinook salmon. The hatchery program is modest in size, but the natural-origin population is large. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Upper Skagit Chinook salmon population of 10,345 fish. The estimated mean number of natural-origin spawners for this period is 9,724 fish. The remainder of the fish spawning naturally (621 fish, or 6 percent of the mean spawning escapement) were of hatchery origin.

Diversity – The hatchery program would have a negligible benefit to diversity for the same reasons described above for abundance. BMPs would be applied to maintain the diversity of the donor population during operation of the hatchery program (WDFW 2005b). Broodstock (up to 150 adults each year) would be collected from the natural-origin population in the upper Skagit River.

Spatial Structure – The hatchery program would have a negligible benefit on spatial structure. Hatchery-origin fish would be released from an acclimation pond near Newhalem, adjacent to the major spawning area for the natural-origin summer-run Chinook salmon population. Adult fish produced through the program would return to natal natural spawning areas for the population and not to novel habitat proximate to Marblemount Hatchery.

Productivity – The hatchery program would be expected to have a negligible benefit on productivity because of the large size of the natural-origin population in contrast to the small size of the hatchery program, and the subyearling life history release strategy. Ford (2011) reported a short-term (1995 to 2009) median growth rate (lambda) for the composite (hatchery-origin and mainly natural-origin Chinook salmon) naturally spawning Upper Skagit Chinook salmon population of 1.01. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population whose size is increasing. In this case, lambda indicates the population in the short term is at least replacing itself. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be negligible.

Cascade Chinook Salmon. Viability benefits to the Cascade Chinook salmon population from the two Marblemount Hatchery isolated spring-run Chinook salmon programs are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery programs are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook population.

Under Alternative 1 and Alternative 2, the Marblemount Hatchery isolated spring-run Chinook salmon subyearling and yearling programs would provide negligible benefits to the viability of the Cascade Chinook salmon population for the reasons described below.

Abundance – The hatchery programs would have a negligible benefit to the abundance of Cascade Chinook salmon because most adult fish would return to the hatchery rather than contribute to, and benefit, natural spawning. The programs may help preserve the abundance of a mixed-lineage spring-run Chinook salmon population that is similar to fish in the Suiattle River watershed (Buck Creek) from which the Cascade hatchery population was derived. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Cascade population of 336 fish. The estimated mean number of natural-origin spawners for this period is 329 fish. The remainder of the fish spawning naturally (7 fish, or only 2 percent of the mean spawning escapement) were of hatchery origin. The rates at which fish from the Marblemount Hatchery survive to the adult stage are slightly below (for subyearling releases) or well below (for yearling releases) rates for other Puget Sound hatcheries that release Chinook salmon at the same life stages.

Diversity – The hatchery program would have a negligible benefit to diversity. The program would use only hatchery-origin fish as broodstock, and those would originally be of Suiattle River origin. The hatchery population is genetically different from the reference Cascade Chinook salmon population that is of natural origin to the watershed where the hatchery is located. BMPs would be applied at the hatchery to maintain the diversity of the broodstock source (WDFW 2005c; 2005d).

Spatial Structure – The hatchery program would not benefit spatial structure because hatchery-origin adults return to the release site at the hatchery and would be removed. Hatchery-origin fish would be released from an acclimation pond near Newhalem, adjacent to the natal major spawning area for the natural-origin summer-run Chinook salmon population.

Productivity – The hatchery program would not be expected to benefit productivity because of the small number of hatchery-origin fish that would contribute to natural spawning. Ford (2011) reported a short-term (1995 to 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) naturally spawning Cascade population of 1.02. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population whose size is increasing. In this case, lambda indicates the population in the short term is at least replacing itself. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be negligible.

4.3.3.3 Summary – Skagit River Watershed

4.3.3.3.1 Lower Skagit Chinook Salmon

Table C-22 summarizes the risks and benefits for all alternatives pertinent to the Lower Skagit River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, hatchery facilities and operation risks being moderate, and competition and genetic risks being low. Risks are unchanged under Alternative 3 and Alternative 4. Benefits are moderate for total return and negligible for viability, and are unchanged under Alternative 3 and Alternative 4.

4.3.3.3.2 Upper Skagit Chinook Salmon

Table C-23 summarizes the risks and benefits for all alternatives pertinent to the Upper Skagit River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, hatchery facilities and operation risks being moderate, and competition and genetic risks being low. Risks are unchanged under Alternative 3 and Alternative 4. Benefits are high for total return and negligible for viability, and are unchanged under Alternative 3 and Alternative 4.

4.3.3.3.3 Cascade Chinook Salmon

Table C-24 summarizes the risks and benefits for all alternatives pertinent to the Cascade River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, hatchery facilities and operation risks being moderate, and competition and genetic risks being low. Risks are unchanged under Alternative 3 and Alternative 4. Benefits are high for total return and negligible for viability, and are unchanged under Alternative 3 and Alternative 4.

4.3.3.3.4 Lower Sauk Chinook Salmon

Table C-25 summarizes the risks and benefits for all alternatives pertinent to the Lower Sauk River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, competition and genetic risks being low. Hatchery facilities and operation risk and total return and viability benefits are not evaluated because no hatcheries are present in the Sauk River. Risks are unchanged under Alternative 3 and Alternative 4.

4.3.3.3.5 Upper Sauk Chinook Salmon

Table C-26 summarizes the risks and benefits for all alternatives pertinent to the Upper Sauk River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, competition and genetic risks being low. Hatchery facilities and operation risk and total return and viability benefits are not evaluated because no hatcheries are present in the Sauk River. Risks are unchanged under Alternative 3 and Alternative 4.

4.3.3.3.6 Suiattle Chinook Salmon

Table C-27 summarizes the risks and benefits for all alternatives pertinent to the Suiattle River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the 11 salmon and steelhead hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high with predation risks being high, hatchery facility and operation risk being moderate, and competition and genetic risks being low. Total return and viability benefits are not evaluated because no hatchery stocks are of Suiattle Chinook salmon genetic origin. Risks are unchanged under Alternative 3 and Alternative 4.

4.3.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

Provided in Table C-38 is a summary of potential mitigation measures for the Skagit River Chinook salmon population action alternatives. These mitigation measures would help reduce predation and hatchery facilities and operation risks, which are rated as high (predation) and moderate (hatchery facilities and operation for four populations) risks under Alternative 2, Alternative 3, and Alternative 4 (Tables C-21 to Table C-27).

Table C-38. Potential mitigation measures for the Skagit River Chinook salmon populations.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measures P1 and P2.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, and H3.

[1] Refer to Table C-2 for a description of each mitigation measure.

Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the six Skagit River Chinook salmon populations for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and their standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). All Chinook salmon produced through the four Marblemount Hatchery programs are listed and protected under the ESA because the natural-origin Skagit River watershed Chinook salmon populations are used as source broodstock.

4.4 North Fork Stillaguamish Chinook Salmon

4.4.1 Introduction

As shown in Table C-1, the Stillaguamish River watershed includes two natural-origin Chinook salmon populations: North Fork Stillaguamish summer-run and South Fork and mainstem Stillaguamish fall-run. The populations are federally listed as threatened under the ESA. These two populations are evaluated separately in the subsections below; however, several of the hatcheries within the Stillaguamish River watershed can affect both natural-origin populations as explained within the two subsections. This subsection discusses the North Fork Stillaguamish summer-run Chinook salmon population, whereas Subsection 4.5, South Fork and Mainstem Stillaguamish Chinook Salmon, discusses the latter population.

As described in Subsection 2.3, Stillaguamish Chinook Salmon Populations, habitat conditions have severely reduced the productivity of the North Fork Stillaguamish Chinook salmon population. The Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling programs supplement natural-origin escapement to the North Fork Stillaguamish River, resulting in hatchery-origin escapements consistently exceeding the viable threshold level over the last 10 years. Because the two integrated summer-run Chinook hatchery programs operate as a joint program, they are combined in the EIS for the purposes of analysis.

Hatcheries and associated programs that affect the North Fork Stillaguamish population are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon, and include the following areas:

- North Fork and mainstem Stillaguamish River
- Harvey/Armstrong Creek, tributary to the Stillaguamish River at RM 15.3
- Whitehorse Spring Creek (RM 1.5), tributary to North Fork Stillaguamish River at RM 28
- Pilchuck Creek, tributary to North Fork Stillaguamish River at RM 9.4
- Canyon Creek, tributary to the South Fork Stillaguamish River 16 RM above the confluence of the South Fork with the North Fork Stillaguamish River at RM 18

One Chinook salmon hatchery program, one coho salmon hatchery program, and two steelhead hatchery programs from three hatcheries have the potential to impact the North Fork and mainstem Stillaguamish Chinook salmon population (Table C-39 and Table C-40), and are reviewed in this subsection.

Table C-39. Hatchery programs and categories of effects evaluated for North Fork Stillaguamish Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	√	√	√	√	√	√
Coho salmon	Stillaguamish coho salmon integrated yearling	√	√				
Steelhead	Whitehorse Pond isolated summer-run steelhead yearling	√	√				
	Whitehorse Pond isolated winter-run steelhead yearling	√	√				

Table C-40. Hatchery salmon and steelhead production evaluated for North Fork Stillaguamish Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Whitehorse Pond and Harvey Creek Hatchery North Fork Stillaguamish integrated summer-run Chinook salmon subyearling	245,000	245,000	0	465,000	90
Coho salmon	Stillaguamish coho salmon integrated yearling	54,000	27,000	50	54,000	0
Steelhead	Whitehorse Pond isolated summer-run steelhead yearling	70,000	35,000	50	70,000	0
	Whitehorse Pond isolated winter-run steelhead yearling	150,000	75,000	50	150,000	0
	TOTAL	220,000	110,000	50	220,000	0
All	TOTAL	519,000	382,000	26	739,000	42

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.4.2 Methods

In conducting the analysis for the North Fork Stillaguamish Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** The North Fork Stillaguamish Harvey Creek Hatchery program and the Whitehorse Pond program are interdependent and are evaluated for the purposes of this analysis as one hatchery program. Thus, the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling programs are evaluated as a single hatchery for all risks and benefits. The South Fork Stillaguamish Chinook Natural Stock Restoration integrated fall-run Chinook salmon subyearling program is a recent program that did not have fish releases at the time of the EIS fish model runs and subsequent analyses. However, the co-managers requested that this program be included in the EIS, given that three brood years of fish have been obtained from the river to initiate a captive brood that would produce juvenile fish for release beginning in 2013. This hatchery program will also be analyzed for the final EIS.
- **Coho Salmon:** The Stillaguamish coho salmon integrated yearling program is evaluated for competition and predation effects.

- **Steelhead:** The Whitehorse Pond isolated summer-run steelhead yearling and Whitehorse Pond isolated winter-run steelhead yearling programs are evaluated for competition and predation effects.

4.4.3 Results

Results for the North Fork Stillaguamish Chinook salmon population are summarized in Table C-41. The action alternatives would include the use of an adaptive management approach, but the results in Table C-41 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks identified in Table C-41 is explained in the subsequent subsections for this population.

Table C-41. Summary of hatchery-related risks and benefits for the North Fork Stillaguamish Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Moderate	Same as Alternative 1	High
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.4.3.1 Risks

4.4.3.1.1 Competition

Competition risks to the North Fork Stillaguamish Chinook salmon population affected by Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-42. A moderate risk for competition impacts to the natural-origin Chinook salmon population would occur under Alternative 1, Alternative 2, and Alternative 3 for Chinook salmon subyearling releases from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program (Table C-42). The hatchery-origin Chinook salmon would be released in large numbers (245,000 fish) (Table C-40) relative to the size of the natural-origin population high in the watershed and during the time when natural-origin Chinook salmon juveniles are emigrating seaward.

The potentially long duration of interaction with conspecific natural-origin Chinook salmon could lead to negative food resource competition effects in freshwater and nearshore out-migration and rearing areas where both hatchery-origin and natural-origin Chinook salmon reside. Increases in the number of hatchery-origin Chinook salmon that would be released through the program under Alternative 4 (increase of 265,000 fish) (Table C-40) result in a high competition risk (Table C-42).

For the Whitehorse Pond Hatchery isolated summer-run steelhead yearling and Whitehorse Pond isolated winter-run steelhead yearling programs, hatchery fish would be released after May 1, and after the majority of natural-origin Chinook salmon had out-migrated seaward, resulting in a low competition risk.

The overall risk of competition to North Fork Stillaguamish Chinook salmon associated with all hatchery programs is moderate under Alternative 1, Alternative 2, and Alternative 3, and high under Alternative 4 (Table C-42).

Table C-42. North Fork Stillaguamish Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	8.6 (11.1 under Alternative 4)	Moderate	Same as Alternative 1	High
Stillaguamish coho salmon integrated yearling	0.3 (0.1 under Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated summer-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	High

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.4.3.1.2 Predation

Predation risks to the North Fork Stillaguamish Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs are summarized in Table C-43. There is a low risk of predation from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program under Alternative 1, Alternative 2, and Alternative 3. However, hatchery fish production levels from the Stillaguamish hatchery program would be increased under Alternative 4, and predation risk increases to moderate because the number of hatchery-origin Chinook salmon relative to natural-origin Chinook salmon would be much higher. The two steelhead hatchery programs would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead releases would occur in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). For the Whitehorse Pond isolated summer-run steelhead yearling and Whitehorse Pond isolated winter-run steelhead yearling programs, some of the hatchery fish releases from both programs would be expected to occur as far up in the North Fork Stillaguamish River watershed as RM 28, resulting in a high predation risk. The overall risk of predation to North Fork Stillaguamish Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-43).

Table C-43. North Fork Stillaguamish Chinook salmon predation risks by alternative.

Hatchery Program Risk	**Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]**	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	3.2 (5.6 under Alternative 4)	Low	Same as Alternative 1	Moderate
Stillaguamish coho salmon integrated yearling	3.1 (1.6 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated summer-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.4.3.1.3 Genetics

Assessments of genetic risks to the North Fork Stillaguamish Chinook salmon population are primarily based on PNI estimates from the AHA Model derived for each alternative (Table C-44). Risk levels are assigned using the qualitative criteria applied to PNI estimates as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-44. North Fork Stillaguamish Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	0.91 (0.79 for Alternative 4)	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1] From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

The genetic risk associated with the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program is low under all alternatives because the PNI estimate is greater than 0.67 for all alternatives (Table C-44) (Appendix E, Overview of the All-H Analyzer). All alternatives would continue to have high compliance with BMPs for broodstock collection and mating. Subyearling release levels would be the same (245,000) for Alterative 1, Alternative 2, and Alternative 3, but would increase to 465,000 under Alternative 4 (Table C-40). The increased production results in a lower PNI value (0.79), but the decrease in PNI is insufficient to increase the risk level to moderate. The low risk level is consistent with the findings of Eldridge and Killebrew (2008) who analyzed North Fork Stillaguamish Chinook salmon population genetic and demographic data. These authors concluded that genetic diversity of the population has been maintained over multiple generations of supplementation and that the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program has not contributed to a loss in genetic diversity of the population.

4.4.3.1.4 Hatchery Facilities and Operation

The Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program would continue to rear and release fish that are part of the North Fork Stillaguamish Chinook salmon population. Broodstock would be collected from natural-origin and hatchery-origin adult returns to the North Fork Stillaguamish River. Hatchery fish would be incubated and reared at Harvey Creek Hatchery and transferred to Whitehorse Pond for final rearing and release into the river. Hatchery facility conditions and operational practices would be the same under all alternatives. Results for the combined hatchery program using the HPV Tool are provided in Table C-45.

Table C-45. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for North Fork Stillaguamish Chinook salmon.

Hatchery - Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling (facility and release locations: North Fork Stillaguamish River)			
	Facility Compliance		**Overall Facility Risk[1]**
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	Moderate	
Incubation	Moderate	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Negligible

[1] Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

No operational phases received a low compliance score for the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program (Table C-45). The hatchery program would pose a negligible risk of facility and operation effects on the North Fork Stillaguamish Chinook salmon population under all alternatives.

4.4.3.2 Benefits

4.4.3.2.1 Total Return

Table C-46 compares effects of the alternatives on the total return of adult hatchery-origin summer-run Chinook salmon produced by the combined Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin North Fork Stillaguamish Chinook salmon run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-46. Estimated total return contributions for North Fork Stillaguamish Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	1,386	1,386	2,646
Average natural-origin return	716	716	716
Projected average total return	2,102	2,102	3,362
Restoration spawner abundance[1]	18,000	18,000	18,000
Projected average total return as a percent of restoration spawner abundance	12	12	19

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement are low for all alternatives, because the combined total run size is less than 20 percent (from 12 to 19 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-46). Adult fish produced through the hatchery program would continue to be incidentally harvested with natural-origin North Fork Stillaguamish Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canadian Georgia Strait sport and troll fisheries, U.S. sport fisheries, West Coast Vancouver Island troll fisheries, and other Canadian sport fisheries (CTC 2012).

Contributions of hatchery-origin fish to U.S. fisheries would be low because Washington fisheries are managed to reduce incidental harvests of the propagated stock (through time and area closures, and selective fishing practices), consistent with the stock preservation and recovery intent of the program producing the fish. Adult Chinook salmon returns to the North Fork Stillaguamish River resulting from hatchery production under all alternatives would substantially improve returns above the current critically depressed numbers of North Fork Stillaguamish adults escaping to natural areas to spawn. About two thirds of the total number of hatchery-origin North Fork Stillaguamish Chinook salmon produced each brood year would be expected to return to the North Fork Stillaguamish River to spawn naturally (CTC 2012). Adult Chinook salmon contributions to the above fisheries and to natural escapement would be substantial relative to natural-origin Chinook salmon contribution levels under all alternatives.

4.4.3.2.2 Viability

Viability benefits to the North Fork Stillaguamish Chinook salmon population from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon program would benefit the abundance, diversity, and spatial structure of the North Fork Stillaguamish Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of North Fork Stillaguamish Chinook salmon. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the North Fork Stillaguamish population of 943 fish. This average included surplus hatchery-origin adults planted back into the natural environment from Whitehorse Pond and Harvey Creek Hatchery. The estimated mean number of natural-origin spawners for this period is 478 fish. The remainder of the fish spawning naturally (465 fish or 49 percent of the mean spawning escapement) are hatchery-origin summer-run Chinook salmon produced by the program.

Diversity – The hatchery program would benefit diversity. Broodstock (up to 150 adults each year) would be collected from the run at large in the North Fork Stillaguamish River. BMPs s would be applied to maintain the diversity of the propagated population. Broodstock would be collected randomly over the breadth of the return, a large effective breeding population size would be been maintained (e.g., 666 fish from 1997 to 2001), and a factorial mating scheme would be used during spawning. These measures would continue to maintain the genetic diversity of the propagated population, thus increasing the likelihood that within-population genetic diversity of the natural-origin population would be conserved over time.

Spatial Structure – The hatchery program would benefit spatial structure. Hatchery-origin fish progeny would be released as subyearlings from Whitehorse Pond at RM 27.8 on the North Fork Stillaguamish River. The release site is adjacent to the upper reaches of the natural spawning area for the natural-origin summer-run Chinook salmon population (WDFW 2005e). Spawners would be distributed into areas where natural-origin fish were historically present, thus benefiting spatial structure of the population.

Productivity – The benefit of the hatchery program to productivity is unknown. The continuing low numbers of natural-origin spawners suggests that productivity in natural habitat remains poor, and that the contributions of naturally spawning hatchery-origin fish are not leading to improved productivity. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) North Fork Stillaguamish population of 0.89. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite North Fork Stillaguamish naturally spawning population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 would also be moderate.

Under Alternative 4, annual fish release levels would be increased by 200,000 subyearlings when compared to Alternative 1 and Alternative 2 (Table C-40). Benefits to the abundance of the naturally spawning North Fork Stillaguamish Chinook salmon population would increase relative to Alternative 1, Alternative 2, and Alternative 3, as more adult fish would be produced through the program (an estimated 2,646 fish, compared with 1,386 fish under Alternative 1 and Alternative 2 [Table C-46]). Program benefits to the diversity and spatial structure of the reference population may also increase from those conferred under Alternative 1, Alternative 2, and Alternative 3 as increased numbers of returning adults would help ensure preservation of the gene pool and expand spawner use within available habitat. However, assuming productivity conditions in existing natural habitat would continue to be poor, the increased contribution of naturally spawning hatchery-origin fish under this alternative would not likely lead to improved natural population productivity. Therefore, although benefits from Alternative 4 would be greater than Alternative 1, Alternative 2, and Alternative 3 for abundance, diversity, and spatial structure parameters, productivity would not be benefited. Thus, the overall benefit to viability for Alternative 4 would be moderate.

4.4.3.3 Summary – North Fork Stillaguamish Chinook Salmon

Table C-41 summarizes the risks and benefits for all alternatives pertinent to the North Fork Stillaguamish Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the four hatchery programs evaluated for this population, overall risks to North Fork Stillaguamish Chinook salmon under Alternative 1 and Alternative 2 range from negligible to high with hatchery facilities and operation as a negligible risk, genetics a low risk, competition a moderate risk, and predation a high risk. Competition risk increases to high under Alternative 4 because of a doubling of the Chinook salmon release level. All other risks are the same across alternatives. Under all alternatives, benefits of hatchery programs to North Fork Stillaguamish Chinook salmon total returns would be low and benefits to viability would be moderate.

4.4.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

Provided in Table C-47 is a summary of potential mitigation measures for the North Fork Stillaguamish Chinook salmon population action alternatives. These mitigation measures would help reduce competition and predation risks, which are rated as high (predation) and moderate (competition) risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-41). The competition risk increases to high under Alternative 4.

Table C-47. Potential mitigation measures for the North Fork Stillaguamish Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, and C3.
Predation	Apply Mitigation Measure P1.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above hatchery steelhead program mitigation measures consistent with an adaptive management approach would likely help reduce the risks of competition and predation effects from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program and the Whitehorse Pond isolated summer-run and winter-run yearling programs as operated on the natural-origin and hatchery-origin North Fork Stillaguamish Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would also be based on the assigned value of the North Fork Stillaguamish Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.5 South Fork and Mainstem Stillaguamish Chinook Salmon

4.5.1 Introduction

As shown in Table C-1, the Stillaguamish River watershed supports the natural-origin South Fork and mainstem Stillaguamish fall-run Chinook salmon population. The population is federally listed as threatened under the ESA.

Hatcheries and associated programs that affect the South Fork and mainstem Stillaguamish River are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon, and include the following areas:

- North Fork, South Fork, and mainstem Stillaguamish River
- Harvey/Armstrong Creek, tributary to the mainstem Stillaguamish River at RM 15.3
- Whitehorse Spring Creek (RM 1.5), tributary to North Fork Stillaguamish River at RM 28
- Pilchuck Creek
- Canyon Creek

One Chinook salmon hatchery program, one coho salmon hatchery program, and two steelhead hatchery programs from three hatcheries have the potential to impact the South Fork and mainstem Stillaguamish Chinook salmon population (Table C-48 and Table C-49), and are reviewed in this subsection.

Table C-48. Hatchery programs and categories of effects evaluated for South Fork and mainstem Stillaguamish Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	√	√	√			
	South Fork Stillaguamish integrated fall-run Chinook salmon subyearling[1]						
Coho salmon	Stillaguamish coho salmon integrated yearling	√	√				

[1] This is a recent program. Analysis will be contained in the final EIS.

Table C-48.Hatchery programs and categories of effects evaluated for South Fork and mainstem Stillaguamish Chinook salmon, continued.

Species	Hatchery and Program	Risk				Benefit	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Steelhead	Whitehorse Pond isolated summer-run steelhead yearling	√	√				
	Whitehorse Pond isolated winter-run steelhead yearling	√	√				

Table C-49. Hatchery salmon and steelhead production evaluated for South Fork and mainstem Stillaguamish Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon	Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	245,000	245,000	0	465,000	90
	South Fork Stillaguamish integrated fall-run Chinook salmon subyearling [2]	45,000	45,000	0	45,000	0
	TOTAL	290,000	290,000	0	510,000	76
Coho salmon	Stillaguamish coho salmon integrated yearling	54,000	27,000	50	54,000	0
Steelhead	Whitehorse Pond isolated summer-run steelhead yearling	70,000	35,000	50	70,000	0
	Whitehorse Pond isolated winter-run steelhead yearling	150,000	75,000	50	150,000	0
	TOTAL	220,000	110,000	50	220,000	0
All	TOTAL	564,000	427,000	24	784,000	39

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

[2] This is a recent program. Analysis will be contained in the final EIS.

4.5.2 Methods

In conducting the analysis for the South Fork and mainstem Stillaguamish Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** The North Fork Stillaguamish Harvey Creek Hatchery program and the Whitehorse Pond program are interrelated and are evaluated in the EIS as one hatchery program. The Whitehorse Springs and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program is evaluated for competition, predation, and genetic risks. The hatchery program is not evaluated for hatchery facilities and operation risks, and total return and viability benefits because the hatchery is located in the North Fork Stillaguamish River. Thus, those risks and benefits are described in Subsection 4.4.3.1.4, Hatchery Facilities and Operation (North Fork Stillaguamish) and Subsection 4.4.3.2, Benefits (North Fork Stillaguamish). In addition, the South Fork Stillaguamish Chinook Natural Stock Restoration integrated fall-run Chinook salmon subyearling program is a recent program that had not released fish at the time of the draft EIS, nor had model runs and subsequent analyses been performed. However, the co-managers requested that this program be included in the draft EIS, given that three brood years of fish have been secured from the river to initiate a captive brood that would produce juvenile fish for release beginning in 2013. This hatchery program will be analyzed for the Final EIS.
- **Coho Salmon:** The Stillaguamish coho salmon integrated yearling program is evaluated for competition and predation effects.
- **Steelhead:** The Whitehorse Pond isolated summer-run steelhead yearling and Whitehorse Pond isolated winter-run steelhead yearling programs are evaluated for competition and predation effects.

4.5.3 Results

Results for the South Fork Stillaguamish Chinook salmon population, including the mainstem, are summarized in Table C-50. The action alternatives would include the use of an adaptive management approach, but the results in Table C-50 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks identified in Table C-50 is explained in the subsequent subsections for this population and mainstem area.

Table C-50. Summary of hatchery-related risks and benefits for the South Fork and mainstem Stillaguamish Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Moderate	Same as Alternative 1	High
Predation	Moderate	Same as Alternative 1	Same as Alternative 1
Genetics	Unknown	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	NA	Same as Alternative 1	Same as Alternative 1
Benefits		Same as Alternative 1	Same as Alternative 1
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

4.5.3.1 Risks

4.5.3.1.1 Competition

Competition risks to the South Fork and mainstem Stillaguamish Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-51. The Whitehorse Pond and Harvey Creek Hatchery North Fork Stillaguamish River integrated summer-run Chinook salmon subyearling program poses a moderate competition risk to natural-origin fall-run Chinook salmon under Alternative 1 because the hatchery-origin fish are released relatively high in the watershed and the number of fish released is large relative to the number of natural-origin fish rearing and out-migrating in the watershed. Increases in the number of hatchery-origin Chinook salmon released through the program under Alternative 4 (increase of 265,000 fish) (Table C-49) results in a high competition risk assignment (Table C-51). For the Whitehorse Pond Hatchery isolated summer-run steelhead yearling and Whitehorse Pond isolated winter-run steelhead yearling programs, hatchery fish are released after May 1 and after the majority of juvenile natural-origin Chinook salmon have out-migrated, resulting in a low competition risk.

The overall risk of competition to South Fork Stillaguamish Chinook salmon associated with all hatchery programs is moderate under Alternative 1, Alternative 2, and Alternative 3, and high under Alternative 4 (Table C-51).

Table C-51. South Fork and mainstem Stillaguamish Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	8.6 (11.1 under Alternative 4)	Moderate	Same as Alternative 1	High
Stillaguamish coho salmon integrated yearling	0.3 (0.1 under Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated summer-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	High

[1] From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.5.3.1.2 Predation

Predation risks to the South Fork and mainstem Stillaguamish Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-52. There is a low risk of predation from Whitehorse Pond and Harvey Creek Hatchery North Fork Stillaguamish River integrated summer-run Chinook salmon subyearlings under Alternative 1, Alternative 2, and Alternative 3. However, production levels in the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program are increased under Alternative 4 (increase of 265,000 fish) (Table C-49), and predation risk increases to moderate because of the increased potential for impacts on natural-origin Chinook salmon associated with increased release numbers.

The two steelhead hatchery programs would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead would be released in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). There is a high risk of predation from Whitehorse Pond isolated summer-run and winter-run steelhead yearling programs because of their large size (average size of 8.1 inches fork length)

(EIS Table 3.2-4) relative to juvenile natural-origin Chinook salmon encountered at the time the steelhead would be released (average size of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4), and because the steelhead would be released high in the watershed.

The overall risk of predation to South Fork Stillaguamish Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-52).

Table C-52. South Fork and mainstem Stillaguamish salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling	3.2 (5.6 under Alternative 4)	Low	Same as Alternative 1	Moderate
Stillaguamish coho salmon integrated yearling	3.1 (1.6 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated summer-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Whitehorse Pond isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.5.3.1.3 Genetics

Assessments of genetic risk to the South Fork Stillaguamish Chinook salmon population from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling program are based on PNI estimates from the AHA Model for each alternative (Table C-53). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-53. South Fork Stillaguamish Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from South Fork Stillaguamish integrated fall-run Chinook salmon subyearling	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Introgression risk from straying hatchery-origin summer-run and fall-run Chinook salmon (including loss of among population diversity)	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		Unknown	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

The relatively recent South Fork Stillaguamish Chinook Natural Stock Restoration integrated fall-run Chinook salmon subyearling program (Stillaguamish Tribe and WDFW 2007) had not yet released fish by the time of the draft EIS analysis. Broodstock for the program would be obtained from the river to initiate a captive broodstock that would produce juvenile fish for release beginning in 2013. Numbers of subyearlings released (45,000) would be the same under all alternatives. Risk analyses for this program will be completed before the Final EIS.

There may be some straying of hatchery-origin Chinook salmon into the South Fork and mainstem Stillaguamish River from adjacent hatchery programs (e.g., Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon subyearling and Bernie Kai-Kai Gobin Salmon Hatchery Tulalip isolated summer/fall-run Chinook salmon subyearling programs).

Because of the small number of subyearlings that would be released (45,000) into the South Fork of the Stillaguamish River, the total number of adult fish resulting from the program(s) would be relatively low (approximately 1,400 adults per year), and the number of returning hatchery-origin adults spawning naturally in the South Fork and mainstem of the Stillaguamish River would not likely lead to substantial genetic risks. In addition, there would likely be a short spawn timing overlap between any stray summer-run Chinook salmon produced by the programs in adjacent watersheds and the fall-timed natural-origin South Fork and mainstem Stillaguamish Chinook salmon population.

The overall genetic risk to South Fork and mainstem Stillaguamish Chinook salmon would be low, for the reasons described above.

4.5.3.1.4 Hatchery Facilities and Operation

No Chinook salmon hatchery programs would release fish into the South Fork and mainstem of the Stillaguamish River that impact the Chinook salmon population under any of the alternatives. Thus, there are no hatchery facilities and operation effects on the natural-origin South Fork and mainstem Stillaguamish Chinook salmon population. As described above, the South Fork Stillaguamish Chinook Natural Stock Restoration integrated fall-run Chinook salmon subyearling program will establish a rebuilding program for this critically depressed population. However, the program has yet to be fully initiated and thus was not evaluated in the draft EIS.

4.5.3.2 Benefits

As described in Subsection 4.5.3.1.4, Hatchery Facilities and Operation, there are currently no Chinook salmon hatchery programs located within the South Fork and mainstem Stillaguamish River watershed, nor are there any programs that might benefit the total return or viability of the natural-origin South Fork and mainstem Stillaguamish Chinook salmon population. Thus, there are no benefits to the population from hatchery programs.

4.5.3.3 Summary – South Fork Stillaguamish River Chinook Salmon

Table C-50 summarizes the risks and benefits for all alternatives pertinent to the South Fork Stillaguamish Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the four hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1, Alternative 2, and Alternative 3 are low for genetics and moderate for competition. Competition risk increases to high under Alternative 4 because of a doubling of the Chinook salmon release level in the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon program. Predation risk is high under all alternatives. Because no hatchery programs are evaluated that are in the South Fork Stillaguamish River watershed, there are no hatchery facilities and operation risks or total return and viability benefits for any alternative.

4.5.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

Provided in Table C-54 is a summary of potential mitigation measures for the South Fork and mainstem Stillaguamish Chinook salmon population action alternatives. These mitigation measures would help reduce competition and predation risks, which for competition are rated as moderate under Alternative 2 and Alternative 3, and high under Alternative 4 (Table C-4). Predation risks are rated high under all alternatives.

Table C-54. Potential mitigation measures for the South Fork and mainstem Stillaguamish Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1 and C5.
Predation	Apply Mitigation Measures P1, P2, P5, and P6.

[1]Refer to Table C-2 for a description of each mitigation measure.

Application of the above mitigation measures under an adaptive management approach would likely help reduce the risks of competition and predation impacts from the Whitehorse Pond and Harvey Creek Hatchery integrated summer-run Chinook salmon program, as well as the Whitehorse Pond steelhead yearling program, as operated on the natural-origin South Fork and mainstem Stillaguamish Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the South Fork and mainstem Stillaguamish River population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.6 Skykomish Chinook Salmon

4.6.1 Introduction

As shown in Table C-1 and described in Subsection 2.4, Snohomish Chinook Salmon Population, the Snohomish River watershed supports two natural-origin Chinook salmon populations: Skykomish summer/fall-run and Snoqualmie summer/fall-run. The populations are federally listed as threatened under the ESA. This subsection describes the risks and benefits to the Skykomish Chinook salmon population, whereas Subsection 4.7 Snoqualmie Chinook Salmon, describes the risks and benefits to the Snoqualmie Chinook salmon population.

Skykomish Chinook salmon spawn in the Snohomish River mainstem; the Skykomish, Wallace, Sultan, and Pilchuck Rivers; and Bridal Veil Creek. The hatchery-origin summer-run Chinook salmon produced at the Wallace River Hatchery and Bernie Kai-Kai Gobin Salmon Hatchery are derived from native Skykomish Chinook salmon broodstock. Hatchery-origin Green-origin fall-run Chinook salmon were previously produced by hatcheries in the system, so naturally spawning returns of this hatchery stock likely interbred with native stocks.

Hatcheries and associated programs and release sites relevant to the Skykomish Chinook salmon natural-origin population are evaluated according to their risks and benefits, including effects that occur within the following rivers and streams:

- North Fork and mainstem of the Skykomish River
- Wallace River, which is a tributary to the Skykomish River at RM 36
- Sultan River
- Howard Creek
- Barr Creek
- Tolt River
- Pilchuck River
- Raging River
- Tokul Creek, which is a tributary of the Snoqualmie River at RM 39
- Reiter Pond, which is located by the Skykomish River at RM 45

Three Chinook salmon hatchery programs, one coho salmon hatchery program, and four steelhead programs from four hatcheries have the potential to impact the Skykomish Chinook salmon population (Table C-55 and Table C-56), and are reviewed in this subsection.

Table C-55. Hatchery programs and categories of effects evaluated for Skykomish Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	Predation	Genetics	Facilities and Operation	Total Return	Viability
Chinook salmon	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	√	√	√		√[2]	√
	Wallace River Hatchery integrated summer-run Chinook salmon subyearling	√	√	√[1]	√	√[2]	√
	Wallace River Hatchery integrated summer-run Chinook salmon yearling	√	√	√[1]	√	√[2]	√
Coho salmon	Wallace River Hatchery integrated coho salmon yearling	√	√				
Steelhead	Reiter Pond isolated summer-run steelhead yearling	√	√				
	Reiter Pond isolated winter-run steelhead yearling	√	√				
	Tokul Creek isolated winter-run steelhead yearling	√	√				
	Wallace River Hatchery integrated summer-run steelhead salmon yearling	√	√				

[1] Hatchery programs are evaluated as a group for genetic risks.
[2] Hatchery programs are evaluated as a group for total return benefits.

Table C-56. Hatchery salmon and steelhead production evaluated for Skykomish Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	1,700,000	1,700,000	0	1,700,000	0
	Wallace River Hatchery integrated summer-run Chinook salmon subyearling	1,000,000	500,000	50	1,000,000	0
	Wallace River Hatchery integrated summer-run Chinook salmon yearling	250,000	125,000	50	500,000	100
	Total subyearlings	2,700,000	2,200,000	19	2,700,000	0
	Total yearlings	250,000	125,000	50	500,000	100
	TOTAL	2,950,000	2,325,000	21	3,200,000	8
Coho Salmon	Wallace River Hatchery integrated coho salmon yearling	150,000	75,000	50	300,000	100
Steelhead	Reiter Pond isolated summer-run steelhead yearling	250,000	125,000	50	250,000	0
	Reiter Pond isolated winter-run steelhead yearling	250,000	125,000	50	250,000	0
	Tokul Creek isolated winter-run steelhead yearling	185,000	92,500	50	185,000	0
	Wallace River Hatchery isolated winter-run steelhead yearling	20,000	10,000	50	20,000	0
	TOTAL	705,000	352,500	50	705,000	0
All	TOTAL	3,805,000	2,752,500	28	4,205,000	11

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.6.2 Methods

In evaluating effects on the Skykomish Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** The Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling, Wallace River Hatchery integrated summer-run Chinook salmon subyearling, and Wallace River Hatchery integrated summer-run Chinook salmon yearling programs are evaluated separately for competition and predation risks and viability benefits. For genetic risks, the Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program is evaluated separately, while the Wallace River Hatchery integrated summer-run Chinook salmon subyearling and Wallace River Hatchery integrated summer-run Chinook salmon yearling programs are evaluated together. These three hatchery programs are evaluated together for total return benefits. The Wallace River Hatchery integrated summer-run Chinook salmon subyearling and yearling programs are evaluated separately for hatchery facility and operation risks. The Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program is not evaluated for hatchery facilities and operation because releases would be made into marine waters of Tulalip Bay.
- **Coho Salmon:** The Wallace River Hatchery integrated coho salmon yearling program is evaluated for competition and predation risks. The Bernie Kai-Kai Gobin Salmon Hatchery coho integrated yearling program is not evaluated because hatchery releases would occur in Tulalip Creek (where natural-origin Chinook salmon do not occur) and Tulalip Bay (marine estuary). The Mukilteo net pen isolated steelhead program is not evaluated because fish are released in Port Gardner Bay, which is a marine estuary. The Wallace River Hatchery Possession Point net pen isolated coho program is not evaluated because fish are released in Everett Bay, a marine estuary.
- **Steelhead:** The Reiter Pond isolated summer-run steelhead yearling, Reiter Pond isolated winter-run steelhead yearling, Tokul Creek isolated winter-run steelhead yearling, and Wallace River Hatchery isolated winter-run steelhead yearling are evaluated separately for competition and predation risks.

4.6.3 Results

Results for the Skykomish Chinook salmon population are summarized in Table C-57. The action alternatives would include use of an adaptive management approach, but the results in Table C-57 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-57 is explained in the subsequent subsections for this population.

Table C-57. Summary of hatchery-related risks and benefits for the Skykomish Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Low	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	High
Benefits			
Total Return	Moderate	Same as Alternative 1	High
Viability	Low	Same as Alternative 1	Same as Alternative 1

4.6.3.1 Risks

4.6.3.1.1 Competition

Competition risks to the Skykomish Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-58. There is a negligible or low risk of competition effects on Skykomish Chinook salmon associated with hatchery salmon and steelhead programs under all alternatives. All steelhead hatcheries would release fish in May, and thus are considered to have a low competition risk (Table C-58). The overall risk of competition to Skykomish Chinook salmon associated with all hatchery programs is low under all alternatives (Table C-58).

Table C-58. Skykomish Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	NA	Unknown in nearshore; negligible in river	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	3.3 (1.7 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated coho salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated summer-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Tokul Creek isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated winter-run steelhead salmon yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk	NA	Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.6.3.1.2 Predation

Predation risks to the Skykomish Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-59.

Table C-59. Skykomish Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	NA	Unknown in nearshore; negligible in river	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	7.2 (3.2 under Alternative 3, 17.1 under Alternative 4)	Moderate	Low	High
Wallace River Hatchery integrated summer-run Chinook salmon yearling	8.5 (3.7 under Alternative 3, 17.1 under Alternative 4)	Moderate	Low	High
Wallace River Hatchery integrated coho salmon yearling	3.3 (1.8 under Alternative 3, 7.2 under Alternative 4)	Low	Same as Alternative 1	Moderate
Reiter Pond isolated summer-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Tokul Creek isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated winter-run steelhead salmon yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk	NA	High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Overall predation risks associated with hatchery programs affecting Skykomish Chinook salmon are high under all alternatives, primarily because of steelhead hatchery releases (Table C-58). There is a moderate risk of predation from Wallace River Hatchery Chinook salmon subyearlings and yearlings because the relative size of both the subyearlings (length 3.1 inches fork length) (EIS Table 3.2-4) and the yearlings (length 6.1 inches fork length) (EIS Table 3.2-4) would be large compared to the natural-origin Chinook salmon that the hatchery-origin fish may encounter after release in the watershed (average length of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). Under Alternative 3, the risk falls to low (Table C-59) for both of these programs because of a decreased fish production release of 50 percent (Table C-56). Under Alternative 4, the risk level increases to high (Table C-59) for the yearling Chinook salmon program because of the 100 percent increase in production for the yearling program, but there would be no increased production for the subyearling program (Table C-56).

There would be a low risk of predation from Wallace River Hatchery coho salmon under Alternative 1, Alternative 2, and Alternative 3 because the natural-origin Skykomish Chinook salmon population is relatively large (averaging 1.15 million juvenile out-migrants per year [Appendix D, PCD Risk 1 Assessment]) compared to the coho salmon program (75,000 to 150,000 hatchery-origin fish released) (Table C-56). However, under Alternative 4, the increased production alternative, coho salmon production doubles from 150,000 fish to 300,000 fish (Table C-55), and predation risk increases to moderate (Table C-59) because the relative number of coho salmon to natural-origin Chinook salmon would be much higher.

The four steelhead hatchery programs release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook salmon smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). However, all steelhead hatchery programs would release fish in streams where the release location is at least RM 20, thus resulting in a high predation risk under all alternatives (Table C-59).

4.6.3.1.3 Genetics

Assessments of genetic risks to the Skykomish Chinook salmon population are primarily based on PNI estimates from the AHA Model derived for each alternative (Table C-60). Risk levels are assigned using the qualitative criteria applied to PNI estimates as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-60. Skykomish Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Wallace River Hatchery integrated summer-run Chinook salmon subyearling and yearling	0.77 (0.86 for Alternative 3 and 0.73 for Alternative 4)	Low	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	0.77 (0.86 for Alternative 3 and 0.73 for Alternative 4)	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Genetic risks assigned for the Wallace River Hatchery Chinook salmon programs are low under all alternatives because PNI estimates are all greater than 0.67 (Table C-60) (Appendix E, Overview of the All H Analyzer) and there is a high adherence to BMPs for broodstock collection and mating. Changes in production level between alternatives (Table C-55) do not produce different genetic risk ratings from the AHA Model. The Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program genetic risk is low because the program would use natural-origin Wallace River (Skykomish stock) fish as broodstock. There would be no changes in broodstock collection methods or hatchery fish production levels for the program across the alternatives, thus risks would be the same for all alternatives.

4.6.3.1.4 Hatchery Facilities and Operation

Two programs would be maintained at the Wallace River Hatchery (subyearling and yearling) and would rear and release fish that are part of the Skykomish Chinook salmon population. The broodstock sustaining both programs would be collected as they return to the hatchery and, to a smaller extent, from adults collected and transferred from Sunset Falls Fishway operation on the South Fork Skykomish River. Adults would be held and spawned at Wallace River Hatchery, and all progeny would be incubated, reared, and released at that site. Overall hatchery facilities and operation risks to the Skykomish Chinook salmon population are moderate and would remain the same under all alternatives. Evaluation results for the programs using the HPV Tool are shown in Table C-61 and Table C-62.

Table C-61. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Skykomish Chinook salmon (Wallace River Hatchery subyearling releases).

Hatchery - Wallace River Hatchery subyearlings (facility and release location: Wallace River [RM 4.0], tributary to Skykomish River at RM 36)			
	Facility Compliance		
Operational Phase	**Spatial Target Population Diversity and Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	Moderate	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	Moderate	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

There were no operational phases that received a low compliance score for the Wallace River Hatchery subyearling program. Thus, the overall risk of hatchery facility and operation impacts to listed Skykomish Chinook salmon is negligible under all alternatives (Table C-61).

Table C-62. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Skykomish Chinook salmon (Wallace River Hatchery yearling releases).

Hatchery - Wallace River Hatchery yearlings (facility and release location: Wallace River (RM 4.0), tributary to Skykomish River at RM 36)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	Moderate	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Low	Low	
Facilities	NA	Moderate	
			Moderate (Low under Alternative 3 and High under Alternative 4)

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives. Otherwise, risks are provided for each alternative that is different than Alternative 1.

For the Wallace River Hatchery yearling program, the overall risk of hatchery facilities and operation impacts to the listed Skykomish Chinook salmon population is moderate under Alternative 1 and Alternative 2, although the program is in moderate or high compliance for nearly all operational phases evaluated, except release (Table C-62). The HPV Tool assigned a low compliance score in the release operational phase for the program. Releasing Chinook salmon that are not similar to co-occurring natural-origin Chinook salmon in size, behavior, growth rate, and physiological status may affect performance and increase competition and predation impacts to natural-origin fish. However, the overall risk of the yearling program to the Skykomish Chinook salmon population during the release phase would decrease to low under Alternative 3, because 50 percent fewer yearlings would be released compared to Alternative 1 and Alternative 2 (Table C-55). Under Alternative 4, the yearling program would increase by 100 percent (Table C-55), and the overall risk would be high.

4.6.3.2 Benefits

4.6.3.2.1 Total Return

Table C-63 compares effects of the alternatives on the total return of adult hatchery-origin Skykomish Chinook salmon produced by the Wallace River Hatchery integrated summer-run subyearling and yearling programs, and Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Skykomish Chinook salmon run size. The return of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-63. Estimated total return contributions for Skykomish Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	13,605	10,968	15,980
Average natural-origin return	5,572	5,572	5,572
Projected average total return	19,177	16,540	21,552
Restoration spawner abundance[1]	39,000	39,000	39,000
Projected average total return as a percent of restoration spawner abundance	49	42	55

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be moderate for Alternative 1 and Alternative 2, and Alternative 3 because the combined total run size would be between 20 to 50 percent (49 and 42 percent, for Alternative 1 and 2, and Alternative 3, respectively) of the estimated restoration spawner abundance level (Table C-63). Total annual hatchery production levels are the same for Alternative 1 and Alternative 2, and are 21 percent lower under Alternative 3 (Table C-55). The decrease in hatchery production under Alternative 3 would be insufficient to reduce the benefit from moderate. Under Alternative 4, the hatchery production level would increase 8 percent (Table C-55). This would increase the benefit of Alternative 4 to high, because the total run size would be over 50 percent (55 percent) of the estimated restoration spawner abundance level (Table C-62). Adult fish produced through the programs would continue to be harvested with natural-origin Skykomish Chinook salmon in mixed stock marine area and terminal area sport fisheries directed at Chinook salmon. Mixed stock marine area fisheries benefiting from the hatchery production would include Canadian Georgia Strait sport and troll fisheries, West Coast Vancouver Island troll fisheries, and other Canadian and U.S. sport fisheries (assuming contribution levels consistent with those observed for Upper Skagit Chinook salmon [CTC 2012]).

Washington sport fisheries in the Snohomish River watershed would also harvest hatchery-origin Skykomish Chinook salmon. Hatchery-origin Chinook salmon from the Wallace River Hatchery integrated summer-run subyearling and yearling programs, and Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program would contribute a substantial proportion of the total number of natural spawners in the Skykomish River watershed. Adult Chinook salmon contributions to the above fisheries and to escapement would be substantial relative to natural-origin contribution levels under all alternatives.

4.6.3.2.2 Viability

Viability is evaluated separately for each of the three integrated hatchery programs that benefit the Skykomish Chinook salmon population. Viability results from the three programs are provided in Table C-64.

Table C-64. Skykomish Chinook salmon viability benefits by alternative.

Hatchery Program	Alternatives 1 and 2	Alternative 3	Alternative 4
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	Low	Negligible	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon yearling	Low	Negligible	Same as Alternative 1
Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	Negligible	Same as Alternative 1	Same as Alternative 1

Wallace River Hatchery Summer-run Chinook Salmon Subyearling Program. Viability benefits to the Skykomish summer-run Chinook salmon population from the Wallace River Hatchery integrated summer-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Wallace River Hatchery integrated summer-run Chinook salmon subyearling program would benefit the abundance of the Skykomish summer-run Chinook salmon population. Thus, the viability benefit of the program to the Skykomish summer-run Chinook salmon population is low for the reasons described below.

Abundance – The subyearling hatchery program would benefit the abundance of naturally spawning Skykomish summer-run Chinook salmon. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean natural spawner escapement for the Skykomish population of 3,309 fish. The mean number of natural-origin Skykomish spawners for this period was estimated to be 2,358. The remainder of the mean number of natural spawners, 951 fish or 29 percent of the mean escapement to the river, are hatchery-origin summer-run Chinook salmon. Otolith mark recovery data indicate that the majority of hatchery-origin fish originate from the Wallace River Hatchery (Rawson et al. 2001).

Diversity – The subyearling hatchery program would have a negligible benefit to diversity. BMPs would be applied to maintain the diversity of the Wallace River hatchery population. Measures include collection of large numbers of broodstock (e.g., mean number of effective breeders = 2,866 from 1998-2001), random collection of broodstock over the breadth of the return to the Wallace River and May Creek, and using a factorial mating scheme during spawning. The program would continue to incorporate natural-origin Chinook salmon trapped at Sunset Falls as broodstock to reduce the risk of genetic divergence between the hatchery-origin and natural-origin populations.

Spatial Structure – The subyearling hatchery program would have a negligible benefit to spatial structure. Fish released through the program would continue to return predominantly to the hatchery release site. Up to 500 natural-origin summer-run Chinook salmon would be passed above the weir each year to seed natural habitat (WDFW 2005f). The annual removal of a proportion of the total number of natural-origin Chinook salmon reaching Sunset Falls for use as hatchery broodstock may reduce beneficial effects.

Productivity – The benefit of the subyearling hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Skykomish population of 0.95. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite Skykomish naturally spawning population is nearly replacing itself in the short term. The estimate of lambda conservatively assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. However, if the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the benefit of the subyearling hatchery program to viability would be negligible, because the number of adults contributing to natural spawning would be reduced, corresponding to a 50 percent reduction in subyearling releases compared to Alternative 1 and Alternative 2 (Table C-55). The number of adults expected to return from the program under Alternative 3 would be 1,450 compared to 2,900 for Alternative 1 and Alternative 2. Benefits to diversity, spatial structure, and productivity would be the same as Alternative 1 and Alternative 2 (negligible), because all other aspects of the program would remain unchanged.

Under Alternative 4, annual subyearling Chinook salmon release levels and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be low, the same as for Alternative 1 and Alternative 2.

Wallace River Hatchery Summer-run Chinook Salmon Yearling Program. Viability benefits to the Skykomish summer-run Chinook salmon population from the Wallace River Hatchery integrated summer-run Chinook salmon yearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Wallace River Hatchery integrated summer-run Chinook salmon yearling program would benefit the abundance of the Skykomish summer-run Chinook salmon population. However, the viability benefit of the program to the Skykomish summer-run Chinook salmon population is low for the reasons described below.

Abundance – Like the subyearling hatchery program, the yearling program would benefit the abundance of naturally spawning Skykomish summer-run Chinook salmon. Yearlings released from the Wallace River Hatchery survive to adult return at a rate approximately three times greater than subyearlings. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean natural spawner escapement for the Skykomish population of 3,309 fish. The mean number of natural-origin Skykomish spawners for this period was estimated to be 2,358. The remainder of the mean number of natural spawners, 951 fish or 29 percent of the mean escapement to the river, are hatchery-origin summer-run Chinook salmon.

Diversity – The yearling hatchery program would have a negligible benefit to diversity. BMPs would be applied to maintain the diversity of the Wallace River hatchery population. Measures include collection of large numbers of broodstock (e.g., mean number of effective breeders = 2,866 from 1998-2001), random collection of broodstock over the breadth of the return to the Wallace River and May Creek, and using a factorial mating scheme during spawning. The program would continue to incorporate natural-origin Chinook salmon trapped at Sunset Falls as broodstock to reduce the risk of genetic divergence between the hatchery-origin and natural-origin populations.

Spatial Structure – The yearling hatchery program would have a negligible benefit to spatial structure. Fish released through the program would continue to return predominantly to the hatchery release site. Up to 500 natural-origin summer-run Chinook salmon would be passed above the weir each year to seed natural habitat (WDFW 2005f). The annual removal of a proportion of the total number of natural-origin Chinook salmon reaching Sunset Falls for use as hatchery broodstock may reduce beneficial effects.

Productivity – The benefit of the yearling hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Skykomish population of 0.95. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite Skykomish naturally spawning population is nearly replacing itself in the short term. The estimate of lambda conservatively assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. However, if the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the benefit of the yearling hatchery program to viability would be negligible. This is because natural spawning adult abundance benefits would decrease in response to a release of 50 percent fewer hatchery yearlings compared to Alternative 1 and Alternative 2 (Table C-55). All other aspects of the program would remain unchanged, which would afford negligible benefits to diversity, spatial structure, and productivity.

Under Alternative 4, the benefit of the yearling hatchery program to viability would be low. Under this alternative, abundance benefits would occur because of an annual yearling release of 500,000 fish (Table C-55). This production level would benefit the total abundance of the Skykomish Chinook salmon population, as more adults would be expected to return from the program compared to Alternative 1 and Alternative 2. All other aspects of the program would remain unchanged; thus, there would be no benefits to diversity, spatial structure, and productivity under Alternative 4.

Bernie Kai-Kai Gobin Salmon Hatchery Summer/fall-run Chinook Salmon Subyearling Program. Viability benefits to the Skykomish summer-run Chinook salmon population from the Bernie Kai-Kai Gobin Hatchery integrated summer-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Bernie Kai-Kai Gobin Hatchery integrated summer-run Chinook salmon subyearling program would provide negligible benefits to the viability of the Skykomish summer-run Chinook salmon population for the reasons described below.

Abundance – The hatchery program would have a negligible benefit to the abundance of Skykomish summer-run Chinook salmon. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean natural spawner escapement for the Skykomish population of 3,309 fish. The mean number of natural-origin Skykomish spawners for this period was estimated to be 2,358. The remainder of the mean number of natural spawners, 951 fish or 29 percent of the mean escapement to the river, are hatchery-origin summer-run Chinook salmon, including fish produced by the Bernie Kai-Kai Gobin Hatchery program. Stray hatchery returns that escape to the Skykomish River may enhance the abundance of the genetically similar Wallace River component of the Skykomish population.

Diversity – The hatchery program would have a negligible benefit to diversity. No natural-origin summer-run Chinook salmon broodstock would be collected at the Bernie Kai-Kai Gobin Salmon Hatchery. Instead, the program would use Wallace River Hatchery broodstock. BMPs as described above for the Wallace River Hatchery programs, including broodstock collection, spawning, and rearing measures, would be applied to maintain diversity. The program now incorporates natural-origin Skykomish summer-run Chinook salmon as broodstock at a 10 percent level to maintain genetic diversity and fitness.

Spatial Structure – The hatchery program would have a negligible benefit to spatial structure. Fish released through the program return predominantly to the Bernie Kai-Kai Gobin Salmon Hatchery release site, where they are harvested in intensive Tribal fisheries (90 to 100 percent of the total annual hatchery-origin adult returns are caught in this fishery (Tulalip Tribes 2005). Hatchery-origin summer-run Chinook salmon escaping the tribal fisheries stray into the Snohomish River, and in particular, into Snoqualmie River natural spawning areas (Rawson et al. 2001).

Productivity – The benefit of the hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Skykomish population of 0.95. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda less than 1.0 reflects a population that is not replacing itself. The composite naturally spawning Skykomish Chinook salmon population is not quite replacing itself in the short term, coincident with contribution of naturally spawning hatchery-origin fish through straying. The estimate of lambda conservatively assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. However, if the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be negligible.

4.6.3.3 Summary – Skykomish Chinook Salmon

Table C-56 summarizes the risks and benefits for all alternatives pertinent to the Skykomish Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high, with low risks for competition and genetics, moderate risk for hatchery facilities and operation, and high risk for predation. Benefits under Alternative 1 and Alternative 2 include a moderate benefit for abundance and a low benefit for viability. The decreases in production under Alternative 3 result in low hatchery facilities and operation risk. The increases in production under

Alternative 4 result in high hatchery facilities and operation risk and high abundance benefit. Otherwise, benefits and risks under Alternative 3 and Alternative 4 are the same as Alternative 1.

4.6.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

Provided in Table C-65 is a summary of potential mitigation measures for the Skykomish Chinook salmon population action alternatives. These mitigation measures would help reduce predation and hatchery facilities and operation risks. The predation risk is rated as high under Alternative 2, Alternative 3, and Alternative 4 (Table C-56). The hatchery facilities and operation risk is rated as moderate under Alternative 2 and high under Alternative 4 (Table C-56).

Table C-65. Potential mitigation measures for the Skykomish Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measures P1, P3, P5, and P6.
Hatchery facilities and operation	Apply Mitigation Measure H3.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of these hatchery Chinook salmon, coho salmon, and steelhead program mitigation measures under the adaptive management framework would likely help reduce the risks of predation and hatchery facilities and operation impacts from the programs on the natural-origin Skykomish Chinook salmon population. Decisions regarding the pace and need for implementation of the hatchery risk mitigation actions would also be based on the assigned value of the Skykomish Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.7 Snoqualmie Chinook Salmon

4.7.1 Introduction

As shown in Table C-1, the Snohomish River watershed consists of the Skykomish summer/fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.4, Snohomish River Chinook Salmon Populations, there are two natural-origin summer/fall-run Chinook salmon populations in the Snohomish River watershed: the Skykomish population as described in Subsection 4.6, Skykomish Chinook Salmon, and the Snoqualmie Chinook salmon population, which is described in this subsection.

The Snoqualmie River is a 45-mile long river with three main tributaries: North, Middle, and South Forks. The tributaries drain the west side of the Cascade Mountains just above the Snoqualmie Falls. After the falls, the river flows north before meeting the Skykomish River to form the Snohomish River near Monroe. The natural-origin Snoqualmie Chinook salmon population spawns in the Snoqualmie, Tolt, and Raging Rivers, and Tokul Creek. Hatcheries and their associated programs and release sites within the Snoqualmie River watershed are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon, including the following rivers and streams:

- Skykomish River
- Snohomish River
- Snoqualmie River
- Wallace River, which is a tributary to the Skykomish River at RM 36
- Sultan River
- Howard Creek
- Barr Creek
- Tolt River
- Pilchuck River
- Raging River
- Tokul Creek, which is a tributary of the Snoqualmie River at RM 39
- Reiter Pond, which is located by the Skykomish River at RM 45

There are no hatchery programs in the watershed that propagate Snoqualmie River Chinook salmon. However, three Chinook salmon hatchery programs, one coho salmon hatchery program, and four steelhead programs from four hatcheries have the potential to impact the Snoqualmie River summer/fall-run Chinook salmon population (Table C-66 and Table C-67), and are reviewed in this subsection.

Table C-66. Hatchery programs and categories of effects evaluated for Snoqualmie Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	Predation	Genetics	Hatchery Facilities and Operation	Total Return	Viability
Chinook salmon	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	√	√	√[1]			
	Wallace River Hatchery integrated summer-run Chinook salmon subyearling	√	√	√[1]			
	Wallace River Hatchery integrated summer-run Chinook salmon yearling	√	√	√[1]			
Coho salmon	Wallace River Hatchery integrated coho salmon yearling	√	√				
Steelhead	Reiter Pond isolated summer-run steelhead yearling	√	√				
	Reiter Pond isolated winter-run steelhead yearling	√	√				
	Tokul Creek Hatchery isolated winter-run steelhead yearling	√	√				
	Wallace River winter-run steelhead isolated steelhead yearling	√	√				

[1]These hatcheries are evaluated together as a group for genetic risks.

Table C-67. Hatchery salmon and steelhead production evaluated for Snoqualmie Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	1,700,000	1,700,000	0	1,700,000	0
	Wallace River Hatchery integrated summer-run Chinook salmon subyearling	1,000,000	500,000	50	1,000,000	0
	Wallace River Hatchery integrated summer-run Chinook salmon yearling	250,000	125,000	50	500,000	100
	Total subyearlings	2,700,000	2,200,000	19	2,700,000	0
	Total yearlings	250,000	125,000	50	500,000	100
	TOTAL	2,950,000	2,325,000	21	3,200,000	8
Coho salmon	Wallace River Hatchery integrated coho salmon yearling	150,000	75,000	50	300,000	100
Steelhead	Reiter Pond isolated summer-run steelhead yearling	250,000	125,000	50	250,000	0
	Reiter Pond isolated winter-run steelhead yearling	250,000	125,000	50	250,000	0
	Tokul Creek Hatchery isolated winter-run steelhead yearling	185,000	92,500	50	185,000	0
	Wallace River winter-run steelhead isolated steelhead yearling	20,000	10,000	50	20,000	0
	TOTAL	705,000	352,500	50	705,000	0
All	TOTAL	3,805,000	2,752,500	28	4,205,000	11

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.7.2 Methods

In conducting the analysis for the Snoqualmie Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** The Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling program, and Wallace River Hatchery integrated summer-run Chinook salmon subyearling and yearling programs are evaluated for competition and predation risks. The three programs are evaluated as a group for genetics. None of the programs are evaluated for hatchery facilities and operation, total return, and viability because these programs would not occur in areas where the Snoqualmie Chinook salmon population occurs.
- **Coho Salmon:** The Wallace River Hatchery integrated coho salmon yearling program is evaluated for competition and predation risks. The Bernie Kai-Kai Gobin Salmon Hatchery coho integrated yearling program is not evaluated because hatchery releases would occur in Tulalip Creek (where natural-origin Chinook salmon do not occur) and Tulalip Bay (marine estuary). The Mukilteo net pen isolated steelhead program is not evaluated because fish are released in Port Gardner Bay, which is a marine estuary. The Wallace River Hatchery Possession Point isolated coho program is not evaluated because fish are released in Everett Bay, a marine estuary.
- **Steelhead:** The Reiter Pond isolated summer-run steelhead yearling, Reiter Pond isolated winter-run steelhead yearling, Tokul Creek isolated winter-run steelhead yearling, and Wallace River Hatchery isolated winter-run steelhead yearling programs are evaluated for competition and predation risks.

4.7.3 Results

Results for the Snoqualmie Chinook salmon population are summarized in Table C-68. The action alternatives would include the use of an adaptive management approach, but the results in Table C-68 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-68 is explained in the subsequent subsections for this population.

Table C-68**.** Summary of hatchery-related risks and benefits for the Snoqualmie Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	NA	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

4.7.3.1 Risks

4.7.3.1.1 Competition

Competition risks to the Snoqualmie Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-69. There is a negligible or low risk of competition effects on natural-origin Snoqualmie Chinook salmon associated with Snohomish watershed hatchery salmon and steelhead programs under all alternatives. The overall risk of competition to Snoqualmie Chinook salmon associated with all hatchery programs is low under all alternatives (Table C-69).

Table C-69. Snoqualmie Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	NA	Unknown in near shore; negligible in river	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	3.3 (1.7 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated coho salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	3.3 (1.7 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated summer-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Tokul Creek isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated winter-run steelhead salmon yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.7.3.1.2 Predation

Predation risks to the Snoqualmie Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-70.

Table C-70. Snoqualmie Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling	NA	Unknown in nearshore; negligible in river	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated summer-run Chinook salmon subyearling	7.2 (3.2 under Alternative 3, 17.1 under Alternative 4)	Moderate	Low	High
Wallace River Hatchery integrated summer-run Chinook salmon yearling	8.5 (3.7 under Alternative 3, 17.1 under Alternative 4)	Moderate	Low	High
Wallace River Hatchery integrated coho salmon yearling	3.3 (1.8 under Alternative 3, 7.2 under Alternative 4)	Low	Same as Alternative 1	Moderate
Reiter Pond isolated summer-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Reiter Pond isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Tokul Creek isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Wallace River Hatchery integrated winter-run steelhead salmon yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk	NA	High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

The overall predation risk associated with hatchery programs affecting Skykomish Chinook salmon are high under all alternatives, primarily because of the steelhead hatchery releases (Table C-70). There is a moderate risk of predation from Wallace River Hatchery Chinook salmon subyearlings and yearlings because the relative size of both the subyearlings (average size of 3.1 inches fork length) (EIS Table 3.2-4) and the yearlings (average size of 6.1 inches fork length) (EIS Table 3.2-4) is large compared to the natural-origin Chinook salmon that the hatchery-origin fish may encounter after release in the watershed (average size of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). Under Alternative 3, the risk decreases to low (Table C-70) for both of these programs because fish production decreases 50 percent (Table C-67). Under Alternative 4, the risk level increases to high (Table C-70) for the yearling Chinook salmon program because of the 100 percent increase in production for the yearling program, but there would be no increased production for the subyearling program (Table C-67).

There would be a low risk of predation from Wallace River Hatchery coho salmon under Alternative 1, Alternative 2, and Alternative 3 because the natural-origin Chinook salmon population is relatively large (averaging 515,000 juvenile out-migrants per year [Appendix D, PCD Risk 1 Assessment]) compared to coho salmon annual releases of 75,000 to 150,000 fish. However, under Alternative 4, the increased production alternative, coho salmon production doubles from 150,000 fish to 300,000 fish (Table C-67), and predation risk increases to moderate (Table C-70) because the relative number of coho salmon to natural-origin Chinook salmon would be much higher.

The four steelhead hatchery programs would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook smolt out-migration typically peaks in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). However, all steelhead hatchery programs would release fish in streams where the release location is at least as high as RM 20, thus resulting in a high predation risk under all alternatives (Table C-70).

4.7.3.1.3 Genetics

No hatchery programs would propagate the Snoqualmie Chinook salmon population. Thus, hatchery-induced selection risks would not be posed by any hatchery program under the alternatives, and there are no PNI results from the AHA Model for the Snoqualmie Chinook salmon population. However, summer-run Chinook salmon adults originating from the Wallace River Hatchery and Bernie Kai-Kai Gobin Salmon Hatchery programs may stray into natural-origin Chinook salmon spawning areas in the Snoqualmie River watershed in substantial numbers (Rawson et al. 2001). In that study, stratified sampling of the Snohomish River watershed natural-origin Chinook salmon escapement in 1999 found that 14 percent of 119 adult fish sampled in the Snoqualmie River and 26 percent of 98 fish sampled in

Tokul Creek (a Snoqualmie River tributary located at RM 39.6, approximately 1 mile downstream of Snoqualmie Falls) were otolith-marked hatchery-origin fall-run Chinook salmon from the Bernie Kai-Kai Gobin Salmon Hatchery. Although genetic introgression levels resulting from hatchery fish straying are unknown, this stray rate information indicates the overall genetic risk level is likely moderate for the Snoqualmie Chinook salmon population under Alternative 1 and Alternative 2 (Table C-71).

Table C-71. Snoqualmie Chinook salmon genetic risks by alternative.

Hatchery Program Risk	**PNI or pHOS[1]**	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
Hatchery-induced selection risk from Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip integrated summer/fall-run Chinook salmon subyearling, and Wallace River Hatchery integrated summer-run Chinook salmon subyearling and yearling	NA	Unknown, but likely moderate	Low	Same as Alternative 1
Overall Risk		Moderate	Low	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Under Alternative 3, genetic risk to the Snoqualmie Chinook salmon population would be low, because hatchery summer-run Chinook salmon production from Wallace River Hatchery would be 21 percent less than under Alternative 1 and Alternative 2 (Table C-67), and the number of returning adult fish that might stray into the Snoqualmie Chinook population would likely also be less. Under Alternative 4, releases of hatchery-origin fish would increase compared to Alternative 1 and Alternative 2 (Table C-67), but the increase would be insufficient to raise the risk rating from moderate.

4.7.3.1.4 Hatchery Facilities and Operation

There are no Chinook salmon hatchery facilities producing fish that are part of the Snoqualmie Chinook salmon population or located in areas where natural-origin Snoqualmie Chinook salmon occur. Therefore, there are no hatchery facility or operation risks.

4.7.3.2 Benefits

There are no hatchery programs that propagate Snoqualmie Chinook salmon, so no total returnand viability benefits are afforded to the natural-origin Snoqualmie Chinook salmon population.

4.7.3.3 Summary – Snoqualmie Chinook Salmon

Table C-68 summarizes the risks and benefits for all alternatives pertinent to the Snoqualmie Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to moderate with a low risk for competition, moderate risk for genetics, and high risk for predation. There are no hatcheries in areas where natural-origin Snoqualmie Chinook salmon occur and thus, there would be no hatchery facilities and operation, total return, and viability effects. The decrease in production under Alternative 3 reduces genetic risk to low. Otherwise, all other risks and benefits are the same under all alternatives.

4.7.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection initially include site-specific measures followed by more generalized measures for consideration, which would be applicable to more than one hatchery program as shown in Table C-2.

Hatchery Facilities and Operation. The following site-specific mitigation measure would help to decrease hatchery facilities and operation risks to the Snoqualmie Chinook salmon population.

- There are existing plans for the Bernie Kai-Kai Gobin Salmon Hatchery program to release hatchery-origin Skykomish summer-run Chinook salmon stock secured through the Wallace River Hatchery program. Tribal and Washington Department of Fish and Wildlife spawner survey and mark recovery programs would continue to identify marked adult hatchery-origin Chinook salmon and rates of straying to Snohomish watershed Chinook salmon natural-origin production areas would be documented (Tulalip Tribes 2005). Information from these programs would be used to assess the proportion of hatchery-origin and natural-origin Chinook salmon in those areas, interactions (including interbreeding) between stray hatchery-origin fish and natural-origin Chinook salmon on spawning grounds, and the genetic risk to Snohomish natural-origin Chinook salmon populations posed by the Bernie Kai-Kai Gobin Salmon Hatchery and Wallace River Hatchery programs.

Provided in Table C-72 is a summary of potential mitigation measures for the Snoqualmie Chinook salmon population action alternatives. These mitigation measures would help reduce predation and genetic risks. Predation is rated as high under Alternative 2, Alternative 3, and Alternative 4 (Table C-68). Genetic risk is rated as moderate under Alternative 2 and Alternative 4 (Table C-68).

Table C-72. Potential mitigation measures for the Snoqualmie Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measures P1, P5, and P6.
Genetics	Apply Mitigation Measure G2.

[1]Refer to Table C-2 for a description of each mitigation measure.

Application of these hatchery Chinook salmon, coho salmon, and steelhead program risk mitigation measures would likely help reduce the risks of predation and genetic impacts of the programs on the natural-origin Snoqualmie Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions under an adaptive management approach would be based on the assigned value of the Snoqualmie Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.8 Sammamish Chinook Salmon

4.8.1 Introduction

As shown in Table C-1, the Lake Washington watershed supports the Sammamish fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.5, Lake Washington Chinook Salmon Populations, two fall-run natural-origin Chinook salmon populations occur in the Lake Washington watershed: the Cedar population in the Cedar River and the Sammamish population occupying the northern tributaries to the Sammamish River, including Issaquah, Big Bear, and Cottage Lake Creeks. The Cedar Chinook salmon population is discussed in Subsection 4.9, Cedar Chinook Salmon, whereas this subsection describes project effects to the Sammamish Chinook salmon population. It is uncertain whether the Sammamish River tributaries historically supported a natural-origin Chinook salmon population (Ruckelshaus et al. 2006).

The Sammamish River begins as an outlet on the north shore of Lake Sammamish, which in turn is fed by several creeks that constitute the headwaters of the Sammamish River watershed. The most important of these is Issaquah Creek. Hatcheries and associated programs and release sites within the Lake Washington watershed that may affect the natural-origin Sammamish Chinook salmon are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon and include the following streams:

- Issaquah Creek, tributary to Lake Sammamish
- Cedar River, tributary to Lake Washington
- Portage Bay in the Lake Washington Ship Canal

Juvenile fish from Sammamish River and Issaquah Creek out-migrate through Lake Sammamish, where they are joined by fish from the Cedar River to then out-migrate through Lake Washington and through the Lake Washington Ship Canal (with fish from the Portage Bay Hatchery) to reach the marine waters of Puget Sound.

Two Chinook salmon hatchery programs, two coho salmon hatchery programs, and one sockeye salmon hatchery program from three hatcheries have the potential to impact the Sammamish Chinook salmon population (Table C-73 and Table C-74), and are reviewed in this subsection.

4.8.2 Methods

In evaluating hatchery-related effects on the Sammamish Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The Issaquah Hatchery integrated fall-run Chinook salmon subyearling program is evaluated for all risks and benefits. The Portage Bay Hatchery isolated fall-run Chinook salmon subyearling program is evaluated for competition, predation, and genetic risks.
- **Coho Salmon:** The Issaquah Hatchery integrated coho salmon yearling and Portage Bay Hatchery isolated coho salmon yearling programs are evaluated independently for competition and predation. The Laebugton net pen isolated coho salmon yearling program and Ballard net pen isolated coho salmon yearling program are not evaluated because these programs would release fish directly into marine water and fish would be released in marine areas removed from natural-origin Chinook salmon.

- **Steelhead:** There are no steelhead hatchery program releases in the North Lake Washington watershed.
- **Sockeye:** The Cedar River Hatchery integrated summer-run sockeye salmon fry program is evaluated for competition and predation risks.

Table C-73. Hatchery programs and categories of effects evaluated for Sammamish Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	Predation	Genetics	Hatchery Facilities and Operation	Total Return	Viability
Chinook salmon	Issaquah Hatchery integrated fall-run Chinook salmon subyearlings	√	√	√	√	√	√
	Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	√	√	√			
Coho salmon	Issaquah Hatchery integrated coho salmon yearling	√	√				
	Portage Bay Hatchery isolated coho salmon yearling	√	√				
Sockeye salmon	Cedar River Hatchery integrated summer-run sockeye fry	√	√				

Table C-74. Hatchery salmon and steelhead production evaluated for Sammamish Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Issaquah Hatchery integrated fall-run Chinook salmon subyearling	2,000,000	2,000,000	0	2,000,000	0
	Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	180,000	180,000	0	180,000	0
	TOTAL	2,180,000	2,180,000	0	2,180,000	0
Coho salmon	Issaquah Hatchery integrated coho salmon yearling	450,000	450,000	0	450,000	0
	Portage Bay Hatchery isolated coho salmon yearling	90,000	90,000	0	90,000	0
	TOTAL	540,000	540,000	0	540,000	0
Sockeye salmon	Cedar River Hatchery integrated summer-run sockeye salmon fry	34,000,000	34,000,000	0	34,000,000	0
All	TOTAL	36,720,000	36,720,000	0	36,720,000	0

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.8.3 Results

Results for the Sammamish Chinook salmon population are summarized in Table C-75. The action alternatives would include use of an adaptive management approach, but the results in Table C-75 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-75 is explained in the subsequent subsections for this population.

Table C-75. Summary of hatchery-related risks and benefits for the Sammamish Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	High	Same as Alternative 1	Same as Alternative 1
Predation	Moderate	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.8.3.1 Risks

Lake Washington is one of two large lake systems in Puget Sound that have Chinook salmon populations. The size and biological complexity of the Lake Washington watershed that salmon use for migration and rearing creates a unique ecological situation compared to other Puget Sound systems. Thus, it was not possible to use the PCD Risk Model to evaluate competition and predation effects on Sammamish Chinook salmon. Instead, competition and predation risks to the Sammamish Chinook salmon population are based on the following considerations: 1) the abundance and individual size of the affected natural-origin Sammamish Chinook salmon juveniles, 2) the number of fish released from the hatchery programs, 3) the individual size of fish released by the hatchery programs, 4) the timing of hatchery-origin fish releases relative to natural-origin juvenile Chinook salmon rearing and out-migration periods in the Lake Washington watershed, and 5) the locations within the watershed where the hatchery-origin fish are released. Appendix B, Hatchery Effects and Evaluation Methods for Fish, contains more information on the methods used for competition and predation by salmon and steelhead species.

4.8.3.1.1 Competition

Competition risks to the Sammamish Chinook salmon population from Chinook salmon, coho salmon, and sockeye salmon hatchery programs under the four alternatives in the Lake Washington watershed are summarized in Table C-76.

Chinook Salmon and Coho Salmon Program Effects. The Issaquah Hatchery integrated fall-run Chinook salmon subyearling program would release 2 million Chinook salmon subyearlings under all alternatives (Table C-74) between May and June each year into the uppermost portion of the Lake Washington watershed at an average individual size of 3.1 inches fork length. This number of fish is large relative to the number of natural-origin juvenile Chinook salmon produced in Sammamish tributaries (e.g., 22,197 fish in Bear Creek [Kiyohara 2013]). The hatchery-origin Chinook salmon are similar in size to natural-origin Sammamish Chinook salmon that may be encountered in the watershed after the fish are released into Issaquah Creek (average size of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). Therefore, there would be a high risk of resource competition with rearing and emigrating natural-origin juvenile Chinook salmon that may be present as the hatchery-origin fish emigrate seaward (Table C-76). This high competition risk applies under all alternatives, because the number of fish released would be the same.

Table C-76. Sammamish Chinook salmon population competition risks by alternative.

Hatchery Program Risk	Alternatives 1 and 2	Alternative 3	Alternative 4
Issaquah Hatchery integrated fall-run Chinook salmon subyearling	High	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Issaquah Hatchery integrated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Cedar River Hatchery integrated summer-run sockeye fry	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk	High	Same as Alternative 1	Same as Alternative 1

The Portage Bay Hatchery isolated fall-run Chinook salmon subyearling program would release 180,000 subyearlings each year (Table C-74) into the lower portion of the Lake Washington watershed during the third week of May at an average individual fish size of 4.7 inches fork length. The relatively small size of the program, the lower watershed release location and later timing relative to natural-origin Sammamish Chinook salmon that out-migrate from higher in the watershed, the size of the hatchery-origin fish at release relative to the size of natural-origin juvenile Chinook salmon present (average length 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4), the expectation for rapid dispersal of the hatchery-origin smolts post-release, and the smaller relative size of any natural-origin Chinook salmon encountered during the release period indicates that competition risks to out-migrating and rearing Sammamish natural-origin Chinook salmon in Lake Sammamish and Lake Washington are low (Table C-75). This low risk applies to all alternatives because release levels are the same.

Resource competition risks to natural-origin Sammamish Chinook salmon posed by the Issaquah Hatchery integrated coho salmon yearling program are low, because yearling hatchery-origin fish likely have different food and space preferences compared to the much smaller co-occurring Chinook salmon. Additionally, the program would release yearlings that out-migrate directly to marine areas, which would limit the duration of competitive interactions between hatchery-origin and natural-origin fish in lake rearing areas. The competition risk for the Issaquah Hatchery coho salmon program would be low for all alternatives, because the number of yearlings released (Table C-74) would be the same across alternatives.

Portage Bay Hatchery isolated coho salmon yearling program would release fish at an average length of 4.2 inches fork length into the lower Lake Washington watershed (into the Ship Canal connecting Lake Washington with Lake Union) during May as migration-ready smolts (yearlings). Annual production would be modest in size (90,000 yearlings) (Table C-74). After release, these fish (because they are smolts) would be expected to rapidly disperse into the lower watershed and seaward through the Ballard Locks. Hatchery-origin coho salmon released at an average length of 4.2 inches fork length are not large enough to prey on any natural-origin juvenile Sammamish Chinook salmon (which range in length from 2.8 to 3.3 inches fork length) that may be present during the May coho salmon release period(Seiler et al. 2003b; Kiyohara 2013). For these reasons, Portage Bay Hatchery coho salmon would likely have minimal interactions with, and competition effects on, natural-origin Sammamish Chinook salmon emigrating from the upper watershed tributaries and dispersing into the lakes at the time the hatchery-origin fish are released. This low competition risk would apply to all alternatives, as the number of fish released would be the same (Table C-76).

Sockeye Salmon Program Effects. A hatchery sockeye salmon program operates on the Cedar River, a major tributary within the Lake Washington watershed. Assessments of risks to natural-origin Chinook salmon associated with the Cedar River Hatchery sockeye salmon program use information and findings presented in the Final SEIS for the Cedar River Sockeye Hatchery Project (Seattle Public Utilities 2005). The impacts of competition are evaluated in Seattle Public Utilities (2005) by applying a combination of existing information, theory, and expert opinion to assess how Chinook salmon survival would be affected by a release level of 34 million sockeye salmon fry that would occur if the program were operated at maximum capacity. As described in Seattle Public Utilities (2005), sockeye salmon fry releases and resulting adult returns from the Cedar River Hatchery sockeye salmon program would present risks to the natural-origin Sammamish Chinook salmon population in the following ways:

- competition for food resources during the juvenile life history stages

- competition for spawning sites between hatchery-origin sockeye salmon and natural-origin Chinook salmon
- superimposition of hatchery-origin sockeye salmon redds on pre-existing natural-origin Chinook salmon redds

The number of hatchery-origin fry released (Table C-74) is the same under all alternatives; thus, competition risks would be the same for all alternatives.

The overall competition risk from the sockeye salmon program to Chinook salmon is low under all alternatives (Table C-76) for the reasons described below. In general, biological, ecological, and behavioral differences between species limit the risk of competitive interactions effects (Seattle Public Utilities 2005). Food resource competition risks to Sammamish Chinook salmon juveniles from Cedar River Hatchery sockeye salmon fry releases would be low because of differences in size and associated habitat and diet preferences (Seattle Public Utilities 2005). The high abundance of juvenile salmon prey in Lake Washington and the lack of evidence suggesting increasing levels of Cedar River Hatchery sockeye salmon fry production affected the abundance of juvenile salmon prey in the lake were also factors. Sockeye salmon in Lake Washington are estimated to consume less than 20 percent of the available prey in the lake (Seattle Public Utilities 2005). In addition, available information does not indicate a reduction in growth rates of sockeye salmon fry or smolts between the mid 1990s and 2004 despite a five-fold increase in sockeye salmon fry abundance in the lake (from 10 million to 52 million fry) over the same period during operation of the Cedar River sockeye salmon hatchery (Beauchamp et al. 2004).

The risk of competition effects from hatchery-origin sockeye salmon to natural-origin Sammamish Chinook salmon spawners is low (Seattle Public Utilities 2005). This is primarily because the location of acclimation and releases of sockeye salmon fry under the program would occur relatively high in the Cedar River watershed at RM 21, and thus returning adults would have a strong tendency to home to the Cedar River and not the Sammamish River. In addition, when the two species co-occur, Chinook salmon tend to spawn in deeper and faster water than sockeye salmon, and can actively select such sites when sockeye salmon are more numerous than in years when sockeye salmon are less numerous.

The risk that hatchery-origin sockeye salmon from the program will impact natural-origin Sammamish Chinook salmon by redd superimposition is low. This is primarily because, as mentioned above, returning hatchery-origin adult sockeye salmon would be expected to home to the Cedar River because of the location at which they had been acclimated and released. However, for sockeye salmon that return to the Sammamish River, redd superimposition may occur when gravels into which eggs have already been deposited are used by fish spawning later in the same place. Later spawners can disturb or excavate incubating eggs and thus adversely impact their survival. However, even if sockeye salmon did superimpose their redds on Chinook salmon, the likelihood of significant mortality to the Chinook salmon eggs would be negligible. This is because the larger Chinook salmon deposit their eggs deeper and into larger gravels than the smaller sockeye salmon adults (Seattle Public Utilities 2005). Seattle Public Utilities (2005) found that the smallest Chinook salmon females in the Lake Washington watershed are 15 percent larger than the largest sockeye salmon female, and potential redd superimposition impacts occur only from these largest sockeye salmon strays.

The overall risk of competition to Sammamish Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-76) for the reasons described above.

4.8.3.1.2 Predation

Predation risk levels for the Sammamish Chinook salmon population affected by Chinook salmon, coho salmon, and sockeye salmon hatchery programs under the four alternatives in the Lake Washington watershed are summarized in Table C-77.

Chinook Salmon and Coho Salmon Program Effects. Predation risk for the Sammamish Chinook salmon population affected by Chinook salmon and coho salmon hatchery programs under the four alternatives are summarized in Table C-77.

Predation risks to natural-origin juvenile Chinook salmon posed by the Issaquah Hatchery Chinook salmon and Portage Bay Hatchery Chinook salmon programs are low. Studies conducted in the Lake Washington watershed have not identified any instances of intra-species predation by hatchery-origin Chinook salmon (Tabor et al. 2004). The hatchery-origin fish are released in May and June when natural-origin Chinook salmon that are encountered have grown to a size that makes them unsusceptible to predation by the similarly sized Issaquah Hatchery and Portage Bay Hatchery subyearlings. This assessed low risk of predation applies under all alternatives (Table C-77).

The Issaquah Creek coho salmon program releases 450,000 yearling smolts during April into the uppermost portion of the watershed. The number of hatchery-origin coho salmon smolts released by the program is large relative to other coho salmon programs in Puget Sound. The large release size for the program, combined with the April timing of release and the relatively large average individual size of the yearlings produced (5.2 inches fork length), indicates the potential for their interaction with, and predation on, out-migrating and rearing juvenile natural-origin Sammamish Chinook salmon. Natural-origin Chinook salmon present in the vicinity of the release location have an average length of 2.1 to 2.7 inches fork length during April (Seiler et al. 2003b; Kiyohara 2013). Based on the risk levels estimated using the PCD Risk Model for similarly operated and located hatchery-origin coho salmon programs in Puget Sound, it is assumed that the predation risk for the Issaquah Creek coho salmon program would be moderate under all alternatives (Table C-77).

The Portage Bay Hatchery coho salmon program would release 90,000 fish into the Ship Canal connecting Lake Washington with Lake Union at an average length of 4.2 inches fork length during May as smolts (yearlings). These smolts would be expected to rapidly disperse into the lower watershed and seaward through the Ballard Locks. The Portage Bay Hatchery coho salmon smolts (which range in length from 2.8 to 3.3 inches fork length) would not be large enough to prey on any natural-origin juvenile Sammamish Chinook salmon that may be present during the May release period (Seiler et al. 2003b; Kiyohara 2013). For these reasons, Portage Bay Hatchery coho salmon would likely have minimal interactions with, and predation effects on, natural-origin Sammamish Chinook salmon out-migrating from upper watershed tributaries and dispersing into the lakes at the time the hatchery-origin fish are released. This low predation risk would apply to all alternatives, as the number of fish released would be the same (Table C-77).

Table C-77. Sammamish Chinook salmon predation risks by alternative.

Hatchery Program Risk	Alternatives 1 and 2	Alternative 3	Alternative 4
Issaquah Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Issaquah Hatchery integrated coho salmon yearling	Moderate	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Cedar River Hatchery integrated summer-run sockeye salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
Overall Risk	Moderate	Same as Alternative 1	Same as Alternative 1

Sockeye Salmon Program Effects. As mentioned under Subsection 4.8.3.1.1, Competition (Sammamish Chinook Salmon), unlike other Chinook salmon populations, assessments of risks to natural-origin Chinook salmon associated with the Cedar River Hatchery sockeye salmon program use the information on the biological baseline and effects presented in the Final SEIS for the Cedar River Sockeye Hatchery Project (Seattle Public Utilities 2005). The impacts of predation are evaluated in the Final SEIS by applying a combination of existing information, theory, and expert opinion to assess how Chinook salmon survival would be affected by a release level of 34 million sockeye salmon fry.

The overall predation risk from the Cedar River Hatchery integrated summer-run sockeye salmon program to natural-origin Chinook salmon is negligible under all alternatives (Table C-77) for the reasons described below. As described in Seattle Public Utilities (2005), sockeye salmon fry releases from the Cedar River Hatchery program would not be expected to present a substantial direct predation risk to natural-origin Sammamish Chinook salmon, or indirect risk by increasing the prey base and consequently the number of predators on juvenile Chinook salmon. Sockeye salmon fry released by the hatchery program would initially be of too small a size to be predators of co-occurring natural-origin Chinook salmon fry during out-migration from the Cedar River. Further, sockeye salmon are planktivorous (feed on plankton), not piscivorous, which makes direct predation on natural-origin Chinook salmon by hatchery-origin juvenile sockeye salmon during their freshwater rearing in Lake Washington highly unlikely. The primary predation-related risk to juvenile Chinook salmon survival would be indirect, associated with increased interaction with predators by attracting predators to commingled, abundant hatchery sockeye salmon fry, fingerlings, and smolts produced by the program. Although the program could result in some alteration in spatial distribution of some predators within the watershed, any shift in distribution would have a negligible effect on the survival of emigrating natural-origin Chinook salmon juveniles (Seattle Public Utilities). Finally, juvenile Chinook salmon and sockeye salmon rapidly segregate into different habitats during their lake rearing phases, further reducing the likelihood for substantial increases of predation effects on Chinook salmon associated with sockeye salmon hatchery production. Chinook salmon fry reside in shallow nearshore habitat in the southern third of Lake Washington from February through early May (Tabor et al. 2004), while sockeye salmon fry migrate rapidly into open water habitat with only a small fraction of the migrants overlapping briefly with juvenile Chinook salmon in nearshore marine areas.

The overall risk of predation to Sammamish Chinook salmon associated with all hatchery programs is moderate under all alternatives (Table C-77) for the reasons described above.

4.8.3.1.3 Genetics

Assessments of genetic risks to the Sammamish Chinook salmon population are based on results from the AHA Model for each alternative (Table C-78). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs and pHOS estimates for isolated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-78. Sammamish Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Issaquah Hatchery integrated fall-run Chinook salmon subyearling	0.18	High	Same as Alternative 1	Same as Alternative 1
Introgression risk from Portage Bay Hatchery isolated fall-run Chinook salmon subyearling[2]	100%	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

[2]Although pHOS is 100 percent from the AHA model, other than a few of these fish that escape to spawn in the Cedar River, there is no spawning by fish from this program at the hatchery location.

Genetic risks assigned for the Issaquah Hatchery integrated fall-run Chinook salmon program are high because PNI estimates are less than 0.25 under all alternatives (Table C-78) (Appendix E, Overview of the All-H Analyzer). PNI is low because first generation hatchery-origin fish from the Issaquah Hatchery would be expected to predominate in natural spawning areas for Sammamish Chinook salmon, and relatively few natural-origin fish would be incorporated as broodstock at the hatchery. Genetic risks for the Portage Bay Hatchery isolated fall-run Chinook salmon program are high because only hatchery-origin adults are used for broodstock under all alternatives (Appendix E, Overview of the All H Analyzer).

4.8.3.1.4 Hatchery Facilities and Operation

The Issaquah Hatchery integrated fall-run Chinook salmon program would continue to rear and release subyearling Chinook salmon that are part of the Sammamish Chinook salmon population. Broodstock would be collected as they return to the Issaquah Hatchery rack, and hatchery fish would be released each year into Issaquah Creek. Hatchery facility conditions and operational practices would remain the same under all alternatives. Evaluation results for the program using the HPV Tool are shown in Table C-79.

Table C-79. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Sammamish Chinook salmon.

Hatchery - Issaquah Hatchery integrated fall-run Chinook salmon subyearlings (facility and release locations: Issaquah Creek [RM 3])			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk**[1]
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Overall hatchery facilities and operation risks from the Issaquah Hatchery would be negligible under all alternatives (Table C-79), as there were no operational phases that received low compliance scores.

4.8.3.2 Benefits

4.8.3.2.1 Total Return

Table C-80 compares effects of the alternatives on the total return of adult hatchery-origin Sammamish Chinook salmon produced by the Issaquah Hatchery fall-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Sammamish Chinook salmon run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-80. Estimated total return contributions for Sammamish Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	10,000	10,000	10,000
Average natural-origin return	1,981	1,981	1,981
Projected average total return	11,981	11,981	11,981
Restoration spawner abundance[1]	10,500	10,500	10,500
Projected average total return as a percent of restoration spawner abundance	114	114	114

Source: Chinook returns are from Tynan (2008).
[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement are moderate for all alternatives, because the combined total run size is greater than 50 percent (114 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-80). Adult fish produced through the hatchery program would continue to be harvested with natural-origin Sammamish Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in West Coast Vancouver Island troll fisheries and in U.S. sport fisheries (assuming Nisqually fall-run Chinook salmon catch distributions continue to reflect patterns for other Puget Sound fall-run populations [CTC 2012]).

Limits on terminal area fisheries directed at Issaquah Hatchery adult Chinook salmon surplus to escapement goals because of harvest protection needs for natural-origin populations in the Lake Washington watershed would continue to lead to a large proportion of the total return escaping to Issaquah Creek and Issaquah Hatchery each year. The relative contribution of adult hatchery-origin fish to the total annual Sammamish Chinook salmon return would continue to be substantial relative to natural-origin production in the watershed.

4.8.3.2.2 Viability

Viability benefits to the Sammamish Chinook salmon population from the Issaquah Creek Hatchery integrated fall-run subyearling Chinook salmon program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Because there are no discernible genetic differences between the existing Sammamish River natural-origin Chinook salmon population and Issaquah Hatchery fish, the fish produced by the hatchery program are part of the Puget Sound Chinook salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Issaquah Hatchery integrated fall-run Chinook salmon program would benefit the abundance, diversity, and spatial structure of the Sammamish Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Sammamish Chinook salmon. Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Sammamish population of 249 fish. The estimated mean number of natural-origin spawners for this period is 56 fish. The remainder of the fish spawning naturally (193 fish or 78 percent of the mean spawning escapement) are hatchery-origin fall-run Chinook salmon produced by the program. Mark recovery sampling indicates that 23 percent of the Chinook salmon adults that spawned naturally in the 3 miles of creek downstream of the Issaquah Hatchery weir from 2003 to 2005 were natural-origin fish (Berge et al. 2006). Natural-origin fall-run Chinook salmon in the stream are likely the progeny of naturally spawning Issaquah Hatchery fall-run Chinook salmon produced upstream (fall-run Chinook salmon adults that are surplus to hatchery broodstock collection needs are passed upstream to spawn naturally) or downstream of the hatchery weir.

Diversity – The hatchery program would benefit diversity. The Issaquah Hatchery fall-run Chinook salmon are of Green River origin, which were transferred from Soos Creek Hatchery to the Issaquah Creek Hatchery beginning in 1937 "to create a Chinook salmon run in the Sammamish watershed" (WDF 1939). The Issaquah Hatchery program has been self-sustaining since 1992, when transfers of Green River-lineage fall-run Chinook salmon from other hatcheries ceased. The program would continue to maintain a large effective breeding population size (e.g., 4,633 fish from 1998 to 2001 [WDFW 2005g]). The program may be considered a genetic reserve for the existing population by conserving genetic diversity for the Sammamish Chinook salmon population.

Spatial Structure – The hatchery program has some benefit to spatial structure. The program seeds Issaquah Creek and the other Lake Sammamish tributaries with natural spawners, expanding habitat use and spatial structure of the population.

Productivity – The benefit of the hatchery program to productivity is unknown. The continuing low numbers of natural-origin spawners suggests that productivity in natural habitat remains poor, and that the contributions of naturally spawning hatchery-origin fish are not leading to improved productivity. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Sammamish population of 0.81. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda less than 1.0 reflects a population that is decreasing in size. In this case, the composite Sammamish naturally spawning population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4 the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be moderate.

4.8.3.3 Summary – Sammamish Chinook Salmon

Table C-75 summarizes the risks and benefits for all alternatives pertinent to the Sammamish River natural-origin Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the five hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from negligible to high, with a negligible risk for hatchery facilities and operation, moderate risk for predation, and high risk for competition and genetics. Benefits consist of a high benefit for abundance and moderate benefit for viability. There is no change in production among alternatives, and thus there are no changes in risks or benefits among alternatives.

4.8.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subection include site-specific measures followed by more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Predation. The following site-specific mitigation measure would help to decrease predation risks to the Sammamish Chinook salmon population.

- Delay the timing of hatchery fish releases for the Issaquah Hatchery coho salmon program to match periods when natural-origin juvenile Sammamish Chinook salmon have a size refuge from predation by the hatchery-origin fish, or until after the majority of Sammamish natural-origin juvenile Chinook salmon have emigrated seaward through the Ballard Locks.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the Sammamish Chinook salmon population.

- Replace the Portage Bay Hatchery broodstock with a Chinook salmon stock genetically the same as one of the two natural-origin populations present in the watershed. Implementation of this measure would reduce genetic introgression risks to natural-origin Chinook salmon populations posed by straying of hatchery-origin adults into natural spawning areas used by the natural-origin Sammamish Chinook salmon population.
- Increase the proportion of natural-origin Chinook salmon used as broodstock at Issaquah Hatchery to reduce the risk of genetic diversity and fitness loss in the Sammamish population.
- Reduce the number of hatchery-origin fish spawning naturally in the watershed by decreasing Portage Bay and Issaquah Hatchery Chinook salmon production or by removing returning adult hatchery-origin fish through increased fishery harvest or culling at existing barriers (Issaquah Hatchery weir and Landsburg Dam).

Provided in Table C-81 is a summary of potential mitigation measures for the Sammamish Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, and genetic risks, which are rated as high (competition and genetics) and moderate (predation) under Alternative 2, Alternative 3, and Alternative 4 (Table C-75). Reducing or terminating the programs would also help to reduce and/or eliminate all risk categories.

Table C-81. Potential mitigation measures for the Sammamish Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measure C5.
Predation	Apply Mitigation Measures P2, P5, and P6.
Genetics	Apply Mitigation Measures G1 and G2.

[1]Refer to Table C-2 for a description of each mitigation measure.

Application of these hatchery program mitigation measures through adaptive management would likely help reduce the risks of competition, predation, and genetic impacts from the Issaquah Hatchery Chinook salmon and coho salmon release programs on the natural-origin Sammamish Chinook salmon population.

Other measures, if implemented, would reduce the risk of genetic impacts posed by the Portage Bay Hatchery isolated fall-run Chinook salmon subyearling program for the natural-origin Sammamish Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the Sammamish population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.9 Cedar Chinook Salmon

4.9.1 Introduction

As shown in Table C-1, the Lake Washington watershed supports the Cedar fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.5, Lake Washington Chinook Salmon Populations, two fall-run natural-origin Chinook salmon populations occur in the Lake Washington watershed: the Cedar Chinook salmon population and the Sammamish Chinook salmon population. The Sammamish Chinook salmon population was discussed in Subsection 4.8, Sammamish Chinook Salmon, and the Cedar Chinook salmon population is discussed in this subsection. The Cedar Chinook salmon population occurs in the Cedar River up to Landsburg Dam (RM 22) and, since 2004, some adults have been transported above the dam to spawn naturally in the upper watershed.

The Cedar River is a tributary to Lake Washington at the southernmost extent of the lake. Hatcheries and associated programs and release sites within the Lake Washington watershed that may affect natural-origin Cedar Chinook salmon are evaluated according to their risks and benefits including the following streams:

- Issaquah Creek, tributary to Lake Sammamish
- Cedar River, tributary to Lake Washington
- Portage Bay in the Lake Washington Ship Canal

Fish from Cedar River migrate through Lake Washington and then through the Lake Washington Ship Canal to reach the marine waters of Puget Sound.

Four Chinook salmon hatchery programs, two coho salmon hatchery programs, and one sockeye salmon hatchery program from four hatcheries have the potential to impact the Cedar Chinook salmon population (Table C-82 and Table C-83), and are reviewed in this subsection.

Table C-82. Hatchery programs and categories of effects evaluated for Cedar Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Issaquah Hatchery integrated fall-run Chinook salmon subyearling	√	√	√			
	Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	√	√	√			
	Grovers Creek Hatchery and Satellite Rearing Ponds isolated Chinook salmon subyearling			√[1]			
	Grovers Creek Hatchery and Satellite Rearing Ponds isolated Chinook salmon yearling			√[1]			
Coho salmon	Issaquah Hatchery integrated coho salmon yearling	√	√				
	Portage Bay Hatchery isolated coho salmon yearling	√	√				
Sockeye salmon	Cedar River Hatchery integrated summer-run sockeye fry	√	√				

[1]Programs are evaluated together as a group for genetic risk.

Table C-83. Hatchery salmon production evaluated for Cedar Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Issaquah Hatchery integrated fall-run Chinook salmon subyearling	2,000,000	2,000,000	0	2,000,000	0
	Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	180,000	180,000	0	180,000	0
	TOTAL	2,180,000	2,180,000	0	2,180,000	0
Coho salmon	Issaquah Hatchery integrated coho salmon yearling	450,000	450,000	0	450,000	0
	Portage Bay Hatchery isolated coho salmon yearling	90,000	90,000	0	90,000	0
	TOTAL	540,000	540,000	0	540,000	0
Sockeye salmon	Cedar River Hatchery integrated summer-run sockeye fry	34,000,000	34,000,000	0	34,000,000	0
All	TOTAL	36,720,000	36,720,000	0	36,720,000	0

[1] Not shown are the two East Kitsap hatchery programs outside the population area that are analyzed for genetic risks only.

4.9.2 Methods

In conducting the analysis for the Cedar Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The Issaquah Hatchery integrated fall-run Chinook salmon subyearling and Portage Bay Hatchery isolated fall-run Chinook salmon subyearling programs are evaluated independently for competition, predation, and genetic risks. The programs are not evaluated for hatchery facilities and operation risks or total return and viability benefits because there are no hatchery facilities for Chinook salmon in the Cedar River watershed. The Grovers Creek Hatchery and Satellite Rearing Ponds isolated Chinook salmon subyearling and yearling programs are outside the Lake Washington watershed, but are evaluated for genetic risks because of the potential for strays from those programs to return to and spawn in the Cedar River.

- **Coho Salmon:** The Issaquah Hatchery integrated coho salmon yearling and Portage Bay Hatchery isolated coho salmon yearling programs are evaluated independently for competition and predation. The Laebugton Net Pen isolated coho salmon yearling program and Ballard Net Pen isolated coho salmon yearling program are not evaluated because these programs would release fish directly into marine water and fish would be released in marine areas removed from natural-origin Chinook salmon.
- **Steelhead:** There are no steelhead hatchery program releases in the Cedar River watershed.
- **Sockeye:** The Cedar River Hatchery integrated summer-run sockeye salmon fry program is evaluated for competition and predation risks.

4.9.3 Results

Results for the Cedar Chinook salmon population are summarized in Table C-84. The action alternatives would include use of an adaptive management approach, but the results in Table C-84 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-84 is explained in the subsequent subsections for this population.

Table C-84. Summary of hatchery-related risks and benefits for the Cedar Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	High	Same as Alternative 1	Same as Alternative 1
Predation	Moderate	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	NA	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	NA	Same as Alternative 1	Same as Alternative 1
Viability	NA	Same as Alternative 1	Same as Alternative 1

4.9.3.1 Risks

As described in Subsection 2.5, Lake Washington Chinook Salmon Populations, Lake Washington is one of two large lake systems in Puget Sound that have Chinook salmon populations. The size and biological complexity of the Lake Washington watershed that salmon use for migration and rearing creates a unique ecological situation compared to other Puget Sound systems. Thus, as for Sammamish Chinook salmon, it was not possible to use the PCD Risk Model to evaluate competition and predation effects on Cedar Chinook salmon. The same considerations applied above for evaluating competition and predation risks to Sammamish Chinook salmon by hatchery-origin Chinook salmon and coho salmon production (Subsection 4.8.3.1, Risks [Sammamish Chinook Salmon]) are used to assess risks to Cedar Chinook salmon. Because the two listed natural-origin Chinook salmon populations in the Lake Washington watershed share the same life history traits and conditions, competition and predation risks under the alternatives to juvenile Sammamish Chinook salmon presented above from Chinook salmon, coho salmon, and sockeye salmon hatchery programs (Subsection 4.8.3.1.1, Competition [Sammamish Chinook Salmon]) are assumed to be the same for Cedar Chinook salmon (Table C-85).

4.9.3.1.1 Competition

Competition risks to the Cedar Chinook salmon population from Chinook salmon, coho salmon, and sockeye salmon hatchery programs under the alternatives in the Lake Washington watershed are summarized in Table C-85. The competition risks from the Chinook salmon, coho salmon, and sockeye salmon programs are the same as those identified above for the Sammamish Chinook salmon population, and for the same reasons, range from low to high, with all programs having low risk except the Issaquah Hatchery integrated fall-run Chinook salmon subyearling program, which is a high risk.

The Issaquah Hatchery integrated fall-run Chinook salmon subyearling program would release 2 million Chinook salmon subyearlings under all alternatives (Table C-83) between May and June each year into the uppermost portion of the Lake Washington watershed at an average individual size of 3.1 inches fork length. The hatchery-origin Chinook salmon are similar in size to natural-origin Cedar Chinook salmon that may be encountered in the watershed after the fish are released into Issaquah Creek (average size of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). Therefore, there would be a high risk of resource competition with rearing and emigrating natural-origin juvenile Chinook salmon that may be present as the hatchery-origin fish emigrate seaward (Table C-85). This high competition risk applies under all alternatives, because the number of fish released would be the same.

Overall competition risk is high under Alternative 1 and Alternative 2 (Table C-85). Because production does not change among alternatives, risk levels also do not change among alternatives. See Subsection 4.8.3.1.1, Competition (Sammanish Chinook Salmon) above for a detailed explanation of these risk ratings.

Table C-85. Cedar Chinook salmon competition risks by alternative.

Hatchery Program Risk	Alternatives 1 and 2	Alternative 3	Alternative 4
Issaquah Hatchery integrated fall-run Chinook salmon subyearling	High	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Issaquah Hatchery integrated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Cedar River Hatchery integrated summer-run sockeye fry	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk	High	Same as Alternative 1	Same as Alternative 1

4.9.3.1.2 Predation

Predation risks to Cedar Chinook salmon from the Chinook salmon, coho salmon, and sockeye salmon hatchery programs are the same as those identified above for the Sammamish Chinook salmon population, and for the same reasons, range from negligible to moderate (Table C-86), with a moderate risk from the Issaquah Hatchery integrated coho salmon yearling program (Table C-86).

The Issaquah Creek coho salmon program releases 450,000 yearling smolts during April into the uppermost portion of the watershed. The relatively large size of the program, combined with the April timing of release and the relatively large individual size of the yearlings produced (5.2 inches fork length), indicates the potential for their interaction with emigrating and rearing juvenile natural-origin Cedar Chinook salmon. Natural-origin Chinook salmon present in the vicinity of the release location have an average size of 2.1 to 2.7 inches fork length during April (Seiler et al. 2003b; Kiyohara and Zimmerman 2012). Based on the risk levels estimated using the PCD Risk Model for similarly operated and located hatchery-origin coho salmon programs in Puget Sound, it is assumed that the predation risk for the Issaquah Creek coho salmon program would be moderate under all alternatives (Table C-86).

Overall predation risk is moderate. Because production does not change among alternatives, risk levels also do not change among alternatives. See Subsection 3.8.3.1.2, Predation (Sammamish Chinook Salmon) above for a detailed explanation of these risk ratings.

Table C-86. Cedar Chinook salmon predation risks by alternative.

Hatchery Program Risk	Alternatives 1 and 2	Alternative 3	Alternative 4
Issaquah Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Issaquah Hatchery integrated coho salmon yearling	Moderate	Same as Alternative 1	Same as Alternative 1
Portage Bay Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Cedar River Hatchery integrated summer-run sockeye fry	Negligible	Same as Alternative 1	Same as Alternative 1
Overall Risk	Moderate	Same as Alternative 1	Same as Alternative 1

4.9.3.1.3 Genetics

Assessments of genetic risks to the Cedar Chinook salmon population are primarily based on results from the AHA Model for each alternative (Table C-87). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs and pHOS estimates for isolated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-87. Cedar Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Issaquah Hatchery integrated fall-run Chinook salmon subyearling	0.18	High	Same as Alternative 1	Same as Alternative 1
Introgression risk from Portage Bay Hatchery isolated fall-run Chinook salmon subyearling[2]	100%	High	Same as Alternative 1	Same as Alternative 1
Introgression risk from other out-of-watershed hatcheries (e.g., Grover's Creek Hatchery isolated fall-run Chinook salmon subyearling and yearling programs)	NA	Moderate	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

[2]Although pHOS is 100 percent from the AHA model, other than a few of these fish that escape to spawn in the Cedar River, there is no spawning by fish from this program at the hatchery location.

Although the programs contributing to genetic risk do not release fish directly into the Cedar River watershed, a substantial number of hatchery-origin adults originating from these hatchery programs return to natural spawning grounds in the Cedar River watershed as strays. Genetic risks assigned for the Issaquah Hatchery integrated fall-run Chinook salmon program are high because PNI estimates are less than 0.25 under all alternatives (Table C-87) (Appendix E, Overview of the All-H Analyzer). PNI is low because first generation hatchery-origin fish would be expected to predominate in natural spawning areas for Cedar Chinook salmon, and relatively few natural-origin fish would be incorporated as broodstock at the hatchery. Portage Bay Hatchery Chinook salmon are not included as part of the listed Puget Sound Chinook Salmon ESU (NMFS 2006b). Genetic risks assigned for the Portage Bay Hatchery isolated fall-run Chinook salmon program are high primarily because the estimates of pHOS are 100 percent under all alternatives (Table C-87) (Appendix E, Overview of the All H Analyzer) as all spawners would be hatchery-origin fish.

Introgression risk to the Cedar Chinook salmon population is moderate because of strays from other out-of-watershed hatchery-origin Chinook salmon stocks. From 2003 to 2005, an average of about 30 percent of the total number of Chinook salmon returning to the Cedar River watershed were of hatchery origin (estimated from mark and coded wire tag recoveries). Most of the hatchery-origin Chinook salmon returning to the Cedar River watershed were from the Portage Bay Hatchery. Strays have also been detected from other hatcheries, including the Grover’s Creek Hatchery located on the Kitsap Peninsula, Issaquah Hatchery, Bernie Kai-Kai Gobin Hatchery, and Cowlitz River Hatchery (a hatchery located on a tributary of the lower Columbia River) (Berge et al. 2006).

4.9.3.1.4 Hatchery Facilities and Operation

Hatchery-origin Cedar Chinook salmon are not produced under any alternative and therefore hatchery facilities and operation effects are not evaluated.

4.9.3.2 Benefits

Hatchery-origin Cedar Chinook salmon are not produced under any alternative and therefore total return and viability benefits are not evaluated.

4.9.3.3 Summary – Cedar Chinook Salmon

Table C-84 summarizes the risks and benefits for all alternatives pertinent to the Cedar Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the seven hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from moderate to high, with a moderate risk for predation and high risks for competition and genetics. There are no hatchery facilities and operation risks and no benefits associated with the Cedar Chinook salmon population, because no programs produce hatchery-origin fish for this population. There is no change in production among alternatives, and thus there are also no changes in risks among alternatives.

4.9.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the Cedar Chinook salmon population.

- Replace the Portage Bay Hatchery broodstock with a Chinook salmon stock genetically the same as one of the two natural-origin populations present in the watershed. Implementation of this measure would reduce genetic introgression risks to natural-origin Chinook salmon populations posed by straying of hatchery-origin adults into natural spawning areas for the Cedar population.

- Reduce the number of hatchery-origin fish spawning naturally in the watershed by decreasing Portage Bay and Issaquah Hatchery Chinook salmon production or by removing returning adult hatchery-origin fish through increased fishery harvest or culling at existing barriers (Issaquah Hatchery weir and Landsburg Dam).

Provided in Table C-88 is a summary of potential mitigation measures for the Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, and genetic risks, which are rated as high (competition and genetics) and moderate (predation) under Alternative 2, Alternative 3, and Alternative 4 (Table C-84).

Table C-88. Potential mitigation measures for the Cedar Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measure C5.
Predation	Apply Mitigation Measures P2, P5, and P6.
Genetics	Apply Mitigation Measures G1 and G2.

[1]Refer to Table C-2 for a description of each mitigation measure.

Following the proposed adaptive management approach, application of these hatchery program mitigation measures would likely help reduce the risks of competition, predation and genetic impacts from the two Issaquah Hatchery salmon programs (Chinook salmon and coho salmon) on the natural-origin Cedar Chinook salmon population. Other measures, if implemented, would reduce the risk of genetic impacts by the Chinook salmon programs (Issaquah Hatchery fall-run Chinook salmon subyearling program, Portage Bay hatchery isolated fall-run Chinook salmon subyearling program, and Grover's Creek isolated fall-run Chinook salmon subyearling and yearling programs) for the natural-origin spawning Cedar Chinook salmon population.

4.10 Green Chinook Salmon

4.10.1 Introduction

As shown in Table C-1 and as described in Subsection 2.6, Green Chinook Salmon Population, the Green River watershed supports the Green fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. Green Chinook salmon spawn in the Green River mainstem up to RM 61, where a diversion dam and Howard Hanson Dam block all fish passage, and in two tributaries: Newaukum and Soos Creeks. Hatchery-origin Green Chinook salmon are propagated by programs on Soos, Icy, and Keta Creeks, are derived from the local indigenous populations, and are part of the listed ESU. Returning hatchery adults contribute substantially to natural spawning.

Hatcheries and associated programs and release sites relevant to the Green Chinook salmon natural-origin population are evaluated according to their risks and benefits, including effects that occur within the following rivers and streams:

- Green River
- Soos Creek, tributary to the Green River at RM 33
- Icy Creek, tributary to the Green River at RM 48.3
- Keta Creek, located at RM 1.0 on Crisp Creek, a tributary to the Green River at RM 40.2

- The Green River becomes the Duwamish River at RM 12. The Green River watershed is often referred to as the Duwamish/Green River watershed; however, both terms refer to the same population and watershed for this EIS.

Three Chinook salmon hatchery programs, two coho salmon hatchery programs, and three steelhead hatchery programs operated at four hatcheries have the potential to impact the Green Chinook salmon population (Table C-89 and Table C-90), and are reviewed in this subsection.

Table C-89. Hatchery programs and categories of effects evaluated for Green Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Soos Creek Hatchery integrated fall-run Chinook subyearling	√	√	√[1]	√	√[2]	√[2]
	Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook yearling	√	√	√[1]	√	√[2]	√[2]
	Keta Creek Hatchery integrated fall-run Chinook subyearling	√	√	√[1]		√[2]	√[2]
Coho salmon	Soos Creek Hatchery integrated coho salmon yearling	√	√				
	Crisp Creek Ponds integrated coho salmon yearling	√	√				
Steelhead	Palmer Pond isolated winter-run steelhead yearling	√	√				
	Palmer Pond isolated summer-run steelhead yearling	√	√				
	Soos Creek Hatchery Green River stock integrated winter-run steelhead yearling	√	√				

[1] Programs are evaluated together as a group for genetic risk.
[2] Programs are evaluated together as a group for total return benefit.
[3] Programs are evaluated together as a group for viability benefit.

Table C-90. Hatchery salmon and steelhead production evaluated for Green Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Soos Creek Hatchery integrated fall-run Chinook subyearling	3,200,000	1,600,000	50	3,200,000	0
	Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook yearling	300,000	150,000	50	300,000	0
	Keta Creek Hatchery integrated fall-run Chinook subyearling	600,000	300,000	50	600,000	0
	Total subyearlings	3,800,000	1,900,000	50	3,800,000	0
	Total yearlings	300,000	150,000	50	300,000	0
	TOTAL	4,100,000	2,050,000	50	4,100,000	0
Coho salmon	Soos Creek Hatchery integrated coho salmon yearling	600,000	300,000	50	600,000	0
	Crisp Creek Ponds integrated coho salmon yearling	200,000	100,000	50	200,000	0
	TOTAL	800,000	400,000	50	800,000	0
Steelhead	Palmer Pond isolated winter-run steelhead yearling	220,000	107,500	51	278,000	26
	Palmer Pond isolated summer-run steelhead yearling	80,000	40,000	50	80,000	0
	Soos Creek Hatchery Green River stock integrated winter-run steelhead yearling	50,000	50,000	0	50,000	0
	TOTAL	350,000	197,500	44	408,000	17
All	TOTAL	7,250,000	4,647,500	50	7,308,000	1

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.10.2 Methods

In conducting the analysis for the Green Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The Soos Creek Hatchery integrated fall-run Chinook salmon subyearling and Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling programs are evaluated independently for competition, predation, and hatchery facilities and operation effects, but are evaluated together, along with the Keta Creek Hatchery integrated fall-run Chinook subyearling program, for genetic risk, total return, and viability benefits because these latter effects are inseparable for the three programs because they all use the same broodstock. The Keta Creek Hatchery integrated fall-run Chinook salmon subyearling program is evaluated independently for competition and predation, and is not evaluated for hatchery facilities and operation because the hatchery is located in the upper Green River watershed above Howard Hanson Dam at RM 60.5 where salmon passage is blocked, and thus would not affect natural-origin Green Chinook salmon.
- **Coho Salmon:** The Soos Creek Hatchery integrated coho salmon yearling and Crisp Creek Ponds integrated coho salmon yearling programs are evaluated independently for competition and predation. The Elliot Bay net pens integrated coho salmon yearling, Des Moines net pen isolated coho salmon yearling, and Agate Pass seapens isolated coho salmon yearling programs are not evaluated because releases occur into marine waters. The Marine Technology Center isolated coho salmon program is not evaluated because the release site is not within a stream occupied by natural-origin Chinook salmon (Seahurst Park in Burien, Washington).
- **Steelhead:** The Palmer Ponds isolated winter-run steelhead yearling, Palmer Ponds isolated summer-run steelhead yearling, and Soos Creek Hatchery Green River stock integrated winter-run steelhead yearling programs are evaluated separately for competition and predation.

4.10.3 Results

Results for the Green Chinook salmon population are summarized in Table C-91. The action alternatives would include use of an adaptive management approach, but the results in Table C-91 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-91 is explained in the subsequent subsections for this population.

Table C-91. Summary of hatchery-related risks and benefits for the Green Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	High	Moderate	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Low	Same as Alternative 1

4.10.3.1 Risks

4.10.3.1.1 Competition

Competition risks to the Green Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Green River watershed are summarized in Table C-92. Competition risks range from negligible to high.

Table C-92. Green Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Soos Creek Hatchery integrated fall-run Chinook salmon subyearling	11.0 (8.9 under Alternative 3	High	Moderate	Same as Alternative 1
Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling	0 (0 under Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Keta Creek Hatchery integrated fall-run Chinook salmon subyearling	6.7 (3.5 under Alternative 3)	Moderate	Low	Same as Alternative 1
Soos Creek Hatchery integrated coho salmon yearling	0.1 (0 under Alternative 3)	Negligible	Negligible	Negligible
Palmer Pond isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Palmer Pond isolated summer-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Soos Creek Hatchery Green River stock integrated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Moderate	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

The Soos Creek Hatchery integrated fall-run Chinook salmon subyearling program poses a high competition risk to natural-origin Chinook salmon under Alternative 1 and Alternative 2 (Table C-92), primarily because of the large size of the Soos Creek Hatchery release (3.2 million fish per year) (Table C-90), which represents a large proportion (81 percent) of the total number of hatchery and natural-origin Chinook salmon juveniles estimated to emigrate each year (natural production averages 760,500 out-migrants per year [Appendix D, PCD RISK 1 Assessment]). Additionally, the Soos Creek Hatchery would continue to release fish relatively high in the Green River watershed (RM 34) during the time of the natural-origin Chinook salmon out-migration. Thus, the prospects for and duration of interaction with natural-origin Chinook salmon and the resulting risk of competitive impacts are high.

Under Alternative 3, the competition risk to natural-origin Green Chinook salmon risk is moderate, because the number of fish released would decrease 50 percent (to 1,600,000 million fish per year), compared to Alternative 1 (Table C-90). The competition risk from Chinook salmon releases from the Keta Creek Hatchery is moderate under Alternative 1 and Alternative 2 (Table C-92), primarily because releases would occur high in the Green River watershed (RM 60.5) and during the time of the natural-origin Chinook salmon out-migration. Under Alternative 3, the competition risk from Keta Creek Hatchery releases decreases to low because the number of fish released would be 50 percent less (to 300,000 fish per year) (Table C-90) than under Alternative 1 and Alternative 2. The competition risk from steelhead hatchery programs is low (Table C-92) because all steelhead hatcheries would release fish in May, after the predominant time of the natural-origin Chinook salmon out-migration (peak out-migration of Chinook salmon smolts is typically in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). Under Alternative 4, production levels would be the same as Alternative 1 and Alternative 2; thus, the competition risk is also high. Overall risks are high under Alternative 1 and Alternative 2, moderate under Alternative 3, and high under Alternative 4 (Table C-92).

4.10.3.1.2 Predation

Predation risks to the Green Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-93. Risks of predation range from negligible to high.

Table C-93. Green Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Soos Creek Hatchery integrated fall-run Chinook subyearling	4.3 (2.5 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook yearling	18.4 (8.8 under Alternative 3)	High	Moderate	Same as Alternative 1
Keta Creek Hatchery integrated fall-run Chinook subyearling	0.2 (0.1 under Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Soos Creek Hatchery integrated coho salmon yearling	17.0 (8.1 under Alternative 3)	High	Moderate	Same as Alternative 1
Crisp Creek Ponds integrated coho salmon yearling	4.4 (2.1 under Alternative 3, 6.6 under Alternative 4)	Low	Low	Moderate
Palmer Pond isolated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Palmer Pond isolated summer-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Soos Creek Hatchery Green River stock integrated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1] If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Under Alternative 1 and Alternative 2, the predation risk associated with the Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling program is high (Table C-93). The Soos Creek Hatchery/Icy Creek Hatchery Chinook salmon yearlings would be released high in the Green River watershed (RM 48) at a large individual size (average size 6.1 inches fork length) (EIS Table 3.2-4) compared to the natural-origin Chinook salmon (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4) present in the watershed at the time the hatchery-origin fish are released. These release size and location factors contribute to the high predation risk for the Soos Creek Hatchery/Icy Creek Hatchery yearling program. The predation risk for the program is reduced to moderate under Alternative 3 because the yearling Chinook salmon release levels would be reduced by 50 percent (from 300,000 to 150,000 fish) (Table C-90). Under Alternative 4, production levels would be the same as Alternative 1 and Alternative 2; thus, the predation risk is also high.

Under Alternative 1 and Alternative 2, the predation risk to natural-origin Green Chinook salmon from coho salmon yearling releases from the Soos Creek Hatchery program is high. The coho salmon yearlings are large enough (6.1 inches fork length) to consume natural-origin juvenile Green Chinook salmon (2.2 inches fork length) (WDFW 2005h) that they would encounter at the time the coho salmon are released. Also, the program would release a relatively large number (600,000 fish) (Table C-90) of coho salmon yearlings each year, which would increase the likelihood for interactions with and predation on natural-origin Chinook salmon in the vicinity of the release site and downstream. Under Alternative 3, the predation risk for the coho salmon program would decrease to moderate because the number of coho salmon released would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-90). Under Alternative 4, production levels would be the same as Alternative 1 and Alternative 2; thus, the predation risk is also high.

Predation risks for the three steelhead hatchery programs affecting Green Chinook salmon are high under all alternatives (Table C-93), primarily because releases under the three programs would use at least one site at or above RM 20, which would create a high potential for interaction with the smaller natural-origin Chinook salmon rearing and emigrating in the Green River.

The overall risk of predation impacts associated with hatchery-origin salmon and steelhead production in the watershed is high under all alternatives (Table C-93).

4.10.3.1.3 Genetics

Assessments of genetic risks to the Green Chinook salmon population are primarily based on PNI estimates from the AHA Model for each alternative (Table C-94). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-94. Green Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Soos Creek Hatchery integrated fall-run Chinook subyearling, Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook yearling, and Keta Creek Hatchery integrated fall-run Chinook subyearling	0.23 (0.36 for Alternative 3)	High	Moderate	Same as Alternative 1
Introgression risk from straying hatchery-origin fish (loss of among-population diversity)	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Moderate	Same as Alternative 1

Genetic risks to Green Chinook salmon are high under Alternative 1, Alternative 2, and Alternative 4 (Table C-94), primarily because the PNI estimate is less than 0.35 (Table C-94) (Appendix E, Overview of the All H Analyzer). Chinook salmon produced by the Soos Creek Hatchery integrated fall-run Chinook salmon subyearling, Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling, and the Keta Creek Hatchery integrated fall-run Chinook salmon subyearling programs would continue to originate from the same broodstock collected from adult returns to Soos Creek Hatchery each year. Also contributing to the high genetic risk is the relatively large proportion of hatchery-origin fish spawning naturally each year, averaging 46 percent of the total escapement (NMFS 2011b). Under Alternative 3, the number of Chinook salmon released would decrease 50 percent and genetic risk would be moderate for this alternative because estimated PNI would be between 0.35 and 0.67 (Table C-94) (Appendix E, Overview of the All H Analyzer).

Hatchery-origin Chinook salmon may stray from other watersheds and spawn in the Green River watershed, which poses a genetic risk to the natural-origin Chinook salmon population. Hatchery-origin Chinook salmon from other watersheds in southern Puget Sound have been recovered at the Soos Creek Hatchery rack, indicating that strays could be spawning naturally in the Green River watershed.

4.10.3.1.4 Hatchery Facilities and Operation

Two hatchery programs below Howard Hansen Dam are evaluated for hatchery facilities and operation risks (Soos Creek Hatchery integrated fall-run subyearling and Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run yearling programs), and would continue to rear and release hatchery-origin fish that are part of the Green Chinook salmon population. Although the source of broodstock is the same for both programs, the programs are evaluated independently using the HPV Tool. Hatchery facility conditions and operational practices for the programs would remain the same under all alternatives. Evaluation results for the programs are shown in Table C-95 and Table C-96.

For the Soos Creek Hatchery integrated fall-run Chinook subyearling program, the overall hatchery facilities and operation risk would be negligible under all alternatives (Table C-95) because no operational phases received a low compliance score, even though release levels for Alternative 3 would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-90).

Table C-95. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Green Chinook subyearling salmon.

Hatchery - Soos Creek Hatchery integrated fall-run subyearling program (facility and release location: Green River)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Moderate	Moderate	
Facilities	NA	Moderate	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

For the Soos Creek Hatchery/Icy Creek Hatchery yearling program, the overall risk of hatchery facilities and operation impacts to the listed Green Chinook salmon natural-origin population is moderate under Alternative 1, Alternative 2, and Alternative 4 (Table C-96), because compliance for the program would be low for the release operational phase. Under Alternative 3, the risk is low because the release levels for the program would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-90).

Table C-96. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Green Chinook yearling salmon.

Hatchery - Soos Creek Hatchery/Icy Creek integrated fall-run yearling program (facility and release location: Green River)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	High	
Adult Holding	High	Moderate	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Low	Low	
Facilities	NA	Moderate	
			Moderate (Low for Alternative 3)

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives. Otherwise, risks are shown for each alternative that is different than Alternative 1.

Releasing hatchery-origin fish that are not similar to natural-origin fish in size, behavior, growth rate, and physiological status may alter performance and increase competition and predation impacts in the natural-origin fish. Releasing hatchery-origin yearling fish from the Soos Creek Hatchery/Icy Creek Hatchery acclimation pond may increase survival rates for adult returns, but this practice may increase the risk of competition and predation impacts on co-occurring natural-origin Chinook salmon juveniles. If the hatchery-origin yearlings are released in a not fully smolted condition, the risk of residualism or delayed out-migration would be elevated, increasing the duration of interaction between the hatchery-origin and natural-origin Chinook salmon in fresh water and the potential for competition and predation impacts.

Given that hatchery practices applied at the Soos Creek/Icy Creek Hatchery require release of yearlings as migration-ready smolts, the potential for rapid out-migration is increased. By emigrating from freshwater bottleneck areas rapidly, the potential for interactions with natural-origin Chinook salmon juveniles is reduced.

4.10.3.2 Benefits

4.10.3.2.1 Total Return

Table C-97 compares effects of the alternatives on the total return of adult hatchery-origin Green River Chinook salmon produced by the Soos Creek Hatchery subyearling, Soos Creek Hatchery/Icy Creek Hatchery yearling, and Keta Creek Hatchery subyearling hatchery programs. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Green Chinook salmon adult run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-97. Estimated total return contributions for Green Chinook salmon.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Average hatchery-origin return	18,060	9,030	18,060
Average natural-origin return	21,597	21,597	21,597
Projected average total return	39,657	30,627	39,657
Restoration spawner abundance[1]	22,000	22,000	22,000
Projected average total return as a percent of restoration spawner abundance	180	139	180

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be high for all alternatives, because the combined total run size would be over 50 percent (139 to 180 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-97). Hatchery-origin adults from the programs would continue to be harvested with natural-origin Green Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in West Coast Vancouver Island troll fisheries and in U.S. sport and troll fisheries (assuming Nisqually fall-run Chinook salmon catch distributions [CTC 2012). Treaty Indian net and Washington sport fisheries in the terminal area would also target adult Chinook salmon that are identified as surplus to escapement. Hatchery-origin Chinook salmon would constitute about 30 percent (Alternative 3) to 45 percent (Alternative 1, Alternative 2, and Alternative 4) of the total annual Green Chinook salmon adult return each year (Table C-97).

4.10.3.2.2 Viability

Viability is evaluated separately for each of the three integrated hatchery programs that benefit the Green Chinook salmon population. Viability results from the three programs are provided in Table C-98.

Table C-98. Green Chinook salmon viability benefits by alternative.

Hatchery Program	Alternatives 1 and 2	Alternative 3	Alternative 4
Soos Creek Hatchery integrated fall-run Chinook salmon subyearling	Moderate	Same as Alternative 1	Same as Alternative 1
Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling	Moderate	Low	Same as Alternative 1
Keta Creek Hatchery integrated fall-run Chinook salmon subyearling	Moderate	Low	Same as Alternative 1

Soos Creek Hatchery Integrated Fall-run Subyearling Program. Viability benefits to the Green Chinook salmon population from the Soos Creek Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Soos Creek Hatchery integrated fall-run Chinook salmon subyearling program would benefit the abundance, diversity, and spatial structure of the Green Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Green Chinook salmon. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Green population of 3,077 fish. The estimated mean number of natural-origin spawners for this period is 1,288 fish. The remainder of the fish spawning naturally (1,789 fish or 58 percent of the mean spawning escapement) are hatchery-origin Chinook salmon (composite of Chinook salmon hatchery programs in the Green River).

Diversity – The hatchery program would benefit diversity, as the hatchery program would continue to serve as a genetic reserve for the composite hatchery-origin and natural-origin population. Natural spawners in the Green River watershed (sampled in Newaukum Creek) are genetically similar to Soos Creek Hatchery fish (Marshall et al. 1995). Genetic exchange would continue to occur between natural-origin Green Chinook salmon and hatchery-origin Chinook salmon that return to the hatchery weir and are spawned each year, and between stray hatchery-origin and natural-origin fish that together spawn naturally in the watershed. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly over the breadth of the natural and hatchery-origin adult fish return period to Soos Creek, a large effective breeding population size would be maintained, a factorial mating scheme would be used during spawning, and adult fish would continue to be allowed to access upstream areas in Soos Creek for natural spawning. These measures would continue to maintain the diversity of the propagated population.

Spatial Structure – The hatchery program would benefit spatial structure. Fish released through the program would return predominantly to Soos Creek and to mainstem Green River spawning areas in the vicinity of the river's confluence with Soos Creek. Adult fish would also continue to stray into Green River watershed areas above Soos Creek to spawn naturally. Adult hatchery-origin fish would also be allowed access to upstream areas in Soos Creek to spawn naturally. Thus, the spatial structure of the Green population would be benefited by the program by extending the use of Soos Creek and the Green River by naturally spawning fish.

Productivity – The benefit of the hatchery program to productivity is unknown. However, the relatively poor abundance status of the natural-origin population (and as evidenced by recent mark recovery data showing that first generation hatchery-origin fall-run Chinook salmon account for a large proportion of natural spawning in the river) indicates that the productivity of the natural-origin population in the existing habitat is poor. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Green Chinook salmon population of 0.84. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the lambda for the composite naturally spawning population in the Green River is less than 1.0, and thus the population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger. Substantial numbers of Soos Creek Hatchery fall-run Chinook salmon spawning naturally in the Green River watershed do not appear to have improved productivity of the natural-origin Green Chinook salmon population.

Under Alternative 3, the overall benefit of the Soos Creek hatchery program to viability would be moderate. The annual subyearling release level would be reduced 50 percent under Alternative 3 compared to Alternative 1 and Alternative 2 (Table C-90), but all other aspects of the program would be the same. The reduced release level under Alternative 3 would remain sufficient to benefit Green Chinook salmon abundance, diversity, and spatial structure, although to a lesser extent than under Alternative 1 and Alternative 2. Benefits to total abundance under Alternative 3 would be an estimated 7,200 fish compared to 14,400 fish under Alternative 1 and Alternative 2 (Tynan 2008). Benefits to diversity would be lower because fewer fish would contribute to a genetic reserve, and spatial structure benefits would be less because there would be fewer fish to use available habitat for spawning by the composite Green population. Benefits to productivity would remain unknown.

Under Alternative 4, the number of hatchery-origin subyearling Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate.

Soos Creek Hatchery/Icy Creek Hatchery Integrated Fall-run Yearling Program. Viability benefits to the Green Chinook salmon population from the Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling program would benefit the abundance and spatial structure of the Green Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Green Chinook salmon. The yearling hatchery program would rely on broodstock collected at Soos Creek Hatchery. Icy Creek yearlings survive to return at a fairly high rate. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Green population of 3,077 fish. The estimated mean number of natural-origin spawners for this period is 1,288 fish. The remainder of the fish spawning naturally (1,789 fish or 58 percent of the mean spawning escapement) are hatchery-origin summer-run Chinook salmon (composite of Chinook salmon hatchery programs in the Green River).

Diversity – The yearling hatchery program would have a negligible benefit to diversity. Because of the longer duration of hatchery rearing needed to produce yearling fish, hatchery-origin fall-run Chinook salmon from the Soos Creek Hatchery/Icy Creek Hatchery would be likely at higher risk of hatchery-induced selection relative to subyearling fish (Berejikian and Ford 2004). In addition, because the purpose of adult fish produced by the Soos Creek Hatchery/Icy Creek Hatchery Chinook salmon yearling program would not be to sustain the hatchery program (broodstock for the program would be collected from fish returning to Soos Creek), the potential benefit of the program to natural-origin Green Chinook salmon diversity would be incidental.

Spatial Structure – The yearling hatchery program would benefit spatial structure. Fish would be released relatively high in the Green River watershed (RM 48). Hatchery-origin adults from the Icy Creek Hatchery have been observed spawning both in the mainstem of the Green River near the release site and in upper river tributaries (Newaukum Creek). These watershed areas are historically used by the Green River natural-origin population, and the program would be expected to contribute spawners to these areas and thus benefit population spatial structure.

Productivity – The yearling hatchery program would have a negligible benefit to productivity. The purpose of adult fish produced by the Soos Creek Hatchery/Icy Creek Hatchery Chinook salmon yearling program would not be to sustain the hatchery program (broodstock for the program would be collected from fish returning to Soos Creek), therefore the potential benefit of the program to natural-origin Green Chinook salmon productivity would be incidental.

Under Alternative 3, the benefit of the yearling hatchery program to viability would be low. The number of yearlings released would be reduced 50 percent relative to Alternative 1 and Alternative 2 (Table C-90), and correspondingly fewer adult fish would return (an estimated 1,650 fish versus 3,300 fish [Tynan 2008]). Benefits to the total abundance of the Green Chinook salmon population would remain, but at a reduced level because of the favorable survival of yearling releases. All other aspects of the program would remain unchanged and benefits to diversity, spatial structure, and productivity would be negligible.

Under Alternative 4, the number of hatchery-origin Chinook salmon yearlings released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate.

Keta Creek Hatchery Integrated Fall-run Chinook Salmon Subyearling Program. Viability benefits to the Green Chinook salmon population from the Keta Creek Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Keta Creek Hatchery integrated fall-run Chinook salmon subyearling program would benefit the spatial structure and productivity of the Green Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would have a negligible benefit to the abundance of Green fall-run Chinook salmon. Fish produced by the program would continue to be released upstream of Howard Hansen Dam. Downstream survival rates for hatchery-origin Chinook salmon subyearlings released by the program have been poor (1 to 14 percent through Howard Hanson Dam [Muckleshoot Indian Tribe 2003a]), and would likely continue to be so. The estimated annual adult fish contribution to the Green Chinook salmon population from subyearlings released from the program would be 360 fish under Alternative 1 and Alternative 2 (Tynan 2008). Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Green population of 3,077 fish. The estimated mean number of natural-origin spawners for this period is 1,288 fish. The remainder of the fish spawning naturally (1,789 fish or 58 percent of the mean spawning escapement) are hatchery-origin summer-run Chinook salmon (composite of Chinook salmon hatchery programs in the Green River).

Diversity – The hatchery program would have a negligible benefit to diversity. The program relies on broodstock collected at Soos Creek Hatchery, and the Keta Creek Hatchery program would provide no additional benefit.

Spatial Structure – The hatchery program would benefit spatial structure. Fish produced through the program would continue to be released upstream of Howard Hansen Dam to spawn naturally in areas blocked to returning adults until upstream passage was provided in 2005. Spatial structure would benefit to the extent hatchery-origin Chinook salmon migrate into and help recolonize the upper Green River watershed.

Productivity – The hatchery program would benefit productivity. Fish produced by the program would continue to be released upstream of Howard Hansen Dam to spawn naturally in areas that were blocked to returning adult salmon until upstream passage was provided in 2005. Productivity would benefit to the extent hatchery-origin Chinook salmon migrate into and help recolonize the upper Green River.

Under Alternative 3, the benefit of the subyearling hatchery program to viability would be low. The annual subyearling release level under Alternative 3 would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-90). Benefits to the total abundance of the Green Chinook salmon population would be reduced relative to Alternative 1 and Alternative 2, as fewer adult fish (an estimated 180 fish versus 360 fish [Tynan 2008]) would be produced through the program. Benefits to population abundance, diversity, and productivity would be negligible, and relative benefits to spatial structure would be decreased relative to Alternative 1 and Alternative 2.

Under Alternative 4, the number of hatchery-origin Chinook salmon subyearlings released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate.

4.10.3.3 Summary – Green Chinook Salmon

Table C-91 summarizes the risks and benefits for all alternatives pertinent to the Green Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from moderate to high, with moderate risks identified for hatchery facilities and operation, and high risks for competition, predation, and genetics. Benefits are moderate for viability and high for total return. Reduced production under Alternative 3 decreases the risk level for competition to moderate, hatchery facilities and operation to low, and viability benefits to low, compared to Alternative 1 and Alternative 2. Production levels are the same under Alternative 4 as under Alternative 1 and Alternative 2, and therefore risks and benefits are also the same. All other risks and benefits are the same across alternatives.

4.10.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures followed by more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Predation. The following site-specific mitigation measures would help to decrease predation risks to the Green Chinook salmon population.

- Eliminate on-station hatchery-origin Chinook salmon yearling releases from the Icy Creek Hatchery program. Transport fish ready for release to a down-river location where there would be less interaction with, and predation risks to, rearing and downstream migrating natural-origin juvenile Chinook salmon. Accomplishing this action would require an upgrade in the infrastructure at Soos Creek to allow for rearing additional fish and improvements in the ability to collect and hold adults.
- Transport other fish species and life stages ready to be released from hatcheries in the watershed to a lower Duwamish River location where there would be a reduced likelihood for substantial predation on rearing and downstream migrating natural-origin juvenile Chinook salmon. This measure may also increase the proportion of hatchery-origin fish that survive to reach marine water by circumventing upriver freshwater areas where mortality rates for newly released hatchery-origin fish appear high.

Genetics. The following site-specific mitigation measure would help to decrease genetic risks to the Green Chinook salmon population.

- Install a trap at the Icy Creek confluence with the Green River to remove hatchery-origin Chinook salmon returning to the hatchery release site to prevent the fish from spawning naturally.

Provided in Table C-99 is a summary of potential mitigation measures for the Green Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, genetic, and hatchery facilities and operation risks (Table C-89).

Table C-99. Potential mitigation measures for the Green Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1 and C5.
Predation	Apply Mitigation Measures P1, P5, and P6.
Genetics	Apply Mitigation Measures G1, G2, and G3.
Hatchery facilities and operation	Apply Mitigation Measure H3.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above Chinook salmon, coho salmon, and steelhead hatchery program mitigation measures consistent with an adaptive management approach would likely help reduce the risks of competition, predation, genetic, and hatchery facilities and operation risks of the programs on the natural-origin Green Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the Green Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.11 Puyallup Chinook Salmon

4.11.1 Introduction

As shown in Table C-1, and as described in Subsection 2.7, Puyallup Chinook Salmon Population, the Puyallup River watershed includes two natural-origin Chinook salmon populations: Puyallup fall-run and White spring-run. Both populations are federally listed as threatened under the ESA. The two populations are evaluated in separate subsections; however, several of the hatcheries within the Puyallup River watershed can affect both natural-origin Chinook salmon populations. This subsection discusses the Puyallup Chinook salmon population, whereas Subsection 4.12, White Chinook Salmon, discusses the latter population. The natural-origin Puyallup Chinook salmon population spawns in the Puyallup River mainstem and in several tributaries throughout the watershed, including South Prairie and Wilkeson Creeks, and the Carbon River. Hatchery production occurs at Voights Creek Hatchery and Clarks Creek Hatchery, and at associated acclimation ponds.

Hatcheries and associated programs and release sites relevant to the Puyallup Chinook salmon natural-origin population are evaluated according to their risks and benefits, including effects that occur within the following rivers and streams:

- Voights Creek, which is a tributary to the Carbon River at RM 4.0, which is a tributary to the Puyallup River at RM 17.8
- Mowich River, Meadow Creek, Deer Creek, Rushingwater Creek, which are all tributaries to the upper Puyallup River watershed at RM 31 to RM 49
- Diru Creek, which is a tributary to the Puyallup River at RM 5.7
- Clearwater River, which is a tributary to the White River at RM 35.3
- Huckleberry Creek, which is a tributary to the White River at RM 53.1
- Cripple Creek, which is a tributary to the west fork of White River at RM 2
- Cowskull Creek, which is a tributary to the Puyallup River at RM 44.8

Two Chinook salmon hatchery programs, two coho salmon hatchery programs (involving an acclimation site program), and one steelhead hatchery program from two hatcheries, have the potential to impact the Puyallup Chinook salmon population (Table C-100 and Table C-101), and are reviewed in this subsection.

Table C-100. Hatchery programs and categories of effects evaluated for Puyallup Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	Predation	Genetics	Hatchery Facilities and Operation	Total Return	Viability
Chinook salmon	Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	√	√	√	√	√[2]	√
	Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	√	√	√[1]	√[2]	√[3]	√
Coho salmon	Voights Creek Hatchery integrated coho salmon yearling	√	√				
	Puyallup Acclimation Sites integrated coho salmon yearling	√	√				
Steelhead	Voights Creek Hatchery isolated winter-run steelhead yearling	√	√				

[1] Programs are evaluated together as a group for genetic risk.

[2] Programs are evaluated together as a group for hatchery facilities and operation.

[3] Programs are evaluated together as a group for the total return benefit.

Table C-101. Hatchery salmon and steelhead production evaluated for Puyallup Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	1,600,000	800,000	50	1,600,000	0
	Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	400,000	200,000	50	1,000,000	150
	TOTAL	2,000,000	1,000,000	50	2,600,000	30
Coho salmon	Voights Creek Hatchery integrated coho salmon yearling	780,000	390,000	50	1,180,000	51
	Puyallup Acclimation Sites integrated coho salmon yearling	200,000	200,000	0	200,000	0
	TOTAL	980,000	590,000	40	1,380,000	41
Steelhead	Voights Creek Hatchery isolated winter-run steelhead yearling	200,000	100,000	50	200,000	0
All	TOTAL	3,180,000	1,690,000	47	4,180,000	31

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.11.2 Methods

In conducting the analysis for the Puyallup Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The Voights Creek Hatchery integrated fall-run Chinook salmon subyearling and Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling programs are evaluated independently for most risks and the viability benefit. The two Chinook salmon hatcheries are evaluated together for the total return benefit.
- **Coho Salmon:** The Voights Creek Hatchery integrated coho salmon yearling and Puyallup Acclimation Sites integrated coho salmon yearling programs are evaluated for competition and predation risks.
- **Steelhead:** The Voights Creek Hatchery isolated winter-run steelhead yearling program is evaluated for competition and predation risks.

4.11.3 Results

Results for the Puyallup Chinook salmon population are summarized in Table C-102. The action alternatives would include use of an adaptive management approach, but the results in Table C-102 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-102 is explained in the subsequent subsections for this population.

Table C-102. Summary of hatchery-related risks and benefits for the Puyallup Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Moderate	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	High	Moderate	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.11.3.1 Risks

4.11.3.1.1 Competition

Competition risks to the Puyallup Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-103.

Table C-103. Puyallup Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	7.4 (7.3 for Alternative 3)	Moderate	Same as Alternative 1	Same as Alternative 1
Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	4.1 (2.0 for Alternative 3, 5.9 for Alternative 4)	Low	Same as Alternative 1	Moderate
Voights Creek Hatchery integrated coho salmon yearling	0.2 (0.1 under Alternative 3, 0.2 under Alternative 4)	Negligible	Same as Alternative 1	Same as Alternative 1
Puyallup Acclimation Sites integrated coho salmon yearling	2.4	Low	Same as Alternative 1	Same as Alternative 1
Voights Creek Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Competition risks to Puyallup natural-origin Chinook salmon range from negligible to moderate under all alternatives. Competition risk from the Voights Creek Hatchery integrated fall-run Chinook salmon subyearling program is moderate under all alternatives (Table C-103), because of the release size and location of release in the watershed. The competition risk for the Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program is low under Alternative 1 and Alternative 2, but rises to moderate under Alternative 4, primarily because production would increase 150 percent (from 400,000 to 1 million) (Table C-101). The overall risk of competition impacts to Puyallup Chinook salmon is moderate under all alternatives.

4.11.3.1.2 Predation

Predation risks to the Puyallup Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives are summarized in Table C-104. Predation risks range from negligible to high.

Table C-104. Puyallup Chinook salmon predation risks by alternative.

Hatchery Program Risk	**Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]**	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	0.8 (0.6 for Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	2.2 (1.3 for Alternative 3, 8.3 for Alternative 4)	Low	Same as Alternative 1	Moderate
Voights Creek Hatchery integrated coho salmon yearling	29 (46.3 under Alternative 3, 23.0 under Alternative 4)	High	Same as Alternative 1	Same as Alternative 1
Puyallup Acclimation Sites integrated coho salmon yearling	10.6	High	Same as Alternative 1	Same as Alternative 1
Voights Creek Hatchery isolated winter-run steelhead yearling	NA	High	Moderate	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]If only one score is provided, this score is the same among all alternatives. Otherwise, scores are provided for each alternative that is different than Alternative 1.

The predation risk for the Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program is low under Alternative 1 and Alternative 2, but rises to moderate under Alternative 4 (Table C-104), primarily because production would increase 150 percent (from 400,000 to 1 million) (Table C-101).

The predation risk to natural-origin Puyallup Chinook salmon associated with the Voights Creek Hatchery integrated coho salmon yearling and Puyallup Acclimation Sites integrated coho salmon yearling programs is high (Table C-104), primarily because of the large size of hatchery-origin smolts (average size 6.1 inches fork length) (EIS Table 3.2-4) relative to co-occurring natural-origin Chinook salmon juveniles (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4), and release of the hatchery-origin fish during the natural-origin juvenile Chinook salmon fry and fingerling out-migration period. Also, a large number of yearling coho salmon would be released relative to the estimated number of natural-origin Chinook salmon juveniles present in the Puyallup River watershed (averaging 183,303 juvenile out-migrants per year [Appendix D, PCD RISK 1 Assessment]).

The Voights Creek Hatchery steelhead program would present a high predation risk (Table C-104) because of the large fish size (average size 8.1 inches fork length) (EIS Table 3.2-4) at release and the location of the release high in the Puyallup River watershed. Voights Creek Hatchery steelhead are released upstream (into Voights Creek at RM 22) of a known important natural-origin Chinook salmon rearing area (South Prairie Creek), and the large size of the hatchery-origin steelhead relative to natural-origin juvenile Chinook salmon present in downstream areas (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4) lead to a high predation risk for the program. The 50 percent decrease in hatchery production under Alternative 3 (Table C-101) would reduce the competition risk to moderate.

The overall risk of predation impacts associated with salmon and steelhead hatchery programs is high under all alternatives (Table C-104).

4.11.3.1.3 Genetics

Assessments of genetic risks to the natural-origin Puyallup Chinook salmon population are primarily based on PNI estimates from the AHA Model for each alternative (Table C-105). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-105. Puyallup Chinook salmon genetic risks by alternative.

Hatchery Program Risk	**PNI or pHOS[1]**	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
Hatchery-induced selection risk from Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	0.11 (0.16 for Alternative 3 and 0.10 for Alternative 4)	High	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	0.11 (0.16 for Alternative 3 and 0.10 for Alternative 4)	High	Same as Alternative 1	Same as Alternative 1
Introgression risk from out-of-watershed hatchery Chinook salmon programs	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Genetic risks to Puyallup Chinook salmon are high under all alternatives (Table C-105), because PNI estimates for the Voights Creek Hatchery and Clarks Creek Hatchery integrated programs are less than 0.35 (Appendix E, Overview of the All H Analyzer). PNI is low because relatively few natural-origin fish are included in the hatchery broodstock. The reduction in hatchery production under Alternative 3 would affect PNI estimates and associated genetic risks to the natural-origin population relative to Alternative 1 and Alternative 2, but would not be substantial enough to change the high risk ratings. The genetic risk of introgression to Puyallup Chinook salmon from strays into the Puyallup River watershed from other watersheds is unknown.

4.11.3.1.4 Hatchery Facilities and Operation

Two hatchery programs would rear and release hatchery-origin Chinook salmon that are part of the Puyallup Chinook salmon population. Broodstock for the programs would be collected from hatchery-origin adult fall-run Chinook salmon returns to Voights Creek Hatchery and to Clarks Creek when returns are established. Hatchery-origin fish would be reared and released through the program as subyearlings at three locations in the Puyallup River watershed (Voights Creek, Clarks Creek, and three acclimation sites in the Upper Puyallup River watershed). Hatchery facility conditions and operational practices for the two programs would remain the same under all alternatives. Evaluation results for the programs using the HPV Tool are shown in Table C-106 and Table C-107.

There were no operational phases that received a low compliance score for the Voights Creek Hatchery integrated fall-run Chinook salmon subyearling program; thus, hatchery facilities and operation risks to the natural-origin Puyallup Chinook salmon population are negligible under all alternatives (Table C-106).

Table C-106. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Puyallup Chinook salmon.

Hatchery - Voights Creek Hatchery integrated fall-run Chinook salmon subyearling (facility and release locations: Voights Creek, tributary to the Carbon River)			
Operational Phase	**Facility Compliance**		**Overall Facility Risk**[1]
	Target Population Diversity and Spatial Structure	**Target Population Abundance and Productivity**	
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	Moderate	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

There were no operational phases that received a low compliance score for the Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program; thus, hatchery facilities and operation risks to the natural-origin Puyallup Chinook salmon population are negligible under all alternatives (Table C-107).

Table C-107. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Puyallup Chinook salmon.

Hatchery - Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program (facility and release locations: Clarks Creek; Rushingwater Creek, which is a tributary of the Mowich River; Cowskull Creek)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	Moderate	
Incubation	Moderate	High	
Rearing	High	High	
Release	High	Moderate	
Facilities	NA	High	
			Negligible

[1] Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

4.11.3.2 Benefits

4.11.3.2.1 Total Return

Table C-108 compares effects of the alternatives on the total return of adult hatchery-origin Puyallup Chinook salmon produced by the Voights Creek Hatchery and Clarks Creek Hatchery integrated programs. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Puyallup Chinook salmon adult run size. The return of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-108. Estimated total return contributions for Puyallup Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	9,460	4,730	11,500
Average natural-origin return	4,157	4,157	4,157
Projected average total return	13,617	8,887	15,657
Restoration spawner abundance[1]	18,000	18,000	18,000
Projected average total return as a percent of restoration spawner abundance	76	49	87

Source: Chinook returns are from Tynan (2008).

[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be high under Alternative 1, Alternative 2, and Alternative 4, because the combined total run size would be over 50 percent of the estimated restoration spawner abundance level (76 percent for Alternative 1 and Alternative 2, and 87 percent under Alternative 4) (Table C-108). Under Alternative 3, the total return benefit would be moderate, because the total run size (49 percent) would be between 20 and 50 percent of the estimated restoration spawner abundance level (Table C-108) resulting from a 30 percent reduction in hatchery production compared to Alternative 1 and Alternative 2 (Table C-101). Hatchery-origin adult fish produced through the programs would continue to be harvested with natural-origin Puyallup Chinook salmon in mixed stock marine area and terminal area net and sport fisheries directed at Chinook salmon. Mixed stock marine area fisheries benefiting from the hatchery production in recent years would include Canadian West Coast Vancouver Island troll fisheries, U.S. troll fisheries, and Canadian and U.S. sport fisheries (assuming contribution levels consistent with those observed for South Puget Sound fall-run Chinook salmon subyearlings [CTC 2012]).

Sport fisheries in Commencement Bay and the Puyallup River, and tribal net fisheries directed at Chinook salmon in the Puyallup River, would harvest hatchery-origin Puyallup Chinook salmon. Hatchery-origin Chinook salmon from these programs would contribute a substantial portion of the total number of Chinook salmon escaping to hatcheries and natural spawning areas in the Puyallup River watershed. Adult Chinook salmon contributions to the above fisheries and to escapement would be substantial relative to natural-origin contribution levels under all alternatives.

4.11.3.2.2 Viability

Viability is evaluated separately for two integrated hatchery programs that benefit the Puyallup Chinook salmon population. Viability results from the two programs are provided in Table C-109.

Table C-109. Puyallup Chinook salmon viability benefits by alternative.

Hatchery Program	Alternatives 1 and 2	Alternative 3	Alternative 4
Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	Moderate	Same as Alternative 1	Same as Alternative 1
Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	Moderate	Negligible	Same as Alternative 1

Voights Creek Hatchery. Viability benefits to the Puyallup Chinook salmon population from the Voights Creek Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Voights Creek Hatchery integrated fall-run Chinook salmon subyearling program would benefit the abundance, diversity, and spatial structure of the Puyallup Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Puyallup fall-run Chinook salmon. Hatchery-origin Chinook salmon are listed with natural-origin fish in the watershed as part of the Puyallup Chinook salmon population, and have been helping to sustain the abundance of the naturally spawning population (WDFW and Puyallup Tribe of Indians [Puyallup Tribe] 2000). Voights Creek Hatchery adults surplus to broodstock needs would continue to be used to seed previously unused natural spawning areas upstream of Electron Dam, thus contributing to naturally spawning fall-run Chinook salmon abundance. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Puyallup population of 1,960 fish. The estimated mean number of natural-origin spawners for this period is 775 fish. The remainder of the fish spawning naturally (1,185 fish or 60 percent of the mean spawning escapement) are hatchery-origin fall-run Chinook salmon (composite of Chinook salmon hatchery programs in the Puyallup River).

Diversity – The hatchery program would benefit diversity. Analyses indicate that the hatchery-origin and natural-origin fall-run Chinook salmon populations are genetically similar. BMPs would be applied to maintain the diversity of the Voights Creek hatchery population. Measures include collection of large numbers of broodstock, random collection of broodstock over the breadth of the return to the Voights Creek Hatchery, and using a factorial mating scheme during spawning (WDFW 2005i).

Spatial Structure – The hatchery program would benefit spatial structure. Voights Creek Hatchery adults that are surplus to broodstock needs would continue to be used to seed previously unused natural spawning areas upstream of Electron Dam, benefiting spatial structure of the naturally spawning fall-run Chinook salmon population. Fish returning to Voights Creek Hatchery may freely bypass the hatchery weir and water intake and spawn in upper Voights Creek (WDFW 2005i), thus benefiting spatial structure. Surplus hatchery-origin adults would continue to be provided to the Puyallup Tribe to seed natural production areas in the upper Puyallup River, which would also benefit spatial structure of the population.

Productivity – The program's effects on productivity are unknown, but the poor abundance status of the natural-origin Puyallup Chinook salmon population indicates that the population's productivity in the existing natural environment is poor, and that contributions by naturally spawning hatchery-origin fish are not leading to improved natural-origin fish productivity. If habitat conditions in the Puyallup River watershed and in the estuary are limiting to natural-origin Chinook salmon productivity, the Voights Creek Hatchery program is an important means to artificially sustain the Puyallup Chinook salmon population until habitat limiting factors are remedied. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Puyallup population of 0.83. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite Puyallup naturally spawning population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the overall benefit of the Voights Creek hatchery program to viability would be moderate. The annual subyearling release level would be reduced 50 percent under Alternative 3 compared to Alternative 1 and Alternative 2 (Table C-101), but all other aspects of the program would be the same. The reduced release level under Alternative 3 would remain sufficient to benefit Puyallup

Chinook salmon total abundance, diversity, and spatial structure, although to a lesser extent than under Alternative 1 and Alternative 2, as fewer but still substantial numbers of adult fish (estimated 4,240 fish versus 8,480 fish) would result from Alternative 3.

Under Alternative 4, the number of hatchery-origin subyearling Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate.

Clarks Creek Hatchery. Viability benefits to the Puyallup Chinook salmon population from the Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling program would benefit the abundance and spatial structure of the naturally spawning Puyallup Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would modestly benefit the abundance of Puyallup fall-run Chinook salmon. The program would continue to rely on broodstock collected in Clarks Creek, a lower river tributary to the Puyallup River. A total of 400,000 subyearlings would be released at the hatchery and from acclimation ponds in the upper Puyallup River. The hatchery is located downstream of major natural-origin Chinook salmon spawning areas in the Puyallup River, and thus benefits to the abundance of naturally spawning Chinook salmon from releases at the hatchery would be small. Releases from acclimation ponds in the upper Puyallup River would continue to be subjected to substantial mortality from a water diversion that feeds Lizard Lake and its associated hydroelectric operation. These losses likely limit the survival of acclimation pond releases of Chinook salmon that could otherwise return and contribute to abundance. Hatchery releases produce an estimated 980 adults (total contribution to fisheries and spawning escapement) (Tynan 2008), compared with an estimated total annual Puyallup Chinook salmon contribution of about 3,000 adults.

Diversity – The hatchery program may benefit diversity to some extent but the overall diversity benefit would be negligible. Analyses indicate that the hatchery-origin and natural-origin fall-run Chinook salmon are genetically similar. Measures would be applied to maintain the diversity of the Clarks Creek hatchery population, including random collection of broodstock over the breadth of the return to the Clarks Creek Hatchery and using a factorial mating scheme during spawning (Puyallup Tribe 2005).

Spatial Structure – Benefits of the program to the spatial structure of the Puyallup Chinook salmon population may exist through the extension of Chinook salmon returns and spawning into Clarks Creek. In addition, to the extent that naturally spawning fall-run Chinook salmon would be re-established in the natural habitat that had been blocked to salmon by Electron Dam for nearly 100 years (but is now accessible to upstream migrating Chinook salmon), releases from the upper Puyallup acclimation sites would benefit the spatial structure of the Puyallup Chinook salmon population.

Productivity – The overall benefits of the hatchery program to productivity are unknown. If habitat conditions in the Puyallup River watershed and in its associated estuary are limiting to natural-origin Chinook salmon productivity, the hatchery program may provide an important means to artificially sustain the Puyallup Chinook salmon population until habitat limiting factors are remedied. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Puyallup population of 0.83. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite Puyallup naturally spawning population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the overall benefit of the hatchery program to viability would continue to be moderate. The annual subyearling release level under Alternative 3 would be reduced by 50 percent (Table C-101). Benefits to the total abundance of the Puyallup Chinook salmon population would be reduced relative to Alternative 1 and Alternative 2, as fewer adult fish would be expected to return from releases (estimated 490 fish versus 980 fish under Alternative 1 and Alternative 2) (Tynan 2008). Relative benefits of Alternative 3 to diversity, spatial structure, and productivity would remain unchanged (moderate) relative to Alternative 1 and Alternative 2.

Under Alternative 4, the overall benefit of the hatchery program to viability would be moderate, the same as under Alternative 1 and Alternative 2. Under this alternative, the number of subyearlings released would more than double that of Alternative 1 and Alternative 2 (Table C-101). All of the increase would be from the hatchery. The release level under Alternative 4 would benefit the abundance of Puyallup Chinook salmon, producing an estimated 2,720 adults compared with 980 adults under Alternative 1 and Alternative 2 (Tynan 2008). All other aspects of the program would remain unchanged, thus there would be moderate benefits to diversity, spatial structure, and productivity under Alternative 4.

4.11.3.3 Summary – Puyallup Chinook Salmon

Table C-102 summarizes the risks and benefits for all alternatives pertinent to the Puyallup Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the five hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from negligible to high with negligible risks identified for hatchery facilities and operation, moderate risks for competition, and high risks for predation and genetics. Under Alternative 1 and Alternative 2, benefits are high for total return and moderate for viability. Decreases in hatchery production under Alternative 3 result in a moderate benefit to total return compared to Alternative 1 and Alternative 2, but changes in hatchery production do not alter any other risk or benefit ratings. All other risks and benefits are the same across alternatives.

4.11.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which would be applicable to more than one hatchery program as shown in Table C-2.

Predation. The following site-specific mitigation measure would help to decrease predation risks to the Puyallup Chinook salmon population.

- Transport hatchery-origin yearling coho salmon and steelhead downstream to the mouth of the Puyallup River for release as a means to reduce interactions with emigrating and rearing natural-origin Chinook salmon that may lead to predation. Implementation of this measure may also increase the number of hatchery-origin coho salmon and steelhead that survive to enter marine water.

Genetics. The following site-specific mitigation measure would help to decrease genetic risks to the Puyallup Chinook salmon population.

- Increase the estimated PNI assessed for the Chinook salmon hatchery programs by reducing the number of first generation hatchery-origin adults in natural spawning areas or by increasing the number and proportion of natural-origin fish used as hatchery broodstock. These measures may reduce hatchery-induced selection and fitness loss risks to the Puyallup Chinook salmon population.

Provided in Table C-110 is a summary of potential mitigation measures for the Puyallup Chinook salmon population action alternatives. These mitigation measures would help reduce competition, predation, and genetic risks (Table C-101). Reducing or terminating the programs would help to reduce and/or eliminate all risk categories.

Table C-110. Potential mitigation measures for the Puyallup Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1 and C5.
Predation	Apply Mitigation Measures P1, P2, P3, P4, and P5.
Genetics	Apply Mitigation Measures G1 and G2.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above Chinook salmon, coho salmon, and steelhead hatchery program mitigation measures consistent with an adaptive management approach would likely help reduce the risks of competition, predation, and genetic impacts of the programs on the natural-origin Puyallup Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would also be based on the assigned value of the Puyallup Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.12 White Chinook Salmon

4.12.1 Introduction

As shown in Table C-1, the White River watershed supports the natural-origin White spring-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.8, White Chinook Salmon Population, the White River supports the only existing natural-origin spring-run Chinook salmon population in southern Puget Sound, and represents a unique component of the diversity of the ESU. Adult fish return to the lower White River below the diversion dam at Buckley, and returning adults not used as hatchery broodstock at the White River Hatchery are transported above Mud Mountain Dam to spawn naturally in the upper watershed. Hatchery-origin fish are produced at the White River Hatchery (yearlings and subyearlings), in three acclimation ponds in the upper river, and at Hupp Springs, a satellite facility in Carr Inlet. These hatchery programs helped maintain the population after the natural-origin population declined to a very low level in the 1970s. The White River watershed is within the larger Puyallup River watershed; thus, hatcheries associated with the Puyallup River are also evaluated for the White River.

Hatcheries and associated programs and release sites relevant to the White Chinook salmon natural-origin population are evaluated according to their risks and benefits in this subsection. The White River joins the Puyallup River at RM 29.5. Evaluated rivers and creeks where hatchery programs occur, as well as release sites, include the following:

- White River
- Clearwater River (tributary to the White River at RM 35.3)
- Huckleberry Creek (tributary to the White River at RM 53.1)
- Cripple Creek (tributary to the west fork of the White River at RM 2)

Seven Chinook salmon hatchery programs and one steelhead hatchery program from seven hatcheries have the potential to impact the White Chinook salmon population (Table C-111 and Table C-112) and are reviewed in this subsection.

Table C-111. Hatchery programs and categories of effects evaluated for White Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	White River Hatchery integrated spring-run Chinook salmon subyearling	√	√	√[1]	√	√[4]	√[5]
	White River Hatchery integrated spring-run Chinook salmon yearling	√	√	√[1]	√	√[4]	√[5]
	Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling	√	√	√[1]	√	√[4]	√

Table C-111.Hatchery programs and categories of effects evaluated for White Chinook salmon, continued.

Species	Hatchery and Program	Risk				Benefit	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
	White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling			√[1]	√[3]	√[4]	√[6]
	White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon yearling			√[1]	√[3]	√[4]	√[6]
	Voights Creek Hatchery integrated fall-run Chinook salmon subyearling			√[2]			
	Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling			√[2]			
Steelhead	Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling	√	√				

[1]Evaluated together as a genetic risk.
[2] Evaluated together as a genetic risk.
[3] Evaluated together as a hatchery facilities and operation risk.
[4] Evaluated together as a total return benefit.
[5] Evaluated together as a viability benefit.
[6] Evaluated together as a viability benefit.

Table C-112. Hatchery salmon and steelhead production evaluated for White Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	White River Hatchery integrated spring-run Chinook salmon subyearling	260,000	260,000	0	260,000	0
	White River Hatchery integrated spring-run Chinook salmon yearling	90,000	90,000	0	90,000	0
	Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling	840,000	840,000	0	840,000	0
	White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling	250,000	250,000	0	250,000	0
	White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon yearling	85,000	85,000	0	85,000	0
	Voights Creek Hatchery integrated fall-run Chinook salmon subyearling	1,600,000	800,000	50	1,600,000	0
	Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling	400,000	200,000	50	1,000,000	150
	Total subyearlings	3,350,000	2,350,000	30	3,950,000	18
	Total yearlings	175,000	175,000	0	175,000	0
	TOTAL	3,525,000	2,525,000	28	4,125,000	17
	Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling	35,000	35,000	0	35,000	0
All	TOTAL	4,740,000	3,250,000	31	5,740,000	21

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.12.2 Methods

In conducting the analysis for the White Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The White River Hatchery integrated spring-run Chinook salmon subyearling and White River Hatchery integrated spring-run Chinook salmon yearling programs, and the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program are evaluated separately for risks and benefits, except for genetic risks (and combined with the White River Spring Chinook - Hupp Springs Hatchery as mentioned below) and total return benefits (which combines all programs for evaluation). White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearlings and yearlings are evaluated together for genetics (combined with the other hatchery programs mentioned above), hatchery facilities and operation, total return and viability (which combines all programs for evaluation). The White River Spring Chinook - Hupp Springs Hatchery program is not evaluated for competition and predation because the release site is at RM 0.5 of Minter Creek, which is a tributary to Carr Inlet, South Puget Sound. Because the release site is so close to marine waters, competition and predation risk was determined to be negligible. The Voights Creek Hatchery integrated fall-run Chinook salmon subyearling and Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling programs are evaluated together for genetic risk because they use the same broodstock and benefits are not separable. However, the release sites are in the Puyallup River watershed, away from the White Chinook salmon population.
- **Coho Salmon:** There are no coho salmon hatchery program release sites in the White River watershed.
- **Steelhead:** The Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling program is evaluated for competition and predation risks.

4.12.3 Results

Results for the White Chinook salmon population are summarized in Table C-113. The action alternatives would include use of an adaptive management approach, but the results in Table C-113 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-113 is explained in the subsequent subsections for this population.

Table C-113. Summary of hatchery-related risks and benefits for the White Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	High	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Moderate	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.12.3.1 Risks

4.12.3.1.1 Competition

Competition risks to the White Chinook salmon population from Chinook salmon and steelhead hatchery programs under the four alternatives are summarized in Table C-114. Risks of competition effects to natural-origin Chinook salmon resulting from hatchery production in the White River watershed range from negligible to high. Risks are the same under all of the alternatives because release levels would be the same.

Competition risk from the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program is high (Table C-114) because releases would occur from acclimation ponds high in the watershed, and the hatchery-origin fish would have high spatial overlap with natural-origin Chinook salmon smolts. Thus, there is a high potential for interaction with rearing and emigrating natural-origin White Chinook salmon.

Competition risks from the Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling programs are low (Table C-114) because releases would be in May, after the majority of natural-origin Chinook salmon juveniles have out-migrated seaward. The overall risk of competition impacts to White Chinook salmon is high under all alternatives (Table C-114).

Table C-114. White Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
White River Hatchery integrated spring-run Chinook salmon subyearling	4.5	Low	Same as Alternative 1	Same as Alternative 1
White River Hatchery integrated spring-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling	18.1	High	Same as Alternative 1	Same as Alternative 1
Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.12.3.1.2 Predation

Predation risks to the White Chinook salmon population from salmon and steelhead hatchery programs are summarized in Table C-115. Predation risks range from negligible to high and are the same under all alternatives because release levels are the same.

The predation risk for yearling Chinook salmon releases from White River Hatchery is high because the hatchery-origin fish are large in size (average size 6.1 inches fork length) (EIS Table 3.2-4) relative to the natural-origin fish they would encounter in the White River watershed at the time of release (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4) (Table C-115).

Table C-115. White Chinook salmon predation risks by alternative.

Hatchery Program Risk	**Mortality Rate Index (%) from Chinook Salmon[1]**	**Alternatives 1 and 2**	**Alternative 3**	**Alternative 4**
White River Hatchery integrated spring-run Chinook salmon subyearling	1.0	Negligible	Same as Alternative 1	Same as Alternative 1
White River Hatchery integrated spring-run Chinook salmon yearling	14.2	High	Same as Alternative 1	Same as Alternative 1
Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling	1.5	Low	Same as Alternative 1	Same as Alternative 1
Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling	NA	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High		

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

The Diru Creek Hatchery and White River Hatchery White River integrated winter-run steelhead yearling program would release fish after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead would be released in May; natural-origin Chinook salmon smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon). However, the program would release steelhead high in the watershed (White River at RM 33), resulting in a high predation risk.

The overall risk of predation impacts to natural-origin White Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-115).

4.12.3.1.3 Genetics

Assessments of genetic risks to the White Chinook salmon population are primarily based on PNI estimates for integrated programs and one isolated program (the White River Spring Chinook –Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling program), using the AHA Model for each alternative (Table C-116). Risk levels are assigned using the qualitative criteria applied to PNI estimates as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-116. White Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from White River Hatchery integrated spring-run Chinook salmon subyearling and yearling programs, the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program, and White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling program	0.69	Low	Same as Alternative 1	Same as Alternative 1
Introgression risk from out-of-watershed hatcheries (Voights Creek Hatchery integrated fall-run Chinook salmon subyearling and Clarks Creek Hatchery integrated fall-run Chinook salmon subyearling programs)	NA	Moderate	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Hatchery-induced selection risks to White Chinook salmon from the three White River hatchery programs (White River Hatchery integrated spring-run Chinook salmon subyearling and yearling programs, Puyallup White River Acclimation Sites program, and White River Spring Chinook - Hupp Springs Hatchery subyearling and yearling programs) are low (Table C-116) because PNI estimates are greater than 0.65 for all alternatives (Table C-116) (Appendix E, Overview of the All H Analyzer). The programs would continue to contribute fish each year for release into the upper White River watershed through the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program. The White River Hatchery - Hupp Springs Hatchery program recently started incorporating natural-origin Chinook salmon as broodstock at a low level (10 percent) as a means to reduce divergence between natural-origin White Chinook salmon and hatchery-origin fish. Most of the natural-origin fish used as broodstock would continue to be progeny of naturally spawning hatchery-origin fish.

Fall-run Chinook salmon that are likely from the Voights Creek and Clarks Creek integrated hatchery programs in the Puyallup River watershed may stray into the White River watershed (Muckleshoot Indian Tribe 2012). Hatchery-origin adult fall-run Chinook salmon are commonly captured at the Buckley Diversion trap during and after the spring-run White Chinook salmon migration period. Fall-run hatchery-origin fish would normally be excluded from upstream spawning during the diversion trapping process. However, in years of high salmon abundance (e.g., in odd-numbered years when pink salmon return), some stray fall-run hatchery-origin Chinook salmon may be inadvertently trucked upstream and released into the upper White River. Introgression risk to natural-origin White Chinook salmon from natural spawning by stray fall-run Chinook salmon would continue to be moderate under all alternatives (Table C-116), pending effective exclusion of hatchery-origin fall-run Chinook salmon from the upper watershed.

The overall genetic risk to all Chinook salmon populations in the White River watershed is moderate under all alternatives (Table C-116).

4.12.3.1.4 Hatchery Facilities and Operation

Three hatchery programs (White River Hatchery subyearling and yearling programs, Puyallup White River Acclimation Sites program, and White River Spring Chinook - Hupp Springs Hatchery subyearling and yearling program), would rear and release Chinook salmon into the White River watershed. The programs are evaluated independently for potential hatchery facilities and operation effects on White Chinook salmon using the HPV Tool (Table C-117 to Table C-120). Summarized separately are the White River Hatchery integrated subyearling and yearling programs, the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program, and the White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling program. Hatchery facility conditions and operational practices for the programs remain the same under all alternatives because production levels would be the same under all alternatives.

Under all alternatives, for the two White River Hatchery programs the overall risk of hatchery facilities and operation impacts on the White Chinook salmon population is negligible (Table C-117 and Table C-118), because there were no operational phases that received low compliance scores.

Table C-117. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for White Chinook salmon subyearlings.

Hatchery - White River Hatchery integrated spring-run Chinook salmon subyearling program (facility and release locations: White River)			
	Facility Compliance		**Overall Facility Risk**[1]
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	Moderate	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Table C-118. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for White Chinook salmon yearlings.

Hatchery - White River Hatchery integrated spring-run Chinook salmon yearling program (facility and release locations: White River)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	Moderate	
Spawning	High	High	
Incubation	Moderate	High	
Rearing	High	High	
Release	Moderate	Moderate	
Facilities	NA	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

For the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program, the overall risk of hatchery facilities and operation impacts to the White Chinook salmon population is moderate under all alternatives (Table C-119), because compliance is low for the facilities operational phase and production levels are the same for all alternatives. Factors related to the low facilities compliance score include locations of pond sites in remote areas with no electrical service, reliance on gravity flows to sustain fish rearing, and lack of facilities for staff that provide security for the facility.

Table C-119. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for White Chinook salmon.

Hatchery - Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program (facility and release locations: Clearwater River, Huckleberry Creek, Cripple Creek).			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk**[1]
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	Moderate	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	Low	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

For the White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon program, the overall risk of hatchery facilities and operation impacts to the White Chinook salmon population is moderate under all alternatives (Table C-120), because compliance is low for the release operational phase and production levels are the same for all alternatives. The primary factor related to the low compliance score for the release operational phase is the yearling release strategy. The yearling release strategy is different from the natural life history strategy for White Chinook salmon in terms of fish out-migrant size, behavior, growth rate and physiological status. Although releasing yearling fish from Hupp Springs Hatchery would increase survival rates for adult returns relative to subyearling releases, production of yearlings would increase the risk that the hatchery population would diverge from the natural-origin White Chinook salmon population.

Table C-120. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for White Chinook salmon.

Hatchery - White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling program (facility and release locations: Minter Creek).			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Low	Low	
Facilities	NA	High	
			Moderate

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

4.12.3.2 Benefits

4.12.3.2.1 Total Return

Table C-121 compares effects of the alternatives on the total return of adult hatchery-origin White Chinook salmon produced by the White River Hatchery integrated spring-run subyearling and yearling programs, the Puyallup White River Acclimation Sites subyearling program, and the White River Spring Chinook - Hupp Springs Hatchery isolated spring-run subyearling and yearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin White Chinook salmon adult run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-121. Estimated total return contributions for White Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	3,407	3,407	3,407
Average natural-origin return	1,723	1,723	1,723
Projected average total return	5,130	5,130	5,130
Restoration spawner abundance[1]	14,200	14,200	14,200
Projected average total return as a percent of restoration spawner abundance	36	36	36

Source: Chinook returns are from Tynan (2008).

[1] Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be moderate for all alternatives, because the combined total run size would be between 20 and 50 percent (36 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-121). Subyearling and yearling Chinook salmon release levels would be the same under all alternatives. Hatchery-origin adult fish would be harvested incidentally in mixed stock marine area fisheries directed at Chinook salmon, predominantly in Canada (Georgia Strait sport fishery, and West Coast Vancouver Island troll and sport fisheries, based on contribution estimates from White River Hatchery yearling Chinook salmon indicator stock recoveries [CTC 2012]). Contributions of these fish to U.S. fisheries would be low because Washington fisheries are managed to reduce incidental harvests of this and other unmarked hatchery stocks (through time and area closures, and selective fishing practices), consistent with the stock recovery intent of the program producing the fish. A relatively small number of these hatchery-origin fish (approximately 300 fish) would continue to be targeted each year in a Muckleshoot Indian tribal elder fishery in the White River mainstem downstream of Buckley. Hatchery-origin adult Chinook salmon returns to the White River watershed under all alternatives would increase the total returns of the stock, helping to bolster escapement of White Chinook salmon adults to the Buckley Diversion trap for passage upstream (Puyallup White River Acclimation Sites fish) and to the White River Hatchery integrated program and White River Spring Chinook - Hupp Springs Hatchery isolated programs.

4.12.3.2.2 Viability

Viability is evaluated separately for two integrated programs and one isolated hatchery program that benefit the White Chinook salmon population. Viability results from the three programs are provided in Table C-122.

Table C-122. White Chinook salmon viability benefits by alternative.

Hatchery Program	Alternatives 1 and 2	Alternative 3	Alternative 4
White River Hatchery integrated spring-run Chinook salmon subyearling and yearling	Moderate	Same as Alternative 1	Same as Alternative 1
Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling	Moderate	Same as Alternative 1	Same as Alternative 1
White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling	Moderate	Same as Alternative 1	Same as Alternative 1

White River Hatchery Integrated Spring-run Chinook Salmon Subyearling and Yearling Programs. Viability benefits to the White Chinook salmon population from the White River Hatchery integrated spring-run Chinook salmon subyearling and yearling programs are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery programs are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the White River Hatchery integrated spring-run Chinook salmon subyearling and yearling programs would benefit the abundance, diversity, and spatial structure of the White Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of White Chinook salmon. The purpose of all three hatchery programs evaluated for White Chinook salmon would continue to be to prevent extirpation of the White Chinook salmon population, and to re-establish hatchery-origin and natural-origin spring-run Chinook salmon adult returns to the White River. The programs would continue to serve as a genetic reserve for the natural-origin White Chinook salmon population, preserving the genome while efforts proceed to restore self-sustaining natural-origin production.

Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the

White Chinook salmon population of 1,869 fish. The estimated mean number of natural-origin spawners for this period is 1,306 fish. The remainder of the fish spawning naturally (563 fish or 30 percent of the mean spawning escapement) are hatchery-origin Chinook salmon produced by the program. This information is consistent with the Muckleshoot Indian Tribe (2003b) who found adult returns from the programs have contributed an average of 42 percent of the total spring-run Chinook salmon return (1997 to 2001 return years) to the White River. Hatchery-origin yearlings produced through the program would be expected to continue to contribute to fisheries and escapement at a rate over three times greater than for subyearlings (for information on subyearling and yearling survival rates, see EIS Table 3.2-9). However, adult return numbers would be nearly equal for the yearling and subyearling groups because there would be nearly three times as many subyearling releases as yearling releases.

Diversity – The hatchery program would benefit diversity. Only known (coded wire tagged or DNA) White River Hatchery spring-run Chinook salmon would be used as broodstock to prevent inadvertent incorporation of stray Chinook salmon from other populations. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly over the breadth of the return to the White River, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning. These measures would continue to maintain the diversity of the propagated population.

Spatial Structure – The hatchery program would not directly benefit spatial structure, because most years, adult fish produced by the program would not be passed upstream to spawn naturally.

Productivity – The benefit of the hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) White Chinook salmon population of 1.07. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. The lambda of 1.07 for the composite White Chinook salmon population is the highest estimated short-term median growth rate of all of the populations that constitute the ESU. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon subyearlings and yearlings released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

Puyallup White River Acclimation Sites Integrated Spring-run Chinook Salmon Subyearling Program. Viability benefits to the White Chinook salmon population from the Puyallup White River acclimation sites integrated spring-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Puyallup White River acclimation sites integrated spring-run Chinook salmon subyearling program would benefit the abundance, diversity, and spatial structure of the White Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of White Chinook salmon. As mentioned for the White River Hatchery, the purpose of the hatchery program would continue to be to prevent extirpation of the White Chinook salmon population, and to re-establish hatchery-origin and natural-origin spring-run Chinook salmon adult returns to the White River.

Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the White Chinook salmon population of 1,869 fish. The estimated mean number of natural-origin spawners for this period is 1,306 fish. The remainder of the fish spawning naturally (563 fish or 30 percent of the mean spawning escapement) are hatchery-origin Chinook salmon produced by the program. This information is consistent with the Puyallup Tribe (2003), who found adult returns from the hatchery programs producing spring-run Chinook salmon have contributed an average of 42 percent of the total spring-run Chinook salmon return (1997 to 2001 return years) to the White River.

Diversity – The hatchery program would benefit diversity. Broodstock for the hatchery program would continue to be obtained from the White River Hatchery program. As described for that program, only known (coded wire tagged or DNA) White River Hatchery spring-run Chinook salmon would be used as broodstock to prevent inadvertent incorporation of stray Chinook salmon from other populations. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly over the breadth of the return to the White River, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning. These measures would continue to maintain the diversity of the propagated population.

Spatial Structure – The hatchery program would benefit spatial structure. The Puyallup White River acclimation sites integrated spring-run Chinook salmon subyearling program component of the combined conservation hatchery effort would benefit spatial structure by re-establishing adult spring-run White Chinook salmon returns into the upper White River watershed upstream of Mud Mountain Dam. The White Chinook salmon population historically accessed this area prior to the construction of the Buckley water diversion in 1911 and Mud Mountain Dam in 1948, both of which are impassable barriers to salmon migration (WDFW et al. 1996).

Productivity – The benefit of the hatchery program (fish reproducing naturally in the upper river) to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) White Chinook salmon population of 1.07. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. The lambda of 1.07 for the White population is the highest estimated short-term median growth rate of all Puget Sound Chinook salmon populations. The estimate of lambda assumes that the reproductive success of naturally spawning hatchery-origin fish is equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin subyearling Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

Under Alternative 3 and Alternative 4, the number of hatchery-origin subyearling Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

White River Spring Chinook - Hupp Springs Hatchery Isolated Spring-run Chinook Salmon Subyearling and Yearling Programs. Viability benefits to the White Chinook salmon population from the White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling programs are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the White River Spring Chinook - Hupp Springs Hatchery isolated spring-run Chinook salmon subyearling and yearling program would benefit the abundance and diversity of the White Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Operating since 1974, this program would continue to serve as an out-of-watershed reserve for the White Chinook salmon population, sustaining the natural-origin population while habitat factors threatening the population in its home watershed are addressed.

Abundance – The hatchery program would benefit the abundance of White Chinook salmon. As mentioned previously, the purpose of the three hatchery programs evaluated for White Chinook salmon would continue to be to prevent loss of the White Chinook salmon population, and to re-establish hatchery-origin and natural-origin spring-run Chinook salmon adult returns to the White River.

Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the White Chinook salmon population of 1,869 fish. The estimated mean number of natural-origin spawners for this period is 1,306 fish. The remainder of the fish spawning naturally (563 fish or 30 percent of the mean spawning escapement) are hatchery-origin Chinook salmon produced by the program. The estimated hatchery contribution of hatchery-origin adult fish to the total White Chinook salmon population would be 877 fish (Tynan 2008), or 43 percent compared with an estimated recent year average total natural-origin run size for White Chinook salmon population of 2,033 fish. Hatchery-origin yearlings produced through the program would be expected to continue to contribute substantially to fisheries and escapement. However, adult return numbers would be nearly equal for yearlings and subyearlings because the number of subyearlings released would be about three times larger than the number of yearlings released.

Diversity – The hatchery program would benefit diversity. Specific measures are applied in the hatchery program to preserve the diversity of the propagated Hupp Springs White Chinook salmon population. Only known (coded wire tagged or DNA) Hupp Springs Hatchery spring-run Chinook salmon are used as broodstock to prevent inadvertent incorporation of stray fall-run Chinook salmon from other Puget Sound populations. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly over the breadth of the return to the White River, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning. These measures would continue to maintain the diversity of the propagated population.

Spatial Structure – The hatchery program would not directly benefit spatial structure. Most of the spring-run Chinook salmon hatchery-origin fish produced by the program would be released at the hatchery, which is outside the range of the natural-origin White Chinook salmon population. However, surplus subyearlings would be transferred for release from the Puyallup White River Acclimation Sites integrated spring-run Chinook salmon subyearling program, which could benefit White Chinook salmon spatial structure by seeding historically used habitat in the upper watershed.

Productivity – The benefit of the hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) White Chinook salmon population of 1.07. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. The lambda of 1.07 for the White population is the highest estimated short-term median growth rate of all Puget Sound Chinook salmon populations. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon subyearlings and yearlings released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

4.12.3.3 Summary – White Chinook Salmon

Table C-113 summarizes the risks and benefits for all alternatives pertinent to the White Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight hatchery programs evaluated for this population, overall risks under Alternative 1 and Alternative 2 range from moderate to high with moderate risks for genetics and hatchery facilities and operation, and high risks for competition and predation. Benefits for total return and viability are moderate. There is no change in production among alternatives; thus, there are no changes in risks or benefits among alternatives.

4.12.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which would be applicable to more than one hatchery program as shown in Table C-2.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the White Chinook salmon population.

- Increase the estimated PNI associated with the current integrated Chinook salmon programs by increasing the number of natural-origin fish incorporated as broodstock at White River hatchery programs, potentially reducing hatchery-induced selection and fitness loss risks to the White Chinook salmon population.
- Reduce hatchery-origin fall-run Chinook salmon straying and genetic introgression risks to the White Chinook salmon population by reducing the annual number of hatchery-origin fall-run Chinook salmon produced by the Voights Creek Hatchery and Clarks Creek Hatchery programs.
- Apply measures to reduce the number of stray hatchery-origin fall-run Chinook salmon trapped at the Buckley diversion and inadvertently trucked upstream for release above Mud Mountain Dam.

Provided in Table C-123 is a summary of potential mitigation measures for the White Chinook salmon population action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as high (competition, predation, and genetics) and moderate (hatchery facilities and operation) risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-110).

Table C-123. Potential mitigation measures for the White Chinook salmon population.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measure C1.
Predation	Apply Mitigation Measures P1 and P5.
Genetics	Apply Mitigation Measure G2.
Hatchery facilities and operation	Apply Mitigation Measures H4 and H5.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above measures consistent with an adaptive management approach would likely help reduce the risks of competition, predation, genetic, and hatchery facilities and operation impacts of the programs on the natural-origin White Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on acquisition of new information regarding hatchery effects, the assigned value of the White Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). The White Chinook salmon population is the only remaining spring-run stock in the Central/South Major Population Group, and its recovery to a low extinction risk status is required under the NMFS delisting criteria for the recovery and delisting of the ESU.

4.13 Nisqually Chinook Salmon

4.13.1 Introduction

As shown in Table C-1, the Nisqually River watershed supports the fall-run Nisqually Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.9, Nisqually Chinook Salmon Population, the Nisqually River supports a natural-origin population, which spawns in the mainstem up to about RM 40 and in the Mashel River. Hatchery-origin subyearling Chinook salmon are produced at the Clear Creek and Kalama Creek facilities. Hatchery-origin adults contribute about half of the total natural spawning escapement to the river.

Hatcheries and associated programs and release sites within the Nisqually River, Clear Creek, and Kalama Creek are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon.

Six Chinook salmon hatchery programs and two coho salmon hatchery programs from five hatcheries have the potential to impact the Nisqually Chinook salmon population (Table C-124 and Table C-125), and are reviewed in this subsection.

Table C-124. Hatchery programs and categories of effects evaluated for Nisqually Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Clear Creek Hatchery isolated fall-run Chinook salmon subyearling	√	√	√	√	√	√
	Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling	√	√	√	√	√	√
	Tumwater Falls Hatchery isolated fall-run Chinook salmon subyearling			√[1]			
	Tumwater Falls Hatchery isolated fall-run Chinook salmon yearling			√[1]			
	Garrison Springs isolated fall-run Chinook subyearling			√[1]			
	Chambers Creek isolated fall-run Chinook salmon yearling			√[1]			
Coho salmon	Clear Creek Hatchery isolated coho salmon yearling	√	√				
	Kalama Creek Hatchery isolated coho salmon yearling	√	√				

[1] These four programs are evaluated together for genetic risk.

Table C-125. Hatchery salmon and steelhead production evaluated for Nisqually Chinook salmon.

			Alternative 3		Alternative 4	
Species	**Hatchery and Program[1]**	**Release Number for Alternatives 1 and 2**	**Release Number**	**Percent Decrease from Alternatives 1 and 2**	**Release Number**	**Percent Increase from Alternatives 1 and 2**
Chinook salmon	Clear Creek Hatchery isolated fall-run Chinook salmon subyearling	3,400,000	1,700.000	50	3,700,000	9
	Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling	600,000	300,000	50	600,000	0
	TOTAL	4,000,000	2,000,000	50	4,300,000	8
Coho salmon	Clear Creek Hatchery isolated coho salmon yearling	630,000	315,000	50	630,000	0
	Kalama Creek Hatchery isolated coho salmon yearling	350,000	175,000	50	350,000	0
	TOTAL	950,000	475,000	50	950,000	0
All	TOTAL	4,950,000	2,475,000	50	5,250,000	6

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.13.2 Methods

In conducting the analysis for the Nisqually Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon in rivers and streams are evaluated.
- **Chinook Salmon:** The Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling programs are evaluated independently for all risks and benefits. The Tumwater Falls Hatchery isolated fall-run Chinook salmon subyearling and yearling programs, Garrison Springs fall-run Chinook salmon subyearling program, and the Chambers Creek fall-run Chinook salmon yearling program are evaluated for genetic introgression risks.
- **Coho Salmon:** The Kalama Creek Hatchery isolated coho salmon yearling program is evaluated for competition and predation risks.
- **Steelhead:** No hatchery programs release steelhead into the Nisqually River watershed.

4.13.3 Results

Results for the Nisqually Chinook salmon population are summarized in Table C-126. The action alternatives would include use of an adaptive management approach, but the results in Table C-126 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this population are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-126 is explained in the subsequent subsections for this population.

Table C-126. Summary of hatchery-related risks and benefits for the Nisqually Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	Moderate	Low	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Low	Same as Alternative 1

4.13.3.1 Risks

4.13.3.1.1 Competition

Competition risks to the Nisqually Chinook salmon population from Chinook salmon and coho salmon hatchery programs under the four alternatives are summarized in Table C-127. Competition risks range from negligible to low for Alternative 1 and Alternative 2. The overall risk of competition impacts to Nisqually Chinook salmon associated with all hatchery programs is low under all alternatives (Table C-127). Under Alternative 3, the production of hatchery-origin salmon would be 50 percent less than for Alternative 1 and Alternative 2, but the decrease would not result in lower competition risk. Under Alternative 4, the competition risk would be the same (low) as under Alternative 1 and Alternative 2 because production levels would be only slightly larger than under Alternative 1 and Alternative 2.

Table C-127. Nisqually Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Clear Creek Hatchery isolated fall-run Chinook salmon subyearling	1.9 (2.0 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling	1.9 (1.3 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Clear Creek Hatchery isolated coho salmon yearling[2]	NA	Unknown, but likely Negligible	Same as Alternative 1	Same as Alternative 1
Kalama Creek Hatchery isolated coho salmon yearling	0.2 (0.1 under Alternative 3)	Negligible	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative.

[2]No PCD Risk Model results available. Risk of competition effects is assumed to be the same as for the Kalama Creek Hatchery isolated coho salmon yearling program.

4.13.3.1.2 Predation

Predation risks to the Nisqually Chinook salmon population from Chinook salmon and coho salmon hatchery programs under the four alternatives are summarized in Table C-128. Overall risks of predation under Alternative 1 and Alternative 2 are moderate because hatchery-origin Chinook salmon and coho salmon would typically be larger in size (average hatchery-origin subyearling Chinook salmon size 3.1 inches fork length, and average hatchery-origin yearling coho salmon size 5.5 inches fork length) (EIS Table 3.2-4) compared to natural-origin subyearling Chinook salmon (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). In addition, the large number of emigrating hatchery-origin salmon relative to the natural-origin Chinook salmon juvenile population in the lower Nisqually River and estuarine areas would contribute to the moderate predation risk. Although PCD Risk Model results are not available for the Clear Creek Hatchery isolated coho salmon yearling program, it is assumed that predation risks for that program are the same as for the Kalama Creek isolated coho salmon yearling program under all alternatives.

Predation risks under Alternative 3 are low for the Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery isolated coho salmon yearling programs because of a 50 percent reduction in production level from Alternative 1 and Alternative 2 (Table C-125).

Under Alternative 4, the predation risk would be the same (moderate) as under Alternative 1 and Alternative 2 because production levels would be only slightly larger than under Alternative 1 and Alternative 2.

Table C-128. Nisqually Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Clear Creek Hatchery isolated fall-run Chinook salmon subyearling	8.4 (7.2 under Alternative 3, and 8.9 under Alternative 4)	Moderate	Same as Alternative 1	Same as Alternative 1
Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling	5.1 (2.3 under Alternative 3)	Moderate	Low	Same as Alternative 1
Clear Creek Hatchery isolated coho salmon yearling[2]	NA	Unknown, but likely Moderate	Unknown, but likely Low	Same as Alternative 1
Kalama Creek Hatchery isolated coho salmon yearling	8.5 (4.7 under Alternative 3)	Moderate	Low	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

[2]PCD Risk Model results not available. Risk of predation effects is assumed to be the same as for the Kalama Creek Hatchery isolated coho salmon yearling program.

4.13.3.1.3 Genetics

Assessments of genetic risks to the Nisqually Chinook salmon population are primarily based on pHOS estimates from the AHA model for each alternative (Table C-129). Risk levels are assigned using the qualitative criteria applied to pHOS estimates for isolated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-129. Nisqually Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling	19% (10% for Alternative 3 and 20% for Alternative 4)	High	Same as Alternative 1	Same as Alternative 1
Introgression risk from out-of-watershed hatcheries (Tumwater Falls Hatchery isolated fall-run Chinook subyearling and yearling programs, Garrison Springs isolated fall-run Chinook subyearling, and Chambers Creek isolated fall-run Chinook yearling)	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Genetic risks to Nisqually Chinook salmon are high under all alternatives (Table C-129), primarily because pHOS is over 10 percent for all alternatives (Table C-129) (Appendix E, Overview of the All H Analyzer). Clear Creek and Kalama Creek isolated hatchery programs are part of the listed ESU. The hatchery-origin and natural-origin populations are genetically identical, but the hatchery programs would continue to be isolated where interbreeding between the natural-origin and hatchery-origin fish is not an objective. Adults originating from releases from the two programs would continue to stray into the Nisqually River watershed upstream of the release sites where they may interbreed with natural-origin Nisqually Chinook salmon of the same introduced Green River hatchery-lineage. Although under Alternative 3 the number of Chinook salmon subyearlings released would decrease by 50 percent, but the genetic risk to the Nisqually Chinook salmon population from the isolated programs would remain high because estimated pHOS would remain over 10 percent (Table C-129) (Appendix E, Overview of the All H Analyzer).

Genetic risks to the Nisqually Chinook salmon population associated with strays from Chinook salmon originating from two hatchery programs located in adjacent watersheds (Chambers Creek and Deschutes River) are unknown (Table C-129). Those programs also would continue to use broodstock with a Green River fall-run Chinook salmon lineage. Releases would occur close to marine water (less than 0.5 RM).

Under Alternative 4, genetic risks to Nisqually Chinook salmon from strays from the two adjacent programs would increase to an unknown extent relative to Alternative 1 and Alternative 2. Releases from the Chambers Creek Hatchery isolated fall-run yearling program would increase 1300 percent (from 200,000 to 2,800,000 yearlings), and releases from the Tumwater Falls Hatchery isolated fall-run Chinook subyearling program would increase 53 percent (from 3,800,000 to 5,800,000) (Appendix A, Puget Sound Hatchery Programs and Facilities Information).

4.13.3.1.4 Hatchery Facilities and Operation

Two hatchery programs rear and release fish that are part of the Nisqually Chinook salmon population (Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling programs). Although the lineage of the broodstock is the same for both programs, the programs are evaluated independently using the HPV Tool. Hatchery facility conditions and operational practices at the two hatcheries would remain the same under all alternatives.

Evaluation results for the Clear Creek Hatchery isolated fall-run Chinook salmon subyearling program are shown in Table C-130. Overall hatchery facilities and operation risks are negligible under all alternatives even though fewer fish would be released under Alternative 3 and more would be released under Alternative 4 (Table C-125), because all operational phases received high compliance scores.

Table C-130. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Nisqually Chinook salmon.

Hatchery - Clear Creek Hatchery isolated fall-run Chinook salmon subyearling program (facility and release locations: Clear Creek)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

For the Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling program, the overall risk of hatchery facilities and operation impacts to listed Nisqually Chinook salmon is moderate under Alternative 1 and Alternative 2 (Table C-131), because the program is in moderate or high compliance for all but one operational phase evaluated (facilities). The low facilities score resulted from a lack of hatchery compliance with IHOT or NMFS water intake screening standards, posing a risk to emigrating or rearing natural-origin juvenile Chinook salmon that may become impinged. Also contributing to the low facilities compliance score are the location of the facility in an area with high susceptibility to flooding and the lack of continuous staff at the facility. Under Alternative 3, the risk decreases to low because hatchery production would be reduced 50 percent (Table C-126). Under Alternative 4, hatchery production would increase, but the extent of the increase (9 percent) would be insufficient to raise the risk from moderate (Table C-131). Both of these factors increase the likelihood for catastrophic fish loss at the hatchery, which are reflected in the low compliance score under the facilities operational phase (Table C-131).

Table C-131. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Nisqually Chinook salmon.

Hatchery - Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling program (facility and release locations: Kalama Creek)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk**[1]
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	High	High	
Facilities	NA	Low	
			Moderate (Low for Alternative 3)

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives. Otherwise, risks are shown for each alternative that is different than Alternative 1.

4.13.3.2 Benefits

4.13.3.2.1 Total Return

Table C-132 compares effects of the alternatives on the total return of adult hatchery-origin fish produced by the Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery Clear Creek Hatchery isolated fall-run Chinook salmon subyearling programs. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average Nisqually Chinook salmon natural-origin run size. The return of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-132. Estimated total return contributions for Nisqually Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	31,720	15,860	34,090
Average natural-origin return	8,450	8,450	8,450
Projected average total return	40,170	24,310	42,550
Restoration spawner abundance[1]	13,000	13,000	13,000
Projected average total return as a percent of restoration spawner abundance	309	187	327

Source: Chinook returns are from Tynan (2008).
[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be high for all alternatives, because the combined total adult run size would be greater than 50 percent (187 to 327 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-132). The combined total adult run size (mainly hatchery-origin fish) would be 209 percent higher than the restoration spawner abundance level under Alternative 1 and Alternative 2, 87 percent higher under Alternative 3, and 227 percent higher under Alternative 4 (Table C-132).

Adult fish produced through the hatchery program would continue to be harvested with natural-origin Nisqually Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon, predominantly in West Coast Vancouver Island troll fisheries and in U.S. sport and troll fisheries (CTC 2012). Treaty Indian net and Washington sport fisheries in the terminal area would also target adult

Chinook salmon that are identified as surplus to escapement. Tribal net fisheries in the Nisqually River have accounted for about 35 percent of the total fisheries and escapement contribution in recent years.

4.13.3.2.2 Viability

Viability benefits to the Nisqually Chinook salmon population from the Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery Clear Creek Hatchery isolated fall-run Chinook salmon subyearling programs are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). The fish produced by the hatchery programs are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Fish from the programs have supplanted the natural-origin fall-run Chinook salmon historically present in the Nisqually River watershed—an indigenous Nisqually Chinook salmon population no longer exists. Clear Creek and Kalama Creek hatchery-origin fish are the best source for re-establishing a localized and self-sustaining fall-run Chinook salmon population in the watershed (Ruckelshaus et al. 2006). Under all alternatives, the hatchery programs would continue to use hatchery-origin fish of the Green River lineage. To the extent habitat conditions in the Nisqually River watershed and estuary limit the status of natural-origin Chinook salmon productivity (NCRT 2001), the hatchery programs would continue to provide an important means to artificially sustain the existing Nisqually Chinook salmon population until habitat limiting factors are remedied.

Under Alternative 1 and Alternative 2, the Clear Creek Hatchery isolated fall-run Chinook salmon subyearling and Kalama Creek Hatchery isolated fall-run Chinook salmon subyearling programs would benefit the abundance, diversity, and spatial structure of the Nisqually Chinook salmon population. Thus, the viability benefit of the programs is moderate for the reasons described below.

Abundance – The hatchery programs would benefit the abundance of Nisqually Chinook salmon. Naturally spawning Chinook salmon in several upper Nisqually River tributaries have been shown to be genetically similar to Green Chinook salmon and their hatchery derivatives (Nisqually Indian Tribe 2003a, 2003b). Nisqually Indian Tribe (2003a, 2003b) estimated that the programs contributed a 1990 to 1993 brood year average of 1,596 fish to natural spawning in the mainstem river and upper tributaries. Assuming recent year fisheries and escapement contribution rates, the programs would produce 31,720 hatchery-origin adults each year (Tynan 2008), compared with an estimated recent year average natural-origin total run size of 4,793 fish (to fisheries and escapement) (NMFS 2005). Finally, production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford

(2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Nisqually population of 1,892 fish. The estimated mean number of natural-origin spawners for this period is 566 fish. The remainder of the fish spawning naturally (1,326 fish or 70 percent of the mean spawning escapement) are hatchery-origin fall-run Chinook salmon produced by the programs. In summary, hatchery-origin fish from the hatchery programs would continue to contribute substantially to abundance of naturally spawning Chinook salmon in the watershed.

Diversity – The hatchery program would benefit diversity. BMPs would continue to maintain diversity and limit the likelihood that the hatchery-origin fish would diverge from the natural-origin population. Broodstock would be collected randomly over the breadth of the return, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning.

Spatial Structure – The hatchery program would inadvertently benefit the spatial structure of the Nisqually Chinook salmon population to the extent stray adult fish from the hatchery stray spawn in the mainstem of the Nisqually River and the tributaries of the watershed.

Productivity – The benefit of the hatchery programs to productivity is unknown. However, the relatively poor abundance status of the natural-origin population indicates that the productivity of the natural-origin population in the existing habitat is poor. Contributions (at unknown levels) by naturally spawning hatchery-origin fish do not appear to be leading to improved productivity of natural-origin fish. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Nisqually Chinook salmon population of 0.88. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the lambda for the composite naturally spawning population in the Nisqually River is less than 1.0; thus, the population is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the benefit of the hatchery programs to viability would be moderate. The abundance of fish available to spawn naturally would benefit, although the number of subyearlings released would be reduced 50 percent relative to Alternative 1 and Alternative 2 (Table C-125), and the corresponding total abundance of potentially spawning adult fish would be lower (an estimated 15,860 fish under Alternative 1 and Alternative 2 versus 31,720 fish under Alternative 3) (Table C-132). Benefits to population diversity and spatial structure would remain unchanged from Alternative 1 and Alternative 2.

Under Alternative 4, the benefit of the hatchery programs to viability would also be moderate. The number of subyearlings released would increase 8 percent (300,000 fish) compared to Alternative 1 and Alternative 2 (Table C-125), and benefits to the abundance of the Nisqually Chinook salmon population would increase as more adult fish would be expected to return to the watershed (an estimated 34,090 fish under Alternative 4 compared with 31,720 fish under Alternative 1 and Alternative 2) (Table C-132). Benefits to diversity and spatial structure would be higher under Alternative 4 compared to Alternative 1 and Alternative 2 because of increased numbers released. Increased spawning in natural conditions by hatchery-origin fish would not likely lead to improved productivity of the natural-origin population.

4.13.3.3 Summary – Nisqually Chinook Salmon

Table C-126 summarizes the risks and benefits for all alternatives pertinent to the Nisqually Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the eight hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to high, with competition as a low risk, predation and hatchery facilities and operation as moderate risks, and genetics as a high risk. Benefits would be high for total return and moderate for viability under Alternative 1 and Alternative 2. Coho salmon and steelhead production changes under Alternative 3 decrease three of the six risk and benefit levels (predation, total return, and viability). Under Alternative 4, hatchery production would increase 8 percent, which does not alter risk or benefit levels compared to Alternative 1. All other risks and benefits are the same across alternatives.

4.13.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which would be applicable to more than one hatchery program as shown in Table C-2.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the Nisqually Chinook salmon population.

- Reduce the number of first generation hatchery-origin fish spawning naturally to reduce hatchery-induced selection risks to natural-origin Nisqually Chinook salmon associated with straying of adult hatchery-origin fish produced by the two Chinook salmon programs. Possible ways to limit the number of hatchery-origin fish on the spawning grounds may include: reduction in subyearling Chinook salmon release numbers from one or both hatcheries; operation of a weir to sort Chinook salmon adults by origin for upstream passage of natural-origin fish and culling ad-marked hatchery-origin fish; and/or implementation of mark-selective fisheries aimed at removing adipose fin clipped hatchery-origin adults as they return to the Nisqually River.
- Increase the numbers and proportion of natural-origin Chinook salmon incorporated as broodstock at the hatcheries to reduce domestication risks to the natural-origin Nisqually Chinook salmon population.

Provided in Table C-133 is a summary of potential mitigation measures for the Nisqually Chinook salmon population action alternatives. These mitigation measures would help reduce predation and hatchery facilities and operation risks, which are rated as moderate under Alternative 2 and Alternative 4 (Table C-126).

Table C-133. Potential mitigation measures for the Nisqually Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measures P3 and P5.
Hatchery facilities and operation	Apply Mitigation Measures H6 and H7.

[1]Refer to Table C-2 for a description of each mitigation measure.

Application of the above mitigation measures consistent with an adaptive management approach would likely help reduce risks to the natural-origin Nisqually Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the Nisqually Chinook salmon population for the recovery of the Puget Sound Chinook

Salmon ESU to a viable status, and its standing relative to delisting criteria for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007).

4.14 Skokomish Chinook Salmon

4.14.1 Introduction

As shown in Table C-1, the Skokomish River watershed supports the Skokomish fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.10, Skokomish Chinook Salmon Population, the Skokomish River supports a natural-origin fall-run Chinook salmon population that spawns in the North Fork Skokomish River up to RM 17, where passage is blocked by a hydroelectric dam, and in the South Fork Skokomish River up to RM 5. Hatchery-origin Chinook salmon production occurs at the George Adams Hatchery and Rick's Pond Hatchery facilities, both of which currently use broodstock originating from the Green River.

Hatcheries and associated programs and release sites within the Skokomish River and Purdy Creek (a tributary low in the Skokomish River) are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon.

Four Chinook salmon hatchery programs, one coho salmon hatchery program, and one steelhead hatchery program from three hatcheries have the potential to impact the Skokomish Chinook salmon population (Table C-134 and Table C-135), and are reviewed in this subsection.

4.14.2 Methods

In conducting the analysis for the Skokomish Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon and steelhead in rivers and streams are evaluated.
- **Chinook Salmon:** Two hatchery programs (George Adams Hatchery integrated fall-run Chinook salmon subyearling and George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling) are evaluated for all risks and benefits. The Hoodsport Hatchery isolated fall-run Chinook salmon subyearling and yearling programs are evaluated for genetic risk only, because the fish are released into Finch Creek at RM 0.0, which is a tributary to west Hood Canal.
- **Coho Salmon:** The George Adams Hatchery isolated coho salmon yearling program is evaluated for competition and predation risks. The Snow Creek coho salmon supplementation program and Quilcene National Fish Hatchery coho salmon production program are not evaluated for

competition and predation because the fish release sites are not near an existing natural-origin Chinook salmon population. The Port Gamble coho salmon net pens and Quilcene coho salmon net pen are not evaluated because fish are released into marine water and are not near the freshwater production areas for Skokomish Chinook salmon.

- **Steelhead:** The McKernan Hatchery component of the Hood Canal Steelhead Supplementation Project integrated steelhead yearling program is evaluated for competition and predation risks.

Table C-134. Hatchery programs and categories of effects evaluated for Skokomish Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	George Adams Hatchery integrated fall-run Chinook salmon subyearling	√	√	√	√	√	√
	George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling	√	√	√	√	√	√
	Hoodsport Hatchery isolated fall-run Chinook salmon subyearling			√			
	Hoodsport Hatchery isolated fall-run Chinook salmon yearling			√			
Coho salmon	George Adams Hatchery isolated coho salmon yearling	√	√				
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling - McKernan Hatchery	√	√				

Table C-135. Hatchery salmon and steelhead production evaluated for Skokomish Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	George Adams Hatchery integrated fall-run Chinook salmon subyearling	3,800,000	1,900,000	50	3,800,000	0
	George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling	120,000	60,000	50	120,000	0
	Total subyearlings	3,800,000	1,900,000	50	3,800,000	0
	Total yearlings	120,000	60,000	50	120,000	0
	TOTAL	3,920,000	1,960,000	50	3,920,000	0
Coho salmon	George Adams Hatchery isolated coho salmon yearling	300,000	150,000	50	300,000	0
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling - McKernan Hatchery	34,000	34,000	0	34,000	0
All	TOTAL	4,220,000	2,110,000	50	4,220,000	0

[1]Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.14.3 Results

Results for the Skokomish Chinook salmon population are summarized in Table C-136. The action alternatives would include use of an adaptive management approach, but the results in Table C-136 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-136 is explained in the subsequent subsections for this watershed.

Table C-136. Summary of hatchery-related risks and benefits for the Skokomish Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	Moderate	Same as Alternative 1	Same as Alternative 1
Genetics	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.14.3.1 Risks

4.14.3.1.1 Competition

Competition risks to the Skokomish Chinook salmon population from salmon and steelhead hatchery programs under each of the alternatives are summarized in Table C-137. Competition risks range from negligible to low for all alternatives. The overall risk of competition impacts to Skokomish Chinook salmon associated with all hatchery programs is low under all alternatives (Table C-137).

Table C-137. Skokomish Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
George Adams Hatchery integrated fall-run Chinook salmon subyearling	2.0 (2.2 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery isolated coho salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Hood Canal Steelhead Supplementation Project integrated steelhead yearling - McKernan Hatchery	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.14.3.1.2 Predation

Predation risks to the Skokomish Chinook salmon population from salmon and steelhead hatchery programs are summarized in Table C-138. Predation risks to natural-origin Skokomish Chinook salmon range from low to moderate under the alternatives (Table C-138). Risks of predation under Alternative 1 and Alternative 2 are moderate for the George Adams Hatchery coho salmon yearling program, because the hatchery-origin yearling coho salmon are substantially larger than natural-origin Chinook salmon juveniles that may be present in the lower watershed and estuary when the hatchery-origin coho salmon are released. Predation risks under Alternative 3 are low for the coho salmon hatchery program, because of a 50 percent reduction in production level compared to Alternative 1 and Alternative 2 (Table 133). Predation risks and release levels for the coho program under Alternative 4 are the same (moderate) as under Alternative 1 and Alternative 2.

Table C-138. Skokomish Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
George Adams Hatchery integrated fall-run Chinook salmon subyearling	4.0 (3.1 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling	2.9	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery isolated coho salmon yearling	9.9 (5.0 under Alternative 3)	Moderate	Low	Same as Alternative 1
Hood Canal Steelhead Supplementation Project integrated steelhead yearling - McKernan Hatchery	NA	Moderate	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Predation risks for the McKernan Hatchery component of the Hood Canal Steelhead Supplementation Project integrated steelhead yearling program are moderate under all alternatives (Table C-138), because fish from the program would be released in April, immediately following the primary natural-origin juvenile Chinook salmon out-migration period (natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon), and because hatchery-origin steelhead would be released below RM 20.

The overall risk of predation impacts to Skokomish Chinook salmon associated with all hatchery programs is moderate under all alternatives (Table C-135) for the reasons described above.

4.14.3.1.3 Genetics

Assessments of genetic risks to the Skokomish Chinook salmon population using the AHA Model are not available because insufficient information was available to estimate PNI at the time of modeling. Risk levels are assigned (Table C-139) as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, using inferences based on the best available information.

Table C-139. Skokomish Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from George Adams Hatchery integrated fall-run Chinook salmon subyearling	NA	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling	NA	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Hatchery-induced selection risk from other Chinook salmon programs (Hoodsport Hatchery isolated fall-run Chinook salmon programs)	NA	Unknown	Same as Alternative 1	Same as Alternative 1
Overall Risk		Unknown, but likely High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Hatchery-induced selection risks associated with the George Adams Hatchery integrated fall-run Chinook salmon subyearling and George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling programs are unknown but likely high under Alternative 1, Alternative 2, and Alternative 4 (Table C-139), because the hatchery-origin fish would continue to spawn in substantial numbers in the Skokomish River watershed under all alternatives. Mark recovery and scale pattern analysis data collected by the co-managers indicate that the contribution of hatchery-origin Chinook salmon spawning naturally in the Skokomish River watershed has been substantial, exceeding 50 percent of total annual escapements (WDFW 2005j, 2005k; NMFS 2011b). Identically low PNI estimates for the two programs would likely be derived because they would use the same broodstock. Fall-run Chinook salmon hatchery production would be reduced 50 percent under Alternative 3 compared to Alternative 1 (Table C-135) and fewer hatchery-origin adults would return to and spawn in the watershed, but this may not reduce the genetic risk from high.

Genetic risks to the Skokomish Chinook salmon population associated with hatchery-origin fall-run Chinook salmon from the Hoodsport Hatchery isolated fall-run Chinook salmon subyearling and yearling programs are unknown. Hatchery-origin adults from the Hoodsport Hatchery programs would continue to stray into and spawn in natural spawning areas in the Skokomish River watershed. However, the hatchery-origin fish from the Hoodsport Hatchery programs are genetically the same as those produced from the George Adams Hatchery programs, and thus would not pose a risk to among-population genetic diversity. However, stray fish from the Hoodsport Hatchery programs spawning naturally would contribute to hatchery-induced selection risk to the natural-origin Skokomish Chinook salmon population.

For the reasons discussed above, the overall genetic risk to all Chinook salmon populations in the Skokomish River watershed is unknown but likely high under all alternatives (Table C-139).

4.14.3.1.4 Hatchery Facilities and Operation

Two hatchery programs would rear and release Chinook salmon that are part of the Skokomish Chinook salmon population (George Adams Hatchery integrated fall-run Chinook salmon subyearling and George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling programs). Broodstock for the two programs would continue to be collected at George Adams Hatchery. Hatchery facility conditions and operational practices at the two hatcheries would remain the same under all alternatives. Evaluation results for the two programs using the HPV Tool are shown in Table C-140 and Table C-141.

The George Adams Hatchery subyearling program received moderate or high compliance scores for all but one operational phase. The overall hatchery facilities and operation risk for the program would be moderate under Alternative 1 and Alternative 2 (Table C-140), because of a low compliance score for the adult holding operational phase. The low compliance score is associated with a water temperature profile at the hatchery during adult holding that differs substantially from the natural temperature profile. This difference may lead to inadvertent selection pressures for traits such as adult maturation timing and gamete development.

Under Alternative 3, the overall risk would be low (Table C-140), because release levels for the program would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-135). The overall risk under Alternative 4 would be the same (moderate) as under Alternative 1 and Alternative 2, because the release level would be the same.

Table C-140. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Skokomish Chinook salmon.

Hatchery - George Adams Hatchery integrated fall-run Chinook salmon subyearling program (facility and release locations: Purdy Creek -> Skokomish River)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Moderate	Moderate	
Facilities	NA	Moderate	
			Moderate (Low for Alternative 3)

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives. Otherwise, risks are shown for each alternative that is different than Alternative 1.

The George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling program received moderate or high compliance scores for most operational phases. The overall hatchery facilities and operation risk for the program would be moderate under Alternative 1 and Alternative 2 (Table C-141), because of low compliance scores for the adult holding and release operational phases. The low compliance score for adult holding is associated with a water temperature profile at the hatchery during adult holding that differs substantially from the natural temperature profile. This difference may lead to inadvertent selection pressures for traits such as adult maturation timing and gamete development. Adults used as broodstock for both of the hatchery programs are collected and held for spawning at the George Adams Hatchery. Releasing juveniles that are not similar to natural-origin fish in size, behavior, growth rate, and physiological status may affect hatchery-origin fish survival rates, and increase risks to natural-origin fish from hatchery-origin fish.

Under Alternative 3, the overall risk would be low (Table C-141), because release levels for the program would be 50 percent less than under Alternative 1 and Alternative 2 (Table C-135). The overall risk under Alternative 4 would be the same (moderate) as under Alternative 1 and Alternative 2, because the release level would be the same.

Table C-141. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Skokomish Chinook salmon.

Hatchery - George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling program (facility and release locations: Ricks Pond -> Skokomish River)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	High	
Adult Holding	Low	High	
Spawning	High	High	
Incubation	High	High	
Rearing	High	High	
Release	Low	Low	
Facilities	NA	High	
			Moderate (Low for Alternative 3)

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives. Otherwise, risks are provided for each alternative that is different than Alternative 1.

4.14.3.2 Benefits

4.14.3.2.1 Total Return

Table C-142 compares effects of the alternatives on the total return of adult hatchery-origin fish produced by the George Adams Hatchery integrated fall-run Chinook salmon subyearling and George Adams Hatchery Rick's Pond integrated fall-run Chinook salmon yearling programs. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average Skokomish Chinook salmon natural-origin run size. The combined return of hatchery-origin fish produced under each alternative and the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-142. Estimated total return contributions for Skokomish Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	12,912	6,456	12,912
Average natural-origin return	4,996	4,996	4,996
Projected average total return	17,908	11,452	17,908
Restoration Spawner Abundance[1]	12,800	12,800	12,800
Projected average total return as a percent of restoration spawner abundance	140	89	140

Source: Chinook returns are from Tynan (2008).

[1] Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be high under all alternatives, because the combined total adult run size would be greater than 50 percent (89 to 140 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-142). Adult fish produced through the hatchery programs would continue to be harvested with natural-origin Skokomish Chinook salmon in mixed stock marine area and terminal area (marine and freshwater) fisheries directed at Chinook salmon. Fish produced by the programs would be harvested predominantly in U.S. sport fisheries, West Coast Vancouver Island troll fisheries, U.S. troll fisheries, and U.S. net fisheries (George Adams fingerling fall-run Chinook salmon indicator stock fishery contribution estimates from CTC [2012]).

Treaty Indian net and Washington sport fisheries in the Skokomish River would also target adult Chinook salmon that are identified as surplus to hatchery broodstock and natural escapement needs. Adult Chinook salmon contributions to the above fisheries and to escapement resulting from Alternative 1, Alternative 2, and Alternative 4 would be substantially higher than natural-origin Chinook salmon contribution levels under all alternatives.

4.14.3.2.2 Viability

Viability benefits are evaluated separately for the two integrated hatchery programs that benefit the Skokomish Chinook salmon population. Viability results from the programs are provided in Table C-143.

Table C-143. Skokomish Chinook salmon viability benefits by alternative.

Hatchery Program	Alternatives 1 and 2	Alternative 3	Alternative 4
George Adams Hatchery integrated fall-run Chinook salmon subyearling	Moderate	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery Rick’s Pond integrated fall-run Chinook salmon yearling	Moderate	Same as Alternative 1	Same as Alternative 1

George Adams Hatchery Integrated Fall-run Subyearling Program. Viability benefits to the Skokomish Chinook salmon population from the George Adams Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Beginning in 1963, fall-run Chinook salmon broodstock used at the George Adams Hatchery originated from Soos Creek Hatchery (Green River lineage) and other WDFW hatcheries using fish of Green River lineage. The program was self-sustaining for the most part after 1992, when transfers of Green River-lineage salmon from hatcheries outside of Hood Canal ceased. Ruckelshaus et al. (2006) found that the indigenous late-run component of Chinook salmon spawning aggregation in the Skokomish River watershed was extinct, replaced by hatchery-origin fish of Green River lineage. Under the alternatives, broodstock would continue to be obtained from returns to the hatchery.

Under Alternative 1 and Alternative 2, the George Adams Hatchery integrated fall-run Chinook salmon subyearling program would benefit the abundance, diversity, and spatial structure of the Skokomish Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Skokomish fall-run Chinook salmon. Sampling of marked fish in the Skokomish River (WDFW 2005j; NMFS 2011b) suggests that hatchery-origin fish would account for a substantial proportion of the total escapement to natural spawning areas each year. Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Skokomish Chinook salmon population of 1,109 fish. The estimated mean number of natural-origin spawners for this period is 456 fish. The remainder of the fish spawning naturally (653 fish or 59 percent of the mean spawning escapement) are hatchery-origin Chinook salmon. Based on proposed hatchery fish release levels and recent year average contribution rates to fisheries and escapement, 12,540 fish may be produced each year through the program, compared with a return of approximately 2,800 Skokomish natural-origin Chinook salmon (Tynan 2008).

Diversity – The program would benefit diversity, serving as a genetic reserve and providing a source of Skokomish Chinook salmon. Genetic analyses and hatchery-origin fish straying data indicate that the fall-run Chinook salmon returning to George Adams Hatchery are extensively mixed and genetically similar. BMPs would continue to be applied to maintain the diversity of the hatchery fish and potential for local adaptation. Broodstock would be collected randomly over the breadth of the return to the hatchery, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning.

Spatial Structure – The program would benefit spatial structure to the extent that fish spawning in Purdy Creek (the hatchery release site) and elsewhere in the Skokomish River contribute spawners to otherwise unused natural habitat.

Productivity – The benefit of the hatchery program to productivity is unknown. The poor abundance status of natural-origin Skokomish Chinook salmon suggests that their productivity in the existing natural environment is poor, and that contributions by naturally spawning hatchery-origin fish are not leading to improved productivity of natural-origin Skokomish Chinook salmon. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Skokomish Chinook salmon population of 0.76. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite of Skokomish Chinook salmon natural spawners is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the benefit of the subyearling hatchery program to viability would be moderate, although the number of adults contributing to abundance would be reduced, corresponding to a 50 percent reduction in subyearling releases compared to Alternative 1 and Alternative 2 (Table C-135). The number of adults expected to return from the program under Alternative 3 would be 6,270 compared to 12,540 for Alternative 1 and Alternative 2 (Tynan 2008). Benefits to diversity, spatial structure, and productivity would be the same as Alternative 1 and Alternative 2, because all other aspects of the program would remain unchanged.

Under Alternative 4, annual subyearling Chinook salmon release levels and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate, the same as for Alternative 1 and Alternative 2.

George Adams Hatchery Rick's Pond Fall-run Yearling Program. Viability benefits to the Skokomish Chinook salmon population from the George Adams Hatchery integrated fall-run Chinook salmon yearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the George Adams Hatchery integrated fall-run Chinook salmon yearling program would benefit the abundance and diversity of the Skokomish Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Skokomish fall-run Chinook salmon. Sampling of marked fish in the Skokomish River (WDFW 2005k; NMFS 2011b) suggests that hatchery-origin fish would account for a substantial proportion of the total escapement to natural spawning areas each year. Production levels under Alternative 1 and Alternative 2 would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Skokomish Chinook salmon population of 1,109 fish. The estimated mean number of natural-origin spawners for this period is 456 fish. The remainder of the fish spawning naturally (653 fish or 59 percent of the mean spawning escapement) are hatchery-origin Chinook salmon.

Diversity – The program would have some benefit to diversity by contributing to the gene pool for Skokomish Chinook salmon. BMPs would continue to be applied to maintain the diversity of the hatchery fish and potential for local adaptation. Broodstock would be collected randomly over the breadth of the return to the hatchery, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning.

Spatial Structure – The program would benefit spatial structure to the extent that fish spawning in Purdy Creek (the hatchery release site) and elsewhere in the Skokomish River contribute spawners to otherwise unused natural habitat.

Productivity – The benefit of the hatchery program to productivity is unknown. The poor abundance status of the natural-origin population indicates that their productivity in the existing natural environment is poor and that contributions by naturally spawning hatchery-origin fish are not leading to improved productivity of natural-origin Skokomish Chinook salmon. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Skokomish Chinook salmon population of 0.76. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite of Skokomish Chinook salmon natural spawners is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3, the benefit of the yearling hatchery program to viability would be moderate. The program would benefit abundance, even though the number of adults contributing to abundance would be reduced, corresponding to a 50 percent reduction in yearling releases compared to Alternative 1 and Alternative 2 (Table C-135). The number of adults expected to return from the yearling program under Alternative 3 would be 186 compared to 372 for Alternative 1 and Alternative 2 (Tynan 2008). The benefit to spatial structure would be negligible because of the relatively small numbers of adults expected to return under the alternative. Benefits to diversity and productivity would be the same as Alternative 1 and Alternative 2, because all other aspects of the program would remain unchanged.

Under Alternative 4, annual yearling Chinook salmon release levels and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 4 would be moderate, the same as for Alternative 1 and Alternative 2.

4.14.3.3 Summary - Skokomish Chinook Salmon

Table C-136 summarizes the risks and benefits for all alternatives pertinent to the Skokomish Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the six hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from low to moderate, with moderate predation and hatchery facilities and operation risk, low risk for competition, and likely high genetic risk. Decreased production of hatchery-origin Chinook salmon under Alternative 3 would reduce the hatchery facilities and operation risk to low. All other risks and benefits are the same across alternatives. Benefits are high for total return and moderate for viability under all alternatives.

4.14.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits.

However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the Skokomish Chinook salmon population.

- To reduce hatchery-induced selection risks associated with the hatchery programs, decrease the number of hatchery-origin Chinook salmon straying into river reaches that are accessible to natural-origin Chinook salmon spawners. Methods to reduce hatchery stray levels include: installing and operating a weir and trap to control spawning levels by known hatchery-origin fish (adipose fin-marked); increasing selective fisheries harvest rates to reduce hatchery-origin fish proportions escaping to natural spawning areas; and/or reducing the number of hatchery fish released each year to reduce adult hatchery-origin fish return levels.
- Improve the ability to assess natural-origin fall-run Chinook salmon contribution and productivity levels in the watershed, and implement innovative management options for controlling hatchery-origin fish hatchery-induced selection risks.

Provided in Table C-144 is a summary of potential mitigation measures for the Skokomish Chinook salmon population action alternatives. These mitigation measures would help reduce predation, genetic, and hatchery facilities and operation risks, which are rated as likely high (genetics) and moderate (predation and hatchery facilities and operation) risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-136).

Table C-144. Potential mitigation measures for the Skokomish Chinook salmon population.

Risk Category	**Mitigation Measures[1]**
Predation	Apply Mitigation Measures P2 and P5.
Hatchery facilities and operation	Apply Mitigation Measure H1.

[1]Refer to Table C-2 for a description of each mitigation measure.

Application of the above mitigation measures would likely help reduce the risks of predation, genetics, and hatchery facilities and operation impacts of the programs on the natural-origin Skokomish Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would consider the assigned value of the Skokomish Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria for the ESU defined in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). Under the NMFS delisting criteria, as one of only two populations in the Central West (or Hood Canal) Major Population Group, recovery of the Skokomish Chinook salmon population to a low extinction risk status is required for ESU viability and delisting.

4.15 Mid-Hood Canal Chinook Salmon

4.15.1 Introduction

As shown in Table C-1, the Hamma Hamma, Dosewallips, and Duckabush River watersheds support the Mid-Hood Canal fall-run Chinook salmon population. The population is federally listed under the ESA. As described in Subsection 2.11, Mid-Hood Canal Chinook Salmon Population, the Mid-Hood Canal Chinook salmon population spawns in the Hamma Hamma, Dosewallips and Duckabush Rivers.

Hatcheries and associated programs and release sites in the Hamma Hamma and Duckabush Rivers, as well as John Creek (a lower tributary of the Hamma Hamma River), are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon.

One Chinook salmon hatchery program and one steelhead hatchery program have the potential to impact the Mid-Hood Canal Chinook salmon population (Table C-145 and Table C-146), and are reviewed in this subsection.

Table C-145. Hatchery programs and categories of effects evaluated for Mid-Hood Canal Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	√	√	√	√	√	
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling – Lilliwaup Hatchery (Duckabush River)	√	√				

Table C-146. Hatchery salmon and steelhead production evaluated for Mid-Hood Canal Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	110,000	110,000	0	110,000	0
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling – Lilliwaup Hatchery (Duckabush River)	6,897	6,897	0	6,897	0

[1]Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.15.2 Methods

In conducting the analysis for the Mid-Hood Canal Chinook salmon population, the following analyses are applied:

- All hatchery programs that release salmon and steelhead hatchery-origin fish in rivers and streams are evaluated.
- **Chinook Salmon:** One hatchery program (Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling) is evaluated for all risks and benefits.
- **Coho Salmon:** No coho salmon hatchery programs occur within the population boundaries for the Mid-Hood Canal Chinook salmon population.
- **Steelhead:** There are two components of the Hood Canal Supplementation Project integrated steelhead yearling hatchery program within the boundaries of the Mid-Hood Canal Chinook salmon population: releases from the Lilliwaup Hatchery into the Dewatto River and the Duckabush River, and releases into the Dewatto River on the east side of Hood Canal. Releases into the Dewatto River are not evaluated because Chinook salmon would not be impacted from releases in that watershed. Releases into the Duckabush River potentially pose a competition and predation risk to Mid-Hood Canal Chinook salmon and are evaluated. The McKernan Hatchery (Skokomish) component of the Hood Canal Supplementation Project integrated steelhead yearling hatchery program is evaluated for competition and predation risks under Subsection 4.14, Skokomish Chinook Salmon.

4.15.3 Results

Results for the Mid-Hood Canal Chinook salmon population are summarized in Table C-147. The action alternatives would include use of an adaptive management approach, but the results in Table C-147 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-147 is explained in the subsequent subsections for this watershed.

Table C-147. Summary of hatchery-related risks and benefits for the Mid-Hood Canal Chinook salmon population by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Negligible	Same as Alternative 1
Predation	Moderate	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1
Viability	Low	Same as Alternative 1	Same as Alternative 1

4.15.3.1 Risks

4.15.3.1.1 Competition

Competition risks to the Mid-Hood Canal Chinook salmon population from Chinook salmon and steelhead hatchery programs under each of the alternatives in Mid-Hood Canal watersheds are summarized in Table C-148. The competition risks for the Chinook salmon hatchery program are low for Alternative 1, Alternative 2, and Alternative 4, and negligible under Alternative 3. There are no Chinook salmon hatchery programs operating in the Dosewallips or Duckabush Rivers that would affect Mid-Hood Canal Chinook salmon in those watersheds.

The competition risks from the small steelhead program are low for all alternatives, because the releases would occur low (RM 2.3 and RM 5.0) in the Duckabush River watershed.

The overall risk of competition impacts to Mid-Hood Canal Chinook salmon associated with the hatchery programs is low under all alternatives (Table C-148).

Table C-148. Mid-Hood Canal Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	1.1 (0.8 under Alternative 3)	Low	Negligible	Same as Alternatives 1 and 2
Hood Canal Steelhead Supplementation Project integrated steelhead yearling – Lilliwaup Hatchery (Duckabush River)	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.15.3.1.2 Predation

Predation risks to the Mid-Hood Canal Chinook salmon population from salmon and steelhead hatchery programs are summarized in Table C-149. Predation risks for the Hood Canal Steelhead Supplementation Project integrated steelhead yearling - Lilliwaup Hatchery (released in the Duckabush River) would be moderate under all alternatives (Table C-149), because fish from the program would be released in April, immediately following the primary natural-origin juvenile Chinook salmon out-migration period (natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon), and because the fish would be released below RM 20. The overall risk of predation impacts to the Mid-Hood Canal Chinook salmon associated with the hatchery programs is moderate under all alternatives (Table C-149).

Table C-149. Mid-Hood Canal Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	2.5 (1.1 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative
Hood Canal Steelhead Supplementation Project integrated steelhead yearling – Lilliwaup Hatchery (Duckabush River release)	NA	Moderate	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.15.3.1.3 Genetics

Assessments of genetic risks to the Mid-Hood Canal Chinook salmon population are based on PNI estimates from the AHA Model derived for each alternative (Table C-150). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-150. Mid-Hood Canal Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risk from Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	0.50	Moderate	Same as Alternative 1	Same as Alternative 1
Overall Risk		Moderate	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

The genetic risk to the Mid-Hood Canal Chinook salmon population from the Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program is moderate because PNI is between 0.35 and 0.67 for all alternatives (Table C-150) (Appendix E, Overview of the All H Analyzer). A large proportion of the total number of Chinook salmon observed in Hamma Hamma River natural spawning areas each year (one of three watersheds representing the Mid-Hood Canal Chinook salmon population) are hatchery-origin fish (WDFW 2005l). High contributions of hatchery-origin fish in natural spawning areas lowers PNI estimates which reflect greater hatchery-induced selection risks.

4.15.3.1.4 Hatchery Facilities and Operation

The Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program rears and releases fish that are part of the Nisqually Chinook salmon population. Hatchery production relies on collection of broodstock from the river and transfers of eggs/fish from George Adams Hatchery (Skokomish River). The fish are reared and released as subyearlings from hatchery raceways and/or earthen ponds into John Creek, a lower Hamma Hamma River tributary. Hatchery facility conditions and operational practices would remain the same under all alternatives. Evaluation results for the program using the HPV Tool are provided in Table C-151.

Table C-151. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Mid-Hood Canal Chinook salmon.

Hatchery - Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program (facility and release locations: Hamma Hamma Hatchery ->John Creek)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	Moderate	High	
Adult Holding	High	High	
Spawning	High	High	
Incubation	Moderate	High	
Rearing	High	High	
Release	High	Moderate	
Facilities	NA	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

Hatchery facilities and operation risks would be negligible under all alternatives (Table C-151). There are no operational phases that have a low compliance score for the Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program, and risks are the same among alternatives because hatchery production would not change (Table C-151).

4.15.3.2 Benefits

4.15.3.2.1 Total Return

Table C-152 compares effects of the alternatives on the total return of adult hatchery-origin Chinook salmon produced by the Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Mid-Hood Canal Chinook salmon adult run size. The return of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-152. Estimated total return contributions for Mid-Hood Canal Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	700	700	700
Average natural-origin return	155	155	155
Projected average total return	855	855	855
Restoration spawner abundance[1]	11,000	11,000	11,000
Projected average total return as a percent of restoration spawner abundance	8	8	8

Source: Chinook returns are from Tynan (2008).
[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be low under all alternatives, because the combined total adult run size would be less than 20 percent (8 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-153). Benefits would be confined to only one watershed (Hamma Hamma River watershed) within the boundary of the Mid-Hood Canal Chinook salmon population. Hatchery fish production levels and total return benefits would remain the same under all alternatives (Table C-147). Adult fish produced through the hatchery program would be harvested with natural-origin Mid-Hood Canal Chinook salmon in mixed stock marine area and terminal area fisheries directed at Chinook salmon.

Hatchery-origin fish produced by the program would continue to be harvested predominantly in U.S. sport fisheries, West Coast Vancouver Island troll fisheries, and U.S. troll fisheries (assuming George Adams subyearling fall-run Chinook salmon indicator stock fishery contribution estimates from CTC [2012]). There are no directed U.S. net fisheries impacting this stock. Hatchery-origin Chinook salmon from these programs would also contribute a substantial proportion of the total number of Chinook salmon escaping to natural spawning areas in the Hamma Hamma River.

Adult hatchery-origin Chinook salmon contributions to the above fisheries and to escapement could be substantial relative to natural-origin Mid-Hood Canal Chinook salmon under all alternatives. However, because fish from the hatchery program would only be released in the Hamma Hamma River watershed, total return benefits to the larger population would not be substantial.

4.15.3.2.2 Viability

Viability benefits to the Mid-Hood Canal Chinook salmon population from the Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program are evaluated in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery program are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Fish produced by the hatchery program would continue to be of Green River lineage, a stock used at the hatchery beginning in 1995 and obtained from WDFW hatcheries in Hood Canal to which the stock had become localized. Under all alternatives, 50 percent of the hatchery production would originate from broodstock collected at the George Adams Hatchery (Skokomish River watershed), with the remainder collected from the Hamma Hamma River. Ruckelshaus et al. (2006) found that indigenous fall-run Chinook salmon in Mid-Hood Canal rivers were extinct, replaced by hatchery-origin fall-run fish of Green River lineage.

Under Alternative 1 and Alternative 2, the Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling program would benefit the diversity of the Mid-Hood Canal Chinook salmon population. Thus, the viability benefit of the program is low for the reasons described below.

Abundance – The hatchery program would have a negligible benefit to the abundance of Mid-Hood Canal Chinook salmon. The program is modest in size (110,000 subyearlings). Releases from the hatchery program would be confined to only one of the three watersheds (Dosewallips, Duckabush, and Hamma Hamma) used by the Mid-Hood Canal Chinook salmon population. Although the abundance of Chinook salmon spawners in the Hamma Hamma River increased corresponding to the initiation of the hatchery program in 1998, abundance has decreased substantially in recent years (WDFW 2005l). The present and likely future contribution of the hatchery program to the abundance of the Mid-Hood Canal Chinook salmon population is uncertain. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean natural spawner escapement for the Mid-Hood Canal Chinook salmon population of 81 fish. The mean number of natural-origin Mid-Hood Canal spawners for this period was estimated to be 44. The remainder of the mean number of natural spawners, 37 fish or 46 percent of the mean escapement to the river, are hatchery-origin Chinook salmon.

Diversity – The hatchery program would provide some benefit to diversity. Genetic data suggest that Hamma Hamma River fall-run Chinook salmon returns are not genetically distinct from the Skokomish Chinook salmon population, or from the George Adams Hatchery and Hoodsport Hatchery fish used as broodstock for the Hamma Hamma Hatchery program (WDFW 2005l). This suggests that the Hamma Hamma Hatchery program would support and benefit diversity of the Hamma Hamma River portion of the Mid-Hood Canal Chinook salmon population. BMPs would continue to be applied to maintain the diversity of the hatchery fish and potential for local adaptation. Broodstock would be collected randomly over the breadth of the return to the hatchery and a factorial mating scheme would be used during spawning.

Spatial Structure – The benefit of the hatchery program to spatial structure would be negligible. Although returning fish from the program may spawn naturally in areas historically used by natural-origin Chinook salmon, the relatively small numbers of fish returning from the program would contribute minimally to spatial structure of the Mid-Hood Canal Chinook salmon population.

Productivity – The benefit of the hatchery program to productivity is unknown. The poor abundance status of natural-origin Mid-Hood Canal Chinook salmon suggests that their productivity in the existing natural environment is poor and that contributions by naturally spawning hatchery-origin fish are not leading to improved productivity of natural-origin Mid-Hood Canal Chinook salmon. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Mid-Hood Canal Chinook salmon population of 0.86. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite of Mid-Hood Canal Chinook salmon natural spawners is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. This assumption is reasonable because the program would release fish at the subyearling life stage. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would also be low.

4.15.3.3 Summary – Mid-Hood Canal Chinook Salmon

Table C-147 summarizes the risks and benefits for all alternatives pertinent to the Mid-Hood Canal Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the two hatchery programs evaluated for the Mid-Hood Canal Chinook salmon population, overall risks under Alternative 1 and Alternative 2 range from negligible to moderate, with hatchery facilities and operation as a negligible risk, competition as a low risk, and predation and genetics as moderate risks. Production levels do not change among alternatives; thus, all alternatives would have the same risk levels. Benefits would be low for total return and viability under all alternatives.

4.15.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which would be applicable to more than one hatchery program as shown in Table C-2.

Genetics. The following site-specific mitigation measures would help to decrease genetic risks to the Mid-Hood Canal Chinook salmon population.

- Terminate transfers of George Adams Hatchery Chinook salmon that are currently used as a brood source to partially sustain the Hamma Hamma Hatchery program.
- Collect and spawn natural-origin adult Chinook salmon returning to the Hamma Hamma River to sustain the supplementation program. This practice would reduce hatchery-induced selection risks associated with high out-of-watershed hatchery stock transfer and resultant spawning proportions in the Hamma Hamma River.

Provided in Table C-153 is a summary of potential mitigation measures for the Mid-Hood Canal Chinook salmon population action alternatives. These mitigation measures would help reduce predation and genetic risks, which are rated as moderate under Alternative 2, Alternative 3, and Alternative 4 (Table C-147).

Table C-153. Potential mitigation measures for the Mid-Hood Canal Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measure P2.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above mitigation measures consistent with an adaptive management approach would likely help reduce the risks of competition, predation, and genetic impacts from the programs on the natural-origin Mid-Hood Canal Chinook salmon population. Decisions regarding the pace of and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the Mid-Hood Canal natural-origin Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to recovery and delisting criteria for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). There are only two Chinook salmon populations (Skokomish and Mid-Hood Canal) composing the Central West Major Population Group of the Puget Sound Chinook Salmon ESU. To meet NMFS criteria for recovery and delisting of the ESU as a whole, the natural-origin Mid-Hood Canal Chinook salmon population must achieve a low risk of extinction.

4.16 Dungeness Chinook Salmon

4.16.1 Introduction

As shown in Table C-1, the Dungeness River watershed supports the Dungeness spring-run Chinook salmon population. The population is federally listed as threatened under the ESA. As described in Subsection 2.12, Dungeness Chinook Salmon Population, the river supports a natural-origin population of spring-run Chinook salmon that spawn in the mainstem up to about RM 19 and in the Gray Wolf River up to RM 5.

Hatcheries and associated programs within the Dungeness River, Gray Wolf River, and Hurd Creek are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon.

One Chinook salmon hatchery program (evaluated separately), one coho salmon hatchery program, and one steelhead hatchery program from two hatcheries have the potential to impact the Dungeness Chinook salmon population (Table C-154 and Table C-155) and are reviewed in this subsection.

Table C-154. Hatchery programs and categories of effects evaluated for Dungeness Chinook salmon.

		Risk				Benefit	
Species	**Hatchery and Program**	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling	√	√	√[1]	√[1]	√[1]	√[1]
	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	√	√	√[1]	√[1]	√[1]	√[1]
Coho salmon	Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	√	√				
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling	√	√				

[1] These hatchery programs are evaluated as a single Chinook salmon group for specific risks and benefits.

Table C-155. Hatchery salmon and steelhead production evaluated for Dungeness Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling	100,000	100,000	0	100,000	0
	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	100,000	100,000	0	100,000	0
	Total subyearlings	100,000	100,000	0	100,000	0
	Total yearlings	100,000	100,000	0	100,000	0
	TOTAL	200,000	200,000	0	200,000	0
Coho salmon	Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	500,000	250,000	50	500,000	0
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling winter-run	10,000	5,000	50	10,000	0
All	TOTAL	710,000	455,000	36	710,000	0

[1] Not shown are hatchery programs outside the population area that are analyzed for genetic risks only.

4.16.2 Methods

In conducting the analysis for the Dungeness spring-run Chinook salmon population, the following analyses are applied:

- All hatchery programs that release hatchery-origin salmon and steelhead in rivers and streams are evaluated.
- **Chinook Salmon:** The Dungeness integrated spring-run Chinook salmon program uses two hatcheries (Dungeness Hatchery and Hurd Creek Hatchery) to produce subyearling and yearling fish. The two hatcheries within the program are evaluated separately for competition and predation risks and together for all other risks and benefits.

- **Coho Salmon:** The Dungeness River isolated coho salmon yearling program uses two hatcheries (Dungeness Hatchery and Hurd Creek Hatchery) to produce coho salmon, which are evaluated for competition and predation risks.
- **Steelhead:** One hatchery program (Dungeness Hatchery isolated winter-run steelhead yearling) is evaluated for competition and predation risks.

4.16.3 Results

Results for the Dungeness Chinook salmon population are summarized in Table C-156. The action alternatives would include use of an adaptive management approach, but the results in Table C-157 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-156 is explained in the subsequent subsections for this watershed.

Table C-156. Summary of risk and benefits for Dungeness spring-run Chinook salmon by alternative.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.16.3.1 Risks

4.16.3.1.1 Competition

Competition risks to the Dungeness Chinook salmon spring-run population from Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives in the Dungeness River watershed are summarized in Table C-157. Risks of competition effects to natural-origin Chinook salmon resulting from hatchery salmon and steelhead production in the Dungeness River watershed range from negligible to low under all alternatives (Table C-157). The overall risk of competition impacts to Dungeness Chinook salmon associated with all hatchery programs is low under all alternatives (Table C-157).

Table C-157. Dungeness Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling	2.2	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	1.6 (1.4 under Alternative 3)	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

4.16.3.1.2 Predation

Predation risks to the Dungeness Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs are summarized in Table C-158. Predation risks to natural-origin Dungeness Chinook salmon range from negligible to high under the alternatives (Table C-158). Under Alternative 1 and Alternative 2, predation risks are high for the Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling and isolated coho salmon yearling programs (Table C-158), because the total number of yearling hatchery fish released through the programs would be considerable (100,000 Chinook salmon yearlings and 500,000 coho salmon yearlings) (Table C-155), relative to the abundance of natural-origin Chinook salmon juveniles present at the time the hatchery-origin fish would be released.

Table C-158. Dungeness Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling	0.7	Negligible	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	14.4	High	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	15.5 (10.2 under Alternative 3)	High	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

Contributing to this high predation risk is the larger size of hatchery-origin salmon (average hatchery-origin Chinook salmon yearling size is 6.1 inches fork length, coho salmon yearling size is 5.5 inches fork length) (EIS Table 3.2-4) compared to natural-origin juvenile Chinook salmon (average size of 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4). Under Alternative 3, the number of hatchery-origin coho salmon yearlings released would be 50 percent less than under Alternative 1 and Alternative 2, but the decrease would be insufficient to lower the predation risk under that alternative (Table C-158).

There is a low risk of predation from the Dungeness Hatchery winter-run steelhead program (Table C-158), because the hatchery-origin steelhead would be released in the lower Dungeness River at RM 10.5 and released after May 1.

The overall risk of predation to Dungeness Chinook salmon associated with all hatchery programs is high under all alternatives (Table C-158) for the reasons described above.

4.16.3.1.3 Genetics

Assessments of genetic risks to the Dungeness Chinook salmon population from hatchery programs are based on PNI estimates from the AHA Model for each alternative (Table C-159). Risk levels are assigned using the qualitative criteria applied to PNI estimates for integrated programs as defined in Appendix B, Hatchery Effects and Evaluation Methods for Fish.

Table C-159. Dungeness Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risks from Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling and yearling programs	0.08	High	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the AHA Model. If only one value is shown, it is the same for all alternatives. Otherwise, values are shown for each alternative that are different than Alternative 1.

Genetic risks to Dungeness Chinook salmon are high under all alternatives (Table C-159), primarily because PNI is less than 0.35 for all alternatives (Table C-159) (Appendix E, Overview of the All H Analyzer). Hatchery release levels and resultant contributions of naturally spawning adults would be high relative to natural-origin fish spawning levels across alternatives.

4.16.3.1.4 Hatchery Facilities and Operation

The Dungeness Hatchery and Hurd Creek Hatchery subyearling and yearling programs rear and release hatchery fish that are part of the listed Dungeness Chinook salmon population. The subyearling and yearling releases are evaluated together using the HPV Tool. Hatchery facility conditions and operational practices would remain the same under all alternatives.

Evaluation results for the programs using the HPV Tool are shown in Table C-160. There were no operational phases that received a low compliance score for the Dungeness River Hatchery and Hurd Creek Hatchery subyearling and yearling Chinook salmon release programs. Thus, hatchery facilities and operation risks to the natural-origin Dungeness Chinook salmon population would be negligible under all alternatives (Table C-160).

Table C-160. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Dungeness Chinook salmon.

Hatcheries - Dungeness Hatchery and Hurd Creek Hatchery subyearling and yearling programs (facility and release locations: Upper Dungeness River and Gray Wolf Acclimation Pond (RM 1.0) and Dungeness River (RM 10.5)			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[1]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	High	High	
Spawning	High	Moderate	
Incubation	High	High	
Rearing	Moderate	High	
Release	Moderate	Moderate	
Facilities	High	High	
			Negligible

[1]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

4.16.3.2 Benefits

4.16.3.2.1 Total Return

Table C-161 compares effects of the alternatives on the total return of adult hatchery-origin Chinook salmon produced by the Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling and yearling program. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Dungeness Chinook salmon adult run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-161. Estimated total return contributions for Dungeness Chinook salmon.

	Alternatives 1 and 2	Alternative 3	Alternative 4
Average hatchery-origin return	305	305	305
Average natural-origin return	330	330	330
Projected average total return	635	635	635
Restoration spawner abundance[1]	4,700	4,700	4,700
Projected average total return as a percent of restoration spawner abundance	14	14	14

Source: Chinook returns are from Tynan (2008).

[1] Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

The benefits to total return would be low under all alternatives, because the combined total run size would be less than 20 percent (14 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-161). Subyearling and yearling Chinook salmon release levels would be the same under all alternatives (Table C-155). Although the hatchery programs contribute less than half of annual adult returns, the very small size of the natural-origin component of the Dungeness Chinook salmon population is consistent with this benefit level. Adult fish produced through the hatchery programs would continue to be harvested with natural-origin Dungeness Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon. Fish produced by the program would be harvested predominantly in West Coast Vancouver Island troll fisheries, U.S. sport fisheries, and Canadian net fisheries (assumes Hoko fall-run fingerling Chinook salmon indicator stock fishery contribution estimates from CTC [2012]).

No directed U.S. terminal area or river net and sport fisheries would impact this stock. Hatchery-origin Chinook salmon from the programs could contribute a substantial proportion of the total number of Chinook salmon escaping to natural spawning areas in the Dungeness River and Grey Wolf River. Annual hatchery-origin adult Chinook salmon contributions to the above fisheries and to escapement would be nearly equivalent to natural-origin contribution levels under all alternatives (Table C-161).

4.16.3.2.2 Viability

Viability benefits to the Dungeness Chinook salmon population from the Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling and yearling programs are evaluated together in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery programs are part of the Puget Sound Chinook Salmon ESU, and are listed along with the natural-origin Chinook salmon population.

The hatchery program is part of an effort to supplement the natural-origin Dungeness Chinook salmon population (WDFW 2005m). Hatchery-origin fish were derived from natural-origin spring-run Chinook salmon returning to the Dungeness River. Returning hatchery-origin adults spawn in Dungeness Chinook salmon natural spawning areas, and are not collected or spawned at the hatcheries or acclimation ponds that are used for rearing and release.

Under Alternative 1 and Alternative 2, the Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon subyearling and yearling program would benefit the abundance, diversity, and spatial structure of the Dungeness Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery programs would benefit the abundance of Dungeness Chinook salmon. Total adult Chinook salmon returns to the Dungeness River have increased in recent years (Ford 2011). This suggests that the hatchery programs may be contributing to hatchery-origin and natural-origin spawner abundances, compared to abundances observed prior to initiation of the hatchery supplementation effort. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Dungeness Chinook salmon population of 417 fish. The estimated mean number of natural-origin spawners for this period is 161 fish. The remainder of the fish spawning naturally (256 fish or 61 percent of the mean spawning escapement) are hatchery-origin spring-run Chinook salmon.

Diversity – The hatchery programs would benefit diversity. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly, separate families would be maintained, a factorial mating scheme would be used during spawning, and adult fish would continue to be allowed to access upstream areas in the Dungeness River for natural spawning. These measures would continue to maintain the diversity of the propagated population.

Spatial Structure - The hatchery programs would benefit spatial structure. Hatchery-origin fish would continue to be released from acclimation ponds adjacent to up-river natural spawning areas. This will benefit the spatial structure of Dungeness Chinook salmon by contributing fish to historically used spawning areas that most likely had not been used prior to adults returning from the supplementation program.

Productivity – The benefit of the hatchery programs to productivity is unknown. However, the continuing poor abundance status of the natural-origin Dungeness Chinook salmon population suggests that its productivity in the existing natural environment continues to be poor. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Dungeness Chinook salmon population of 0.81. A lambda of 1.0

indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite of Dungeness Chinook salmon natural spawners is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the programs would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

4.16.3.3 Summary – Dungeness Chinook Salmon

Table C-156 summarizes the risks and benefits for all alternatives pertinent to the Dungeness spring-run Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the four hatchery programs evaluated in the Dungeness River watershed, overall risks to natural-origin Chinook salmon under Alternative 1 and Alternative 2 range from negligible to high, with hatchery facilities and operation as a negligible risk, competition as a low risk, and genetics and predation as high risks. Benefits would be low for total return and moderate for viability. Coho salmon and steelhead production decreases under Alternative 3 would not change risk or benefit levels. Alternative 4 would have the same hatchery production as Alternative 1 and Alternative 2 for all species evaluated; thus, risk and benefit levels would be the same under all alternatives.

4.16.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin Chinook salmon from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table C-2 if the measures would result in decreasing more than one risk category.

The mitigation measures identified in this subsection include site-specific measures and more generalized measures for consideration, which could be applicable to more than one hatchery program as shown in Table C-2.

Predation and Genetics. The following site-specific mitigation measure would help to decrease predation and genetic risks to the Dungeness spring-run Chinook salmon population.

- Transition the yearling Chinook salmon production component of the current supplementation effort to a subyearling smolt release program to reduce predation risks to natural-origin Chinook salmon juveniles and reduce potential hatchery-induced selection risks to the natural-origin Dungeness Chinook salmon population.

Provided in Table C-162 is a summary of potential mitigation measures for the Dungeness Chinook salmon population action alternatives. These mitigation measures would help reduce predation and genetic risks, which are rated as high under Alternative 2, Alternative 3, and Alternative 4 (Table C-156).

Table C-162. Potential mitigation measures for the Dungeness Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measure P3.
Genetics	Apply Mitigation Measure G3.

[1] Refer to Table C-2 for a description of each mitigation measure.

Application of the above mitigation measures consistent with an adaptive management approach would likely help reduce the risks of predation and genetic impacts of the programs on natural-origin Dungeness Chinook salmon. Decisions regarding the pace and need for implementation of the hatchery risk mitigation actions would be based on the assigned value of the Dungeness spring-run Chinook salmon population for the recovery of the Puget Sound Chinook Salmon ESU to a viable status, and its standing relative to delisting criteria defined for the ESU in the recovery plan (72 Fed. Reg. 2493, January 19, 2007). Under the NMFS delisting criteria, as one of only two Chinook salmon populations composing the North West (or Strait of Juan de Fuca) Major Population Group, recovery of the natural-origin Dungeness Chinook salmon population to a low extinction risk status is required for ESU viability and delisting.

4.17 Elwha River

4.17.1 Introduction

As shown in Table C-1, the Elwha River watershed supports the natural-origin Elwha summer/fall-run Chinook salmon population. The population is federally listed as threatened under the ESA. Analyses of risks and benefits assume releases of hatchery-origin fish would be made into the unblocked, 5-mile portion of the lower Elwha River watershed within which natural production by salmon and steelhead has been possible for the last 100 years. Dam removal operations are underway and are expected to be fully complete in 2014 (Ward et al. 2008). Hatcheries and associated programs within the Elwha River watershed and Morse Creek are evaluated in this subsection according to their risks and benefits to natural-origin Chinook salmon.

This analysis is consistent with the recent environmental analysis of effects from Elwha hatchery programs NMFS (2012a), although the analytical methods and terms used to summarize negative and beneficial effects differ.

One Chinook salmon hatchery program (with two components), one coho salmon hatchery program, and one steelhead hatchery program from three hatcheries have the potential to impact the Elwha Chinook salmon population (Table C-163 and Table C-164) and are reviewed in this subsection.

Table C-163. Hatchery programs and categories of effects evaluated for Elwha Chinook salmon.

Species	Hatchery and Program	Risk				Benefit	
		Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Chinook salmon	Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling	√	√	√[1]	√[1]	√[1]	√[1]
	Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling	√	√	√[1]	√[1]	√[1]	√[1]
Coho salmon	Lower Elwha Hatchery integrated coho salmon yearling	√	√				
Steelhead	Lower Elwha Hatchery integrated winter-run steelhead yearling	√	√				

[1] These hatchery programs are evaluated as a single Chinook salmon group for specific risks and benefits.

Table C-164. Hatchery salmon and steelhead production evaluated for Elwha Chinook salmon.

Species	Hatchery and Program[1]	Release Number for Alternatives 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternatives 1 and 2	Release Number	Percent Increase from Alternatives 1 and 2
Chinook salmon	Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling[2]	2,500,000	2,500,000	0	2,500,000	0
	Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling[2]	400,000	400,000	0	400,000	0
	Total subyearlings	2,500,000	2,500,000	0	2,500,000	0
	Total yearlings	400,000	400,000	0	400,000	0
	TOTAL	2,900,000	2,900,000	0	2,900,000	0
Coho salmon	Lower Elwha Hatchery integrated coho salmon yearling	425,000	425,000	0	425,000	0
Steelhead	Lower Elwha Hatchery integrated winter-run steelhead yearling	175,000	175,000	0	175,000	0
All	TOTAL	3,500,000	3,500,000	0	3,500,000	0

[1]Not shown are hatchery programs outside the population area that are analyzed for genetic risk only.

[2]These hatchery releases are described in one HGMP. The subyearling and yearling components of the HGMP are evaluated as separate programs for the purposes of this EIS.

4.17.2 Methods

In conducting the analysis for the Elwha Chinook salmon population, the following analyses are applied:

- **Chinook Salmon:** One hatchery program (Elwha River integrated summer/fall-run Chinook salmon program, which includes subyearling releases from the Elwha Channel Hatchery, and yearling releases from the Elwha Channel Hatchery and Morse Creek Hatchery) is evaluated for risks and benefits. The program components are evaluated separately for competition and predation risks and together for all other risks and benefits.

- **Coho Salmon:** The Lower Elwha Hatchery integrated coho salmon yearling program is evaluated for competition and predation.

- **Steelhead:** The Lower Elwha Hatchery integrated winter-run steelhead yearling program is evaluated for competition and predation risks.

4.17.3 Results

Results for the Elwha Chinook salmon population are summarized in Table C-165. The action alternatives would include use of an adaptive management approach, but the results in Table C-165 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this watershed are identified in a later subsection. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for moderate and high risks in Table C-165 is explained in the subsequent subsections for this watershed.

Table C-165. Summary of hatchery-related risks and benefits for the Elwha Chinook salmon population by alternative.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	High	Same as Alternative 1	Same as Alternative 1
Genetics	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Same as Alternative 1	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

4.17.3.1 Risks

4.17.3.1.1 Competition

Competition risks to the Elwha Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs are summarized in Table C-166. Competition risks to Elwha Chinook salmon range from negligible to low under all alternatives. For the Lower Elwha Hatchery integrated winter-run steelhead yearling program, hatchery-origin fish would be released after May 1, resulting in a low competition risk.

The overall risk of competition impacts to natural-origin Chinook salmon resulting from all hatchery programs is low under all alternatives (Table C-166).

Table C-166. Elwha Chinook salmon competition risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling	1.5	Low	Same as Alternative 1	Same as Alternative 1
Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling	0	Negligible	Same as Alternative 1	Same as Alternative 1
Lower Elwha Hatchery integrated coho salmon yearling	0.4[2]	Negligible	Same as Alternative 1	Same as Alternative 1
Lower Elwha Hatchery integrated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		Low	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives. Otherwise, percentages are provided for each alternative that is different than Alternative 1.

[2]PCD Risk Model analysis was performed for a release level of 325,000 fish, which resulted in a negligible competition risk. It is assumed that the increase in coho salmon production by 50,000 fish (13 percent) to current levels (425,000) would be insufficient to increase the risk level from negligible.

4.17.3.1.2 Predation

Predation risks to the Elwha Chinook salmon population from Chinook salmon, coho salmon, and steelhead hatchery programs are summarized in Table C-167. High predation risks are assigned under all alternatives for the Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling and Lower Elwha Hatchery integrated coho salmon yearling programs (Table C-167), because of the larger size of hatchery-origin yearlings compared to natural-origin Chinook salmon juveniles. Hatchery-origin yearling salmon would be released at a substantially larger size (average size of Chinook salmon yearlings is 6.1 inches fork length, steelhead yearling average size is 8.1 inches fork length) compared to natural-origin Chinook salmon juveniles (average size 1.6 to 4.7 inches fork length, dependent on life stage) (EIS Table 3.2-4) that may be encountered as the hatchery-origin and natural-origin fish emigrate seaward downstream from the hatchery release sites. This size differential makes natural-origin juvenile Chinook salmon vulnerable to predation by the larger hatchery-origin yearlings. The confined freshwater and estuarine areas currently available for anadromous salmonid production in the watershed would increase the likelihood of predation effects on natural-origin Chinook salmon.

Under Alternative 2, Alternative 3, and Alternative 4, the number of hatchery-origin coho salmon yearlings and hatchery-origin steelhead yearlings released would be the same as under Alternative 1, and the predation risks would be the same (Table C-167). Predation risks to natural-origin Elwha Chinook salmon from the steelhead program are low (Table C-167), because releases would occur low in the watershed (Elwha River at RM 1.3) after the primary out-migration period for natural-origin juvenile Chinook salmon (steelhead are released in May; natural-origin Chinook smolts typically peak in March, as described in EIS Subsection 3.2.5.1, Life History of Natural-origin Chinook Salmon).

The overall risk of predation impacts to Elwha Chinook salmon from all hatchery programs is high under all alternatives.

Table C-167. Elwha Chinook salmon predation risks by alternative.

Hatchery Program Risk	Mortality Rate Index (%) from Chinook Salmon and Coho Salmon[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling	4.5	Low	Same as Alternative 1	Same as Alternative 1
Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling	19.4	High	Same as Alternative 1	Same as Alternative 1
Lower Elwha Hatchery integrated coho salmon yearling	29.4[2]	High	Same as Alternative 1	Same as Alternative 1
Lower Elwha Hatchery integrated winter-run steelhead yearling	NA	Low	Same as Alternative 1	Same as Alternative 1
Overall Risk		High	Same as Alternative 1	Same as Alternative 1

[1]From the PCD Risk Model. If only one percentage is provided, this percentage is the same among all alternatives.

[2]PCD Risk Model analysis was performed for a release level of 325,000 fish, which resulted in a high predation risk. It is assumed that the increase in coho salmon production by 50,000 fish (13 percent) to current levels (425,000) would also result in a high risk rating.

4.17.3.1.3 Genetics

Assessments of genetic risks to the Elwha Chinook salmon population using the AHA Model are not available because insufficient information was available at the time of modeling. Risk levels are assigned

(Table C-168) as described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, using inferences based on the best available information.

Table C-168. Elwha Chinook salmon genetic risks by alternative.

Hatchery Program Risk	PNI or pHOS[1]	Alternatives 1 and 2	Alternative 3	Alternative 4
Hatchery-induced selection risks from Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling and Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling	NA	Unknown, but likely High	Same as Alternative 1	Same as Alternative 1
Overall Risk		Unknown, but likely High	Same as Alternative 1	Same as Alternative 1

[1] From the AHA Model. If only one value is shown, it is the same for all alternatives.

The hatchery-induced selection risk under the alternatives is unknown, but would likely be high (Table C-168), because of the relatively large proportion of hatchery-origin and natural-origin Chinook salmon that would spawn naturally, and the relatively small numbers of natural-origin Chinook salmon that would be used in hatchery broodstock.

4.17.3.1.4 Hatchery Facilities and Operation

The two components of the Elwha Channel Hatchery program (integrated summer/fall-run Chinook salmon subyearling and Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling) are evaluated independently for hatchery facilities and operation risks using the HPV Tool (Table C-169). The program would continue to rear and release hatchery-origin fish that are part of the listed Elwha Chinook salmon population. Broodstock for the program would be collected from the Elwha River using an in-river weir, the hatchery weirs, and through seining, gill neting and gaffing. Adult holding and spawning would occur at the hatchery. Juvenile hatchery-origin fish would be reared for at least a short period and released at the hatchery sites. Hatchery facility conditions and operational practices would remain the same under all alternatives. Evaluation results for the program using the HPV Tool are provided in Table C-169.

Table C-169. Hatchery facilities and operation compliance with BMPs by operational phase and overall risk for Elwha Chinook salmon.

Hatcheries - Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling, and Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling (facility and release locations: Elwha River [RM 2.9] and Morse Creek (RM 1.0])[1]			
	Facility Compliance		
Operational Phase	**Target Population Diversity and Spatial Structure**	**Target Population Abundance and Productivity**	**Overall Facility Risk[2]**
Broodstock Choice	High	High	
Broodstock Collection	High	High	
Adult Holding	Low	High	
Spawning	High	Moderate	
Incubation	High	High	
Rearing	High	High	
Release	Moderate	Low	
Facilities	NA	High	
			Moderate

[1]Results are from HPV Tool analysis for the Elwha Channel Hatchery. The Morse Creek component was not operational at the time the analysis was conducted. It is assumed that the results for the Elwha Channel Hatchery are also applicable to the Morse Creek Hatchery component.

[2]Compliance results are from the HPV Tool. Risk is determined using criteria in Appendix B, Hatchery Effects and Evaluation Methods for Fish. Risk is the opposite of compliance (high compliance presents no or low risk). If only one risk is shown, this risk is the same among all alternatives.

The overall hatchery facilities and operation risk would be moderate under all alternatives because of low compliance scores for the adult holding and release (juveniles) operational phases (Table C-169), and hatchery release levels that are the same for all alternatives.

The primary factor related to the low compliance score for the juvenile release operational phase is the hatchery water temperature profile that differs from the natural water temperature profile. The yearling release strategy is different from the natural life history strategy for Elwha Chinook salmon in terms of fish out-migrant size, behavior, growth rate, and physiological status. Although releasing yearling fish from the Elwha Channel Hatchery and into Morse Creek would increase survival rates for adult returns relative to subyearling releases, production of yearlings would increase the risk that the hatchery population would diverge from the natural-origin Elwha Chinook salmon population.

The primary factor related to the low compliance score for the adult holding operational phase is a hatchery water temperature profile that differs from the natural water temperature profile. The traits of adults surviving to spawn in the hatchery water temperature profile may differ from those surviving in the water temperature profile in natural conditions. Holding broodstock in water that is warmer than the fish would encounter under natural conditions may accelerate their maturation and gamete development relative to what would occur under natural conditions. This could lead to changes in hatchery-origin fish because only certain adults would survive and be spawned.

4.17.3.2 Benefits

4.17.3.2.1 Total Return

Table C-170 compares effects of the alternatives on the total return of adult hatchery-origin Chinook salmon produced by the Elwha Channel Hatchery integrated summer/fall-run Chinook salmon subyearling and Elwha Channel Hatchery and Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling programs. The estimated total contribution of hatchery-origin fish to fisheries and escapement under each alternative is compared with the recent year average natural-origin Elwha Chinook salmon adult run size. The returns of hatchery-origin fish produced under each alternative plus the recent year average natural-origin run size is contrasted with the restoration spawner abundance estimate for the population.

Table C-170. Estimated total return contributions for Elwha Chinook salmon.

	Alternatives 1 and 2	**Alternative 3**	**Alternative 4**
Average hatchery-origin return	3,433	3,433	3,433
Average natural-origin return	3,762	3,762	3,762
Projected average total return	7,195	7,195	7,195
Restoration spawner abundance [1]	15,100	15,100	15,100
Projected average total return as a percent of restoration spawner abundance	48	48	48

Source: Chinook returns are from Tynan (2008).
[1]Restoration spawner abundance is the equilibrium (replacement) abundance under Properly Functioning Conditions (Ford 2011).

Total return benefits to fisheries and escapement would be moderate under all alternatives, because the combined total adult run size would be between 20 and 50 percent (48 percent) of the estimated restoration spawner abundance level under all alternatives (Table C-170). Subyearling and yearling Chinook salmon release levels would remain the same under all alternatives (Table C-164). Hatchery-origin adults produced through the hatchery program would continue to be harvested with natural-origin Elwha summer/fall-run Chinook salmon in mixed stock marine area fisheries directed at Chinook salmon. Fish produced by the program would be harvested predominantly in West Coast Vancouver Island troll fisheries, U.S. sport fisheries, and Canadian net fisheries (assumes Hoko fall-run fingerling Chinook salmon indicator stock fishery contribution estimates from CTC [2012]). No Chinook salmon-directed

U.S. terminal area or river net and sport fisheries would impact this stock, but some Elwha Chinook salmon may be harvested in terminal area fisheries directed at other species.

Recent otolith mark recovery information that allows for hatchery-origin fish to be distinguished from natural-origin fish indicates that the productivity of natural-origin Elwha Chinook salmon is low (NMFS 2012b). Hatchery-origin Chinook salmon from the program contribute a substantial proportion of the total number of Chinook salmon escaping to natural spawning areas in the Elwha River.

4.17.3.2.2 Viability

Viability benefits to the Elwha Chinook salmon population from the Elwha Hatchery subyearling and Elwha Channel Hatchery and Morse Creek yearling integrated summer/fall-run Chinook salmon programs are evaluated together in the context of VSP parameters (abundance, diversity, spatial structure, productivity). Fish produced by the hatchery programs are part of the Puget Sound Chinook salmon ESU, and are listed along with the natural-origin Chinook salmon population.

Under Alternative 1 and Alternative 2, the Elwha Channel Hatchery subyearling and Elwha Channel Hatchery and Morse Creek yearling integrated summer/fall-run Chinook salmon programs would benefit the abundance and diversity of the Elwha Chinook salmon population. Thus, the viability benefit of the program is moderate for the reasons described below.

Abundance – The hatchery program would benefit the abundance of Elwha Chinook salmon. Available estimates of survival for hatchery-origin Chinook salmon (WDFW 2012) and assessments by biologists familiar with the watershed (NMFS 2012b) suggest that hatchery-origin Chinook salmon returns have sustained the abundance of the natural-origin population and are essential for the maintenance of the population at its current abundance level. Production levels would be consistent with analyses reflected in Ford (2011). Ford (2011) reported a 2005 to 2009 geometric mean total spawner escapement for the Elwha Chinook salmon population of 575 fish. The estimated mean number of natural-origin spawners for this period is 185 fish. The remainder of the fish spawning naturally (390 fish or 68 percent of the mean spawning escapement) are hatchery-origin Chinook salmon.

Diversity – The hatchery program would benefit diversity by acting as a genetic reserve for the Chinook salmon population in confined, degraded natural habitat that limits natural-origin fish survival. BMPs would continue to be applied to maintain the diversity of the hatchery fish and limit the likelihood of their divergence from the natural-origin population. Broodstock would be collected randomly from the mainstem Elwha River over the breadth of the spawner return, a large effective breeding population size would be maintained, and a factorial mating scheme would be used during spawning.

Spatial Structure – The hatchery program would have negligible direct benefit to spatial structure. The spatial structure of the Elwha Chinook salmon population has been severely confined by blockages posed by dams that have limited natural production to the lower 5 miles of the Elwha River. In the future, the program would be expected to benefit the spatial structure of the Elwha Chinook salmon population after dam removal and restoration of fish passage, to the extent hatchery-origin and natural-origin adults return to and use historically accessible spawning areas.

Productivity – The benefit of the hatchery program to productivity is unknown. Ford (2011) reported a short-term (1995 through 2009) median growth rate (lambda) for the composite (hatchery-origin and natural-origin Chinook salmon) Elwha Chinook salmon population of 0.78. A lambda of 1.0 indicates a population that is replacing itself, whereas a lambda greater than 1.0 reflects a population that is growing. In this case, the composite of Elwha Chinook salmon natural spawners is not replacing itself in the short term. The estimate of lambda assumed that the reproductive success of naturally spawning hatchery-origin fish was equivalent to that of natural-origin fish. If the reproductive success of naturally spawning hatchery fish were assumed to be less than for natural-origin fish, then lambda would be larger.

Under Alternative 3 and Alternative 4, the number of hatchery-origin Chinook salmon released and all other aspects of the program would be the same as under Alternative 1 and Alternative 2. Therefore, the viability benefit under Alternative 3 and Alternative 4 would be moderate.

4.17.3.3 Summary – Elwha Chinook Salmon

Table C-165 summarizes the risks and benefits for all alternatives pertinent to the Elwha Chinook salmon population, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the four hatchery programs evaluated for this population, overall risks to natural-origin Chinook salmon under Alternative 1 range from low to high with competition as low risk, hatchery facilities and operation as a moderate risk, and predation and genetics as high and likely high risks, respectively. Under Alternative 1, benefits would be high for abundance and moderate for viability. In summary, risk and benefit levels would be the same under all alternatives because hatchery production levels would be the same.

The analysis of risks and benefits for the Chinook salmon ESU and component populations in this EIS applies different methods and terms than what was used in the environmental analysis of Elwha hatchery programs (NMFS 2012a). EIS results focus on the need for consistent approaches across Puget Sound for each species reviewed for consistency in compiling information ESU-wide.

4.17.3.4 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1, the No-action Alternative. Because hatchery programs affecting Elwha River salmon and steelhead previously received authorization under the ESA (NMFS 2012b) and NEPA (NMFS 2012a), no specific mitigation measures are proposed for Elwha hatchery programs in this EIS. Potential general mitigation measures are included that could be applied over the long term under adaptive management (including updated and new BMPs), consistent with NMFS (2012b).

Provided in Table C-171 is a summary of potential general mitigation measures for the Elwha Chinook salmon population action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as high or likely high for predation and genetic risks, respectively, and moderate for hatchery facilities and operation risks under Alternative 2, Alternative 3, and Alternative 4 (Table C-165).

Table C-171. Potential general mitigation measures for the Elwha Chinook salmon population.

Risk Category	Mitigation Measures[1]
Predation	Apply Mitigation Measure P5.
Genetics	Apply Mitigation Measure G3.
Hatchery facilities and operation	Apply Mitigation Measure H1.

[1]Refer to Table C-2 for a description of each mitigation measure.

5.0 Summary

Total hatchery releases for Chinook salmon populations by age at release and alternative are provided in Table C-172. The total number of Chinook salmon released would be 43,317,000 fish under Alternative 1 and Alternative 2, the same as under existing conditions. Releases under Alternative 3 would decrease 18 percent, and would increase 13 percent under Alternative 4. Most fish released would be subyearlings, accounting for at least 89 percent of the releases compared to yearling releases, under all alternatives. Releases under existing conditions are the same as under Alternative 1 and Alternative 2. The releases do not account for changes under the action alternatives that may occur using adaptive management. Depending on adaptive management changes, specific hatchery program releases may change to decrease risks or increase benefits.

Risk and benefit results for each of the 22 Chinook salmon populations are summarized in Table C-173 for Alternative 1 and Alternative 2 (which also represent existing conditions), Table C-174 for Alternative 3, and Table C-175 for Alternative 4. These results are used to describe overall effects for the

Puget Sound Chinook Salmon ESU in EIS Subsection 3.2.5.4, Hatchery Program Risks and Benefits (Chinook Salmon), and EIS Subsection 4.2.4.15, Summary of Risks and Benefits (Chinook Salmon).

Table C-172. Releases of hatchery-origin Chinook salmon subyearlings and yearlings evaluated by natural-origin Chinook salmon population and alternative. Included are numbers of listed Chinook salmon released associated with each population and where applicable, numbers of non-listed Chinook salmon.

	Alternative 1[1] (No Action)	**Alternative 2 (Proposed Action)**		**Alternative 3 (Reduced Production)**		**Alternative 4 (Increased Production)**	
Life stage of hatchery releases	**Number**	**Number**	**Percent Change from Alternative 1**	**Number**	**Percent Decrease from Alternative 1**	**Number**	**Percent Increase from Alternative 1**
North Fork Nooksack							
Subyearlings	6,750,000	6,750,000	0	6,250,000	7	6,750,000	0
Yearlings	100,000	100,000	0	100,000	0	100,000	0
Total	6,850,000	6,850,000	0	6,350,000	7	6,850,000	0
South Fork Nooksack[2]							
Subyearlings	6,200,000	6,200,000	0	5,700,000	8	6,200,000	0
Yearlings	100,000	100,000	0	100,000	0	100,000	0
Total	6,300,000	6,300,000	0	5,800,000	8	6,300,000	0
Skagit[3]							
Subyearlings	672,000	672,000	0	672,000	0	672,000	0
Yearlings	150,000	150,000	0	150,000	0	150,000	0
Total	822,000	822,000	0	822,000	0	822,000	0
North Fork Stillaguamish							
Subyearlings	245,000	245,000	0	245,000	0	465,000	90
South Fork Stillaguamish							
Subyearlings[4]	290,000	290,000	0	290,000	0	510,000	76
Skykomish[5]							
Subyearlings	2,700,000	2,700,000	0	2,200,000	19	2,700,000	0
Yearlings	250,000	250,000	0	125,000	50	500,000	100
Total	2,950,000	2,950,000	0	2,325,000	21	3,200,000	8
Snoqualmie							
Subyearlings	2,700,000	2,700,000	0	2,200,000	19	2,700,000	0
Yearlings	250,000	250,000	0	125,000	50	500,000	100
Total	2,950,000	2,950,000	0	2,325,000	21	3,200,000	8
Sammamish[6]							
Subyearlings	2,180,000	2,180,000	0	2,180,000	0	2,180,000	0

Table C-172. Releases of hatchery-origin Chinook salmon subyearlings and yearlings evaluated by natural-origin Chinook salmon population and alternative. Included are numbers of listed Chinook salmon released associated with each population and where applicable, numbers of non-listed Chinook salmon, continued.

Life stage of hatchery releases	Alternative 1[1] (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
	Number	Number	Percent Change from Alternative 1	Number	Percent Decrease from Alternative 1	Number	Percent Increase from Alternative 1
Cedar[6]							
Subyearlings	2,180,000	2,180,000	0	2,180,000	0	2,180,000	0
Green[7]							
Subyearlings	3,800,000	3,800,000	0	1,900,000	50	3,800,000	0
Yearlings	300,000	300,000	0	150,000	50	300,000	0
Total	4,100,000	4,100,000	0	2,050,000	50	4,100,000	0
Puyallup							
Subyearlings	2,000,000	2,000,000	0	1,000,000	50	2,600,000	30
White[8]							
Subyearlings	3,350,000	3,350,000	0	2,350,000	30	3,950,000	18
Yearlings	175,000	175,000	0	175,000	0	175,000	0
Total	3,525,000	3,525,000	0	2,525,000	28	4,125,000	17
Nisqually							
Subyearlings	4,000,000	4,000,000	0	2,000,000	50	4,300,000	8
Skokomish							
Subyearlings	3,800,000	3,800,000	0	1,900,000	50	3,800,000	0
Yearlings	120,000	60,000	0	60,000	50	120,000	0
Total	3,920	1,960	0	1,960	50	3,920	0
Mid-Hood Canal							
Subyearlings	110,000	110,000	0	110,000	0	110,000	0
Dungeness							
Subyearlings	100,000	100,000	0	100,000	0	100,000	0
Yearlings	100,000	100,000	0	100,000	0	100,000	0
Total	200,000	200,000	0	200,000	0	200,000	0
Elwha							
Subyearlings	2,500,000	2,500,000	0	2,500,000	0	2,500,000	0
Yearlings	400,000	400,000	0	400,000	0	400,000	0
Total	2,900,000	2,900,000	0	2,900,000	0	2,900,000	0

Table C-172. Releases of hatchery-origin Chinook salmon subyearlings and yearlings evaluated by natural-origin Chinook salmon population and alternative. Included are numbers of listed Chinook salmon released associated with each population and where applicable, numbers of non-listed Chinook salmon, continued.

	Alternative 1[1] (No Action)	Alternative 2 (Proposed Action)		Alternative 3 (Reduced Production)		Alternative 4 (Increased Production)	
Life stage of hatchery releases	**Number**	**Number**	**Percent Change from Alternative 1**	**Number**	**Percent Decrease from Alternative 1**	**Number**	**Percent Increase from Alternative 1**
ESU totals evaluated at the population scale[9]							
Subyearlings	30,452,000	30,452,000	0	22,652,000	26	31,572,000	4
Yearlings	1,595,000	1,595,000	0	1,260,000	21	1,845,000	16
Total	32,047,000	32,047,000	0	23,912,000	25	33,417,000	4
ESU totals evaluated Puget Sound-wide[10]							
Subyearlings	12,350,000	12,350,000	0	12,350,000	0	14,350,000	16
Yearlings	920	920	0	920	0	3,540	285
Total	13,270,000	13,270,000	0	13,270,000	0	17,890,000	35
All releases[11]							
Subyearlings	42,802,000	42,802,000	0	35,002,000	18	45,922,000	7
Yearlings	2,515,000	2,515,000	0	2,180,000	13	5,385,000	114
Total	45,317,000	45,317,000	0	37,182,000	18	51,307,000	13

[1]Release numbers under Alternative 1 are the same as under existing conditions.

[2]Numbers reflect most releases for the North Fork Nooksack Chinook salmon population and additional releases unique to the South Fork Nooksack population.

[3]Numbers reflect a composite of all Chinook salmon populations in the Skagit River watershed (lower Skagit, upper Skagit, Cascade, Suiattle, lower Sauk, and upper Sauk populations).

[4]Numbers reflect releases for the North Fork Stillaguamish population and additional releases unique to the South Fork Stillaguamish population.

[5]Same releases are applicable to the Skykomish and Snoqualmie populations.

[6]Same releases are applicable to the Sammamish and Cedar Chinook salmon populations.

[7]Includes Duwamish.

[8]Numbers reflect releases for the Puyallup population and additional releases unique to the White population.

[9]Releases that are associated with effects evaluations for more than one natural-origin Chinook salmon population (e.g., North Fork Nooksack and South Fork Nooksack, North Fork Stillaguamish and South Fork Stillaguamish, Skykomish and Snoqualmie, Sammamish and Cedar, and Puyallup and White populations) are only counted once in these totals.

[10]These releases are evaluated ESU-wide (e.g., marine releases), not at the scale of individual Chinook salmon populations (Appendix A, Puget Sound Hatchery Programs and Facilities).

[11]Sums of ESU totals evaluated at the population scale, plus those evaluated Puget Sound-wide.

Table C-173. Summary of risks and benefits for the Puget Sound Chinook Salmon ESU by population, under Alternative 1 and Alternative 2.

Population	Risk				Benefit	
	Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
North Fork Nooksack	High	High	High	Moderate	Moderate	Moderate
South Fork Nooksack	High	High	High[1]	NA[2]	Low	Moderate
Lower Skagit	Low	High	Low	Moderate	Moderate	Negligible
Upper Skagit	Low	High	Low	Moderate	High	Negligible
Lower Sauk	Low	High	Low	NA	NA	NA
Upper Sauk	Low	High	Low	NA	NA	NA
Suiattle	Low	High	Low	Moderate	NA	NA
Cascade	Low	High	Low	Moderate	High	Negligible
North Fork Stillaguamish	Moderate	High	Low	Negligible	Low	Moderate
South Fork Stillaguamish	Moderate	Moderate	Low	NA	NA	NA
Skykomish	Low	High	Low	Moderate	Moderate	Low
Snoqualmie	Low	High	Moderate	NA	NA	NA
Sammamish	High	Moderate	High	Negligible	High	Moderate
Cedar	High	Moderate	High	NA	NA	NA
Green	High	High	High	Moderate	High	Moderate
Puyallup	Moderate	High	High	Negligible	High	Moderate
White	High	High	Moderate	Moderate	Moderate	Moderate
Nisqually	Low	Moderate	High	Moderate	High	Moderate
Skokomish	Low	Moderate	High	Moderate	High	Moderate
Mid-Hood Canal	Low	Moderate	Moderate	Negligible	Low	Low
Dungeness	Low	High	High	Negligible	Low	Moderate
Elwha	Low	High	High	Moderate	High	Moderate
Average Overall Rating (score)	**Moderate 37/22 = 1.7**	**High 60/22 = 2.7**	**Moderate 45/22 = 2.0**	**Low 22/22 = 1.0**	**Moderate 36/22 = 1.6**	**Low 24/22 = 1.1**

Note: Risks and benefits under Alternative 1 and Alternative 2 are the same as under existing conditions.

[1] Unknown but likely high.

[2] NA= not applicable or not available.

Table C-174. Summary of risks and benefits for the Puget Sound Chinook Salmon ESU by population, under Alternative 3.

Population	Risk				Benefit	
	Competition	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
North Fork Nooksack	High	High	High	Moderate	Moderate	Moderate
South Fork Nooksack	High	High	High[1]	NA[2]	Low	Moderate
Lower Skagit	Low	High	Low	Moderate	Moderate	Negligible
Upper Skagit	Low	High	Low	Moderate	High	Negligible
Lower Sauk	Low	High	Low	NA	NA	NA
Upper Sauk	Low	High	Low	NA	NA	NA
Suiattle	Low	High	Low	Moderate	NA	NA
Cascade	Low	High	Low	Moderate	High	Negligible
North Fork Stillaguamish	Moderate	High	Low	Negligible	Low	Moderate
South Fork Stillaguamish	Moderate	Moderate	Low	NA	NA	NA
Skykomish	Low	High	Low	Low	Moderate	Low
Snoqualmie	Low	High	Low	NA	NA	NA
Sammamish	High	Moderate	High	Negligible	High	Moderate
Cedar	High	Moderate	High	NA	NA	NA
Green	High	High	High	Low	High	Low
Puyallup	Moderate	High	High	Negligible	Moderate	Moderate
White	High	High	Moderate	Moderate	Moderate	Moderate
Nisqually	Low	Low	High	Low	High	Low
Skokomish	Low	Moderate	High	Moderate	High	Moderate
Mid-Hood Canal	Negligible	Moderate	Moderate	Negligible	Low	Low
Dungeness	Low	High	High	Negligible	Low	Moderate
Elwha	Low	High	High	Moderate	High	Moderate
Average Overall Rating (score)	**Moderate 35/22 = 1.6**	**High 59/22 = 2.7**	**Moderate 44/22 = 2.0**	**Low 19/22 = 0.9**	**Moderate 35/22 = 1.6**	**Low 22/22 = 1.0**

[1] Unknown but likely high.

[2] NA= not applicable or not available.

Table C-175. Summary of risks and benefits for the Puget Sound Chinook Salmon ESU by population, under Alternative 4.

	Risk				Benefit	
Population	**Competition**	**Predation**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
North Fork Nooksack	High	High	High	Moderate	Moderate	Moderate
South Fork Nooksack	High	High	High[1]	NA[2]	Low	Moderate
Lower Skagit	Low	High	Low	Moderate	Moderate	Negligible
Upper Skagit	Low	High	Low	Moderate	High	Negligible
Lower Sauk	Low	High	Low	NA	NA	NA
Upper Sauk	Low	High	Low	NA	NA	NA
Suiattle	Low	High	Low	Moderate	NA	NA
Cascade	Low	High	Low	Moderate	High	Negligible
North Fork Stillaguamish	Moderate	High	Low	Negligible	Low	Moderate
South Fork Stillaguamish	High	Moderate	Low	NA	NA	NA
Skykomish	Low	High	Low	High	High	Low
Snoqualmie	Low	High	Moderate	NA	NA	NA
Sammamish	High	Moderate	High	Negligible	High	Moderate
Cedar	High	Moderate	High	NA	NA	NA
Green	High	High	High	Moderate	High	Moderate
Puyallup	Moderate	High	High	Negligible	High	Moderate
White	High	High	Moderate	Moderate	Moderate	Moderate
Nisqually	Low	Moderate	High	Moderate	High	Moderate
Skokomish	Low	Moderate	High	Low	High	Moderate
Mid-Hood Canal	Low	Moderate	High	Negligible	Low	Low
Dungeness	Low	High	High	Negligible	Low	Moderate
Elwha	Low	High	High	Moderate	High	Moderate
Average Overall Rating (score)	**Moderate 39/22 = 1.8**	**High 60/22 = 2.7**	**Moderate 45/22 = 2.0**	**Low 22/22 = 1.0**	**Moderate 37/22 = 1.7**	**Low 24/22 = 1.1**

[1] Unknown but likely high.

[2] NA= not applicable or not available.

6.0 Estimates of the Number of Juvenile Natural-origin Chinook Salmon Entering Puget Sound

The total number of natural-origin Chinook salmon juveniles historically or currently present in Puget Sound when hatchery-origin Chinook salmon arrive in the estuary is not known with certainty. The number of natural-origin Chinook salmon out-migrating into Puget Sound estuarine and marine areas each year is dependent on adult spawning levels for the contributing brood years, natural egg-to-out-migrant juvenile survival rates (as they are affected by spawner success, hydrologic conditions during incubation, and the condition of freshwater habitat), life history strategy of contributing stocks, and survival rates for out-migrating fish reaching the estuary. Based on available information, it is likely that use of the estuary by natural-origin Chinook salmon for rearing and migration is well below historical levels because natural-origin Chinook salmon spawning escapements have declined over the past century (Myers et al. 1998) and freshwater and estuarine Chinook salmon habitat has been lost or degraded over the same period (Pess et al. 2003; NMFS 2006a). The purpose of this sub-appendix is to provide rough estimates of the historic and likely current annual number of juvenile Chinook salmon entering Puget Sound, using several approaches.

6.1 Historic and Current Naturally Spawning Adult Chinook Salmon Escapement

Myers et al. (1998) estimated that the historic natural-origin Puget Sound Chinook salmon run size in the early 1900s and before significant hatchery production was 690,000 adult fish. This number is within the range and similar to the mode (range 485,000 to 930,000, mode 622,000) identified in a recent analysis by Gayeski et al. (2011). The 690,000 adult fish estimate is assumed for this analysis as the potential historic escapement level for natural-origin Chinook salmon. By comparison, the Puget Sound Technical Recovery Team (Ruckelshaus at al. 2002) derived equilibrium spawner abundance planning ranges for Puget Sound Chinook salmon populations (based on combined PVA and HPVA results using the equilibrium spawner metric from the two analyses) that may reflect the potential spawning abundance each population could have supported under historical conditions. Assuming the high end of the historical spawner capacities for populations where estimates were available (totaling 397,000 fish), and abundances of similar magnitude to like-size watersheds for populations that did not have estimates in Ruckelshaus at al. (2002) (Green, White, Skokomish, Elwha Chinook salmon), the total historic Puget Sound Chinook salmon adult abundance may have exceeded 425,000 fish.

The recent 10 year (2002-2011) average estimated total escapement of Chinook salmon to natural spawning areas in Puget Sound is 45,978 fish (data from WDFW Puget Sound Chinook Run Reconstruction Summary, January 23, 2013). For the purposes of this assessment, it is assumed that the sex ratio for this natural spawner abundance estimate was 1:1, with returns predominately 4-year-old fish.

6.2 Estimation Approaches and Results

6.2.1 Fecundity-survival Based Approach

Average Fecundity of Puget Sound Chinook Salmon. Fecundity (number of eggs per female) for Puget Sound Chinook salmon varies by population, female size, and age at adult return. For example, Fuss and Ashbrook (1995) determined that fecundities for stocks returning to WDFW's Kendall Creek Hatchery averaged 4,818 eggs (range 4,314 to 6,408 eggs) for natural-origin spring Chinook salmon and 3,837 eggs (range 2,558 to 5,028 eggs) for non-native Green River lineage fall Chinook salmon. In a study of initial 4-year-old Chinook salmon returns to the University of Washington hatchery in Lake Washington, the average number of eggs per 4-year-old female was 4,171 eggs, with a range of 2,010 to 5,700 eggs (Donaldson and Menasveta 1961). The 1989 to 1993 average fecundity for Green River fall Chinook salmon collected at Soos Creek Hatchery was 4,507 eggs (s.d. = 292.14) (Tynan 1998). This average fecundity was not significantly different at the 95 percent confidence level from the 1960 to 1988 average for fall Chinook salmon returning to the watershed of 4,669 eggs (s.d. = 363.43) (Tynan 1998). Samish Hatchery fall Chinook salmon exhibited similar fecundity, averaging 4,618 eggs (range 4,329 to 4,880 eggs), and Skagit River spring, summer, and fall Chinook salmon spawned at WDFW's Marblemount Hatchery had average fecundities of 4,063, 4,483, and 4,595 eggs, respectively (Fuss and Ashbrook 1995). Therefore, considering the above fecundity information, an average fecundity of 4,500 eggs per female is assumed as the historic and current egg productivity level for the purposes of this assessment.

Egg-to-out-migrating Juvenile Chinook Salmon Survival Rates. Healey (1991) reported deposited egg to fry (smolt) survival rates for naturally spawned Chinook salmon in Pacific Northwest rivers ranging from 4 to 16 percent. Evaluations by Seiler et al. (2002, 2003a, 2004) and Volkhardt et al. (2006a, 2006b) estimate deposited egg to out-migrating juvenile survival rates for naturally spawning Chinook salmon in four Puget Sound region watersheds. Annual trapping studies were conducted over the longest time period at RM 17 on the Skagit River (all populations combined) for out-migration years 1990 to 2007 (Table C-176).

Based on the Skagit River data, the 18-year mean survival rate for Chinook salmon eggs reaching the juvenile out-migrant stage is 11 percent for subyearlings (includes fry, parr, and subyearling smolts) (Table C-176). Survival rates estimated for the Cedar River were lower than the Skagit River Chinook salmon figures, and estimated egg to out-migrant survivals for Chinook salmon in the Green River and Bear Creek were substantially lower (Table 175). The egg to out-migrating Skagit River juvenile Chinook salmon survival rate for naturally spawned Chinook salmon of 11 percent is assumed for the purposes of this assessment. In addition to having the longest data set for estimating survival rates, the Skagit River figure is appropriate because the watershed accounts for the largest proportion of natural-origin Chinook salmon returns in Puget Sound, it harbors all three runs of Chinook salmon (spring, summer, and fall-runs), the watershed has a mix of habitat conditions in the project area ranging from relatively pristine to degraded, and there are relatively few naturally spawning hatchery-origin fish that may confound annual natural-origin spawner escapement estimates. The 11 percent figure is also within the range of egg to juvenile out-migrant survival rates identified by Healey (1991) for natural-origin Chinook salmon in Pacific Northwest watersheds.

Table C-176. Estimated percent freshwater survival (egg-to-juvenile out-migration) by out-migration year for Puget Sound natural-origin Chinook salmon subyearlings.

Out-migration Year	Green River	Cedar River	Bear Creek	Skagit River	Dungeness River	Information Source[1]
1990				9.0		Volkhardt et al. (2006a)
1991				1.2		Volkhardt et al. (2006a)
1992				13.7		Volkhardt et al. (2006a)
1993				14.4		Volkhardt et al. (2006a)
1994				16.7		Volkhardt et al. (2006a)
1995				10.2		Volkhardt et al. (2006a)
1996				3.8		Volkhardt et al. (2006a)
1997				15.6		Volkhardt et al. (2006a)
1998				16.4		Volkhardt et al. (2006a)
1999		10.3	2.1	16.5		Seiler et al. (2000)
2000	7.3	8.0	2.4	12.7		Seiler et al. (2001)
2001	6.6	13.5	1.8	13.5		Seiler et al. (2002); Topping et al. (2009); Kinsel et al. (2007)
2002	3.4	6.7	3.4	12.9		Seiler et al. (2003a); Kiyohara and Zimmerman (2011a)
2003	4.0	18.6	3.0	10.8		Seiler et al. (2004); Kiyohara and Zimmerman (2011a)
2004	1.9	8.0	3.6	7.0		Volkhardt et al. (2006a); Kiyohara and Zimmerman (2011a)
2005	2.2	5.8	1.7	7.4	3.6	Volkhardt et al. (2006a, 2006b, 2006c); Kiyohara and Zimmerman (2011a)
2006	1.5	7.7	4.1	11.4	6.3	Kinsel et al. (2007); Topping et al. (2008); Kiyohara and Zimmerman (2011a)
2007	0.9	4.7	2.8	3.9		Kiyohara and Zimmerman (2011a); Topping et al. (2009); Kinsel et al. (2007)
2008	3.7	19.1	1.0			Kiyohara and Zimmerman (2011a); Topping and Zimmerman (2011)
2009	2.1	5.2	11.0			Kiyohara and Zimmerman (2011a); Topping and Zimmerman (2011)
2010	5.7	11.9	4.3			Kiyohara and Zimmerman (2011b); Topping and Zimmerman (2011)
2011	8.0	15.7	6.7			Kiyohara and Zimmerman (2012); Topping and Zimmerman (2012)
2012	6.0	61.8	9.0			Kiyohara (2013); Topping and Zimmerman (2013)
Mean (s.d.)	4.1 (2.29)	14.1 (14.01)	4.1 (2.80)	11.0 (4.47)	5.0 (1.35)	

[1] All data from WDFW annual juvenile salmonid out-migrant production evaluation reports.

Based on the above abundance and productivity assumptions, the number of natural-origin juvenile Chinook salmon out-migrants of all life history strategies entering Puget Sound each year are 169 million historically, and 11 million currently (Table C-177).

Table C-177. Estimated historic and current abundance of natural-origin Chinook salmon juvenile out-migrants entering the Puget Sound from fresh water.

	Naturally Spawning Chinook Salmon Escapement	Females	Average Fecundity	Total Number of Eggs Deposited	Percent Egg to Out-migrant Survival	Estimated Number of Juvenile Chinook Salmon Out-migrants Entering Puget Sound
Historic	690,000	345,000	4,500	1.6 billion	11	169 million
Current	45,978 (2002-2011)	22,989	4,500	104 million	11	11 million

6.2.2 Extrapolation Approach

A second approach to estimate annual numbers of natural-origin juvenile Chinook salmon entering Puget Sound is based on extrapolating information from the Skagit River. This method extrapolates the average juvenile out-migrant estimates for the Skagit River (2000 to 2007) from available WDFW out-migrant trapping by the corresponding contributing brood year average percent of total Puget Sound natural-origin Chinook salmon spawner escapement (1999 to 2006) accounted for in the Skagit watershed. Adult escapement to natural spawning areas in the Skagit River averaged 16,274 fish, or 28 percent of total annual average natural-origin escapement estimated for Chinook salmon in Puget Sound for 1999 to 2006 (58,165 fish).

Natural-origin juveniles resulting from Skagit River escapement from 1999 to 2006 averaged 4.13 million fish (data from Kinsel et al. 2008). Assuming from the above assessment that the Skagit River constitutes 28 percent of Puget Sound adult escapement, and sex ratios and fecundities, and deposited egg to out-migrant survival rates are similar across populations, the estimated total annual natural-origin juvenile out-migrant Chinook salmon production in Puget Sound averages 14.75 million fish.

6.2.3 EDT-based Approach

As a third method for comparison, the PCD Risk Model (Appendix D, PCD RISK 1 Assessment) derived estimates of the current annual smolt recruitment for natural-origin Chinook salmon in Puget Sound drainages, using estimates for juvenile fish productivity and capacity from completed EDT watershed analyses. The average annual natural-origin smolt recruitment estimated by the PCD Risk Model was 6.2 million fish, with a range of 4.8 to 8.2 million fish.

6.3 Summary of Estimates

In summary, the different approaches described above (i.e., fecundity-survival based, extrapolation, and EDT-based) result in estimates of the number of juvenile Chinook salmon entering Puget Sound of 11.0 million, 14.75 million, and 6.2 million, respectively. If these estimates are reasonable approximations of current numbers, they are all considerably lower than the estimated number of juveniles to have historically entered Puget Sound (169 million, using the fecundity-survival approach).

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Puget Sound Hatcheries Draft EIS

Appendix D

PCD RISK 1 Assessment

Ecological Risks to Natural Populations of Chinook Salmon by Hatchery Releases of Chinook and Coho Salmon Throughout the Greater Puget Sound Region, Washington: a PCD RISK 1 Assessment

November 15, 2006

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***Consultant services sub-contracted through Mobrand – Jones and Stokes**

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Executive Summary

Program releases of hatchery Chinook and coho salmon were assessed for potential risks to natural juvenile Chinook populations due to mechanisms of predation and competition. This assessment was conducted as part of the Environmental Impact Statement (EIS) for salmon hatchery production programs in the greater Puget Sound region, Washington. As part of the EIS process, fish interaction scenarios were evaluated according to current hatchery production levels with a portion of these programs also evaluated according to proposed alternatives for increased and decreased levels of fish production.

Risk assessments were conducted using the PCD RISK 1 model developed by Busack et al. (2005). The model allows for a suite of parameter inputs in simulating fish interactions in the form of competition and predation. Furthermore, the model is designed to incorporate both uncertainty and variability in the form of probability distributions for parameter input values. This assessment encompassed nearly eighty hatchery production/release scenarios. Given this, approach methodologies and protocol were established in specifying model parameter inputs for all assessed hatchery program scenarios. In this manner, assessment results provide a consistent and relative comparison of risk impacts by coho and Chinook salmon hatchery programs on natural Chinook salmon populations throughout the Puget Sound region.

Introduction

This assessment of freshwater ecological interactions between populations of juvenile Chinook salmon of natural-origin and hatchery releases of Chinook and coho salmon was conducted as part of the Environmental Impact Statement (EIS) for salmon hatchery production programs in the greater Puget Sound region, Washington. As part of the EIS process, fish interaction scenarios were evaluated according to current hatchery production levels with a portion of these programs also evaluated according to proposed alternatives for increased and decreased levels of fish production.

Puget Sound hatchery programs were evaluated using the *PCD RISK 1* model developed by Busack et al. (2005). *PCD RISK 1* encompasses a suite of considerations and empirical support in modeling predation and competition impacts on natural-origin populations by releases of hatchery fish. The primary model intent is to provide a heuristic tool for risk assessment and reduction, not a complete ecological model of the mortality processes it simulates. Only direct interaction mechanisms for predation and competition were addressed in model development; the model does not attempt to capture effects due to indirect ecological mechanisms. Furthermore, model scope is restricted to ecological interactions between hatchery and wild fish within freshwater environments only. Noting these important model premises, results from this assessment should be treated as risk indices in evaluating fish production programs.

This assessment applied *PCD RISK 1* to model perceived risks of predation and competition on populations of natural-origin juvenile Chinook salmon by program releases of yearling and sub-yearling Chinook and coho salmon. Assessments encompassed program releases of hatchery fish within ESA listed Category 1 and 2 watersheds for natural Chinook salmon populations throughout the Strait of Juan de Fuca, Hood Canal and Puget Sound regions, Washington. Program releases of hatchery fish were evaluated on an individual basis with no intent for translation to cumulative program effects.

To facilitate interpretation of the following document, some primary model mechanisms and clarification of applied notation are necessary. *PCD RISK 1* is an individualistic based model which is structured around a primary logic criteria in modeling competition and predation effects: individual sizes (length) of hatchery fish in relation to size of individually sampled wild, or used interchangeably throughout this document, natural fish. To elaborate, within modeled simulations interaction histories of individual fish are constructed and tracked. For a paired interaction scenario between a hatchery and wild fish, the modeled mechanism of predation or competition is determinant upon the relative fish size relationship. In instances when a given wild fish is less than half the size of a paired hatchery fish, the modeled mechanism for interaction is predation; if the relative size criteria is invalid, then the modeled mechanism for interaction is competition. The model logic for determining fish interaction 'pathways' becomes particularly relevant in considering assessment results for yearling versus sub-yearling hatchery programs.

An attractive model feature is the ability to incorporate both uncertainty and/or variability in specifying parameter input values. In the probabilistic mode, the model entails twenty-eight parameter categories (*noted hereafter by the use of italics*) of which the majority can be quantitatively defined using either deterministic or probabilistic methods (Figure 1). Throughout this assessment a probabilistic approach was largely favored. From a risk perspective, the approach was typically chosen in trying to capture sometimes known or at least suspected variability within dynamic and therein complicated community systems. Within the model the user is allowed to specify either uniform probability distributions, which treat each value within a specified range as equally likely, or a triangular distribution, which treats specified endpoints as low probability events with a peak ('middle' value) as the most probable event. Stream temperature data is used to clarify and illustrate notation used:

- *7* a single value indicates a deterministic mode,
- *5_9* two values separated by an underscore indicates a probabilistic mode with a uniform distribution, whereas,
- *5_7_9* indicates a probabilistic mode with a triangular distribution peaked towards a most likely mean or median value of 7.

A primary objective in conducting this assessment was to first and foremost develop and apply consistent methods and logic criteria in quantitatively defining fish interaction scenarios to be modeled using *PCD RISK 1*. Valid comparison of hatchery program assessments across watersheds and regions required such an approach. The following details methods used throughout this assessment and structured in relation to parameter input fields required by the model. For further understanding it is highly recommended that the reader consult Busack et al. (2005) for more detailed explanations on model rationale and computation mechanics.

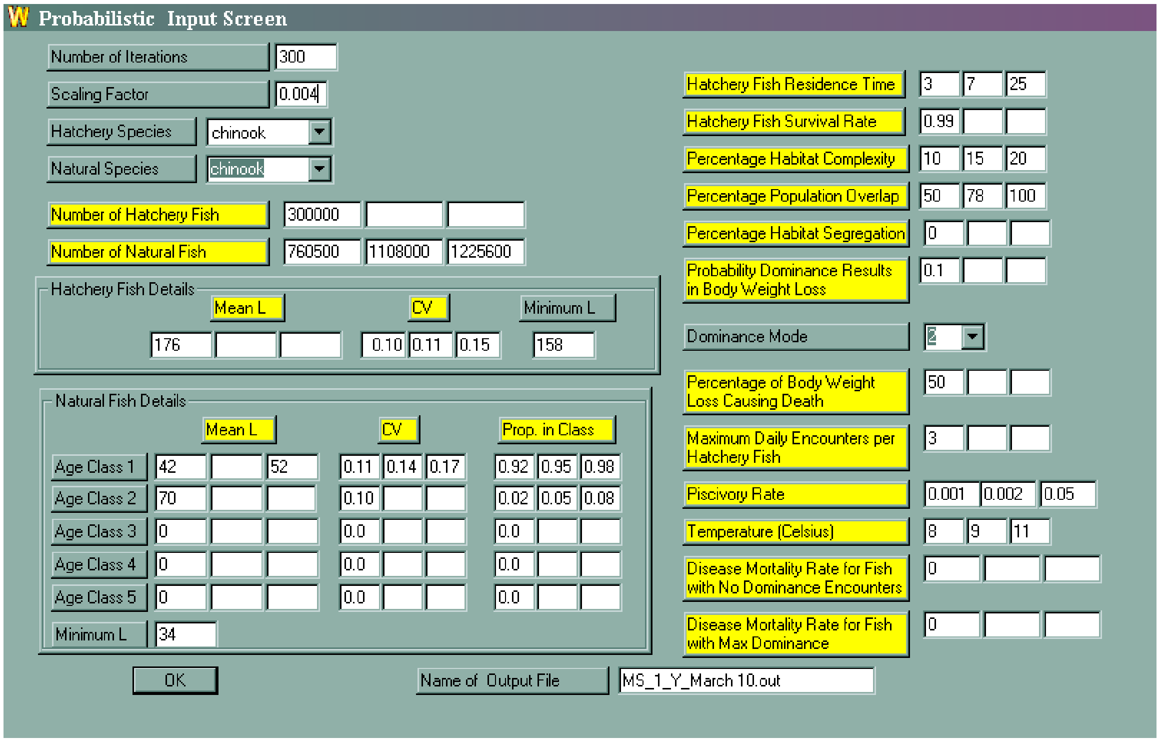

Figure 1. Input screen for probabilistic use of PCD RISK 1. Input values are for Icy Creek Hatchery, Green - Duwamish River, on station release of yearling Chinook salmon.

METHODS

Size and Abundance of Hatchery and Wild Chinook Salmon

Fish size and abundance are key determinants in assessing competition and predation risks on natural juvenile fish populations by releases of hatchery fish. Program specific Chinook and coho salmon Hatchery Genetic Management Plans (HGMPs, submitted to NMFS in 2003 with some program documents subsequently modified) were referenced to establish number of hatchery fish released, fish size at time of release and location of release.

Quantifying population traits for natural Chinook salmon was more involved than that for hatchery fish. Where available, regional data was used to determine size of natural juvenile Chinook salmon at the time of fish releases for a respective hatchery production program. In most instances smolt outmigrant trapping data was used. Trapping data from the Skagit, Stillaguamish, Snoqualmie, Skykomish, Green and Hamma Hamma rivers were extensively referenced for this purpose due to their ability to distinguish between mass-marked hatchery and un-marked natural-origin fish, intensive annual trapping effort and multiple years of trend monitoring (Appendix A). In some instances other site-specific data was applied as with the Nisqually River for example, where lower-river beach seine monitoring has occurred over the past four consecutive years. Where region specific data was flawed or unavailable, proximate regional data was used as a surrogate. Data sources used to determine size of natural fish are referenced within individual 'hatchery program profiles' which specify a suite of *PCD RISK 1* parameter input values (see Appendices B – E).

With the exception of the Green, Duwamish and Elwha River systems, completed EDT analysis was available and used to estimate abundance of natural juvenile Chinook salmon populations in watersheds of interest. EDT estimates of productivity and river system capacity (*per* EDT fish life-stage for 'transient-rearing' sub-yearling Chinook salmon; Mobrand-Jones and Stokes 2006) were paired with estimated abundances of adult Chinook spawners (both hatchery and natural origin) to calculate the number of natural juvenile Chinook (i.e. smolt recruitment). Tables 1 and 2 identify watershed specific parameters in calculating smolt recruitment using the formula:

$$\textit{smolt recruitment} = \left(A_{spawn} * J_{prod}\right)/1+\left(A_{spawn} * J_{prod} / J_{cap}\right)$$

where,

A_{spawn} is the number of adult Chinook on the spawning grounds
J_{prod} is juvenile fish productivity, and

J_{cap} is juvenile fish carrying capcity.

Estimated annual abundance of returning adult Chinook spawners between years 1999 and 2005 (Comprehensive Management Plan for Puget Sound Chinook 2004; Puget Sound Chinook Comprehensive Harvest Management 2005 and 2006) were used to determine the average, minimum and maximum values for adult returns (Table 1). Bracketed abundances of adult return spawners were used to construct a triangular probability distribution for varying annual abundance of smolt recruits (Table 2). In instances where there were multiple populations within a major river system, composite smolt abundances were summed and thus treated as one natural-origin population entity (such as with the Skagit River that encompasses six unique Chinook salmon population groups).

Exceptions to the above approach include the Green / Duwamish and lower Elwha river systems. In the Green /Duwamish River system long-term smolt trap monitoring provided annual estimates of Chinook smolt abundance (Seiler et al. 2002, 2004a, 2004b; Volkhardt et al. 2005). Little site-specific information was available to reliably estimate abundance of natural smolts in the lower Elwha River. Although flawed, EDT estimates of smolt productivity and capacity from the Dungeness River were used as surrogate values for estimating natural smolt recruitment in relation to estimated annual returns of adult spawners to the lower Elwha River. Flawed estimates for the Elwha basin are considered of minor concern given the anticipated removal of two mainstem dams that have been long term barriers to anadromy.

Table 1. Estimated number of adult Chinook salmon on the spawning grounds (of hatchery and natural origin) throughout Puget Sound, Hood Canal and Strait of Juan de Fuca river drainages, Washington. Note: estimates for Nooksack River drainages provided by Ned Currence, Nooksack Tribe, *per* Year 2005 report to the Pacific Salmon Commission on spawner escapement studies.

River System	Drainage	Year									
		1999	2000	2001	2002	2003	2004	2005	AVG	MIN	MAX
Nooksack	NF Nooksack	823	1,242	2,185	3,741	2,857	1,746	2,113	2,314	1,242	3,741
	SF Nooksack	290	365	420	622	569	170	229	396	170	622
Skagit	Lower Skagit	1,043	3,262	2,606	4,866	1,161	3,303	3,320	3,086	1,161	4,866
	Upper Skagit	3,586	13,092	10,084	13,815	7,123	20,145	16,608	13,478	7,123	20,145
	Cascade	83	273	625	340	298	380	420	389	273	625
	Lower Sauk	295	576	1,103	910	1,493	443	875	900	443	1,493
	Upper Sauk	180	388	543	460	193	700	369	442	193	700
	Suiattle	208	360	688	265	353	495	516	446	265	688
Stillaguamish	NF Stillaguamish	845	1,464	1,066	1,253	883	1,358	885	1,152	883	1,464
	SF Stillaguamish	253	158	283	335	105	148	78	185	78	335
Snohomish	Skykomish	3,455	4,665	4,575	4,325	4,239	7,616	3,203	4,771	3,203	7,616
	Snoqualmie	1,344	1,427	3,589	2,895	1,975	2,990	1,281	2,360	1,281	3,589
Duwamish	Duwamish/Green	9,100	6,170	7,975	13,950	10,042	13,991	4,089	9,370	4,089	13,991
Puyallup	White	553	1,523	2,000	803	1,434	1,626	1,756	1,524	803	2,000
	Puyallup	1,988	1,193	1,915	1,590	1,173	1,065	725	1,277	725	1,915
Nisqually	Nisqually	1,399	1,253	1,079	1,542	627	2,788	2,159	1,575	627	2,788
Skokomish	Skokomish	1,817	843	1,794	1,479	1,125	2,398	2,032	1,612	843	2,398
Hood Canal	Hamma Hamma	557	381	248	32	N/A	49	33	149	32	557
Dungeness	Dungeness	75	218	453	663	640	1,014	1,077	678	218	1,077
Elwha	Elwha	1,629	1,959	2,208	2,376	2,305	3,443	2,120	2,402	1,959	3,443

Table 2. Parameters used in estimating the range of annual smolt recruitment for Chinook salmon in Puget Sound, Hood Canal and Strait of Juan de Fuca river drainages, Washington. Estimates for juvenile fish productivity and capacity were according to completed EDT watershed analyses. Note: EDT productivity and capacity estimates for the Elwha River are from analysis on the Dungeness River.

Drainage	Juvenile fish productivity	Juvenile fish capacity	Estimated adult spawning escapement			Estimated smolt abundance		
			AVG	MIN	MAX	AVG	MIN	MAX
NF Nooksack	87.207580	339,887	2,314	1,242	3,741	126,621	82,137	166,463
SF Nooksack	132.048800	229,119	396	170	622	42,560	20,445	60,461
Lower Skagit	291.513700	1,820,209	3,086	1,161	4,866	602,098	285,384	797,223
Upper Skagit	486.250700	1,731,632	13,478	7,123	20,145	1,369,717	1,154,455	1,471,503
Cascade	197.946600	28,423	389	273	625	20,765	18,626	23,113
Lower Sauk	315.105400	541,182	900	443	1,493	186,082	110,969	251,672
Upper Sauk	220.716800	76,547	442	193	700	42,899	27,368	51,187
Suiattle	212.571200	16,125	446	265	688	13,782	12,537	14,524
NF Stillaguamish	171.313900	470,475	1,152	883	1,464	138,990	114,466	163,594
SF Stillaguamish	173.762400	749,338	185	78	335	30,744	13,313	54,014
Skykomish	317.032000	4,855,581	4,771	3,203	7,616	1,153,205	839,821	1,612,616
Snoqualmie	277.719200	2,396,706	2,360	1,281	3,589	514,586	309,776	703,970
Duwamish/Green	N/A	N/A	9,370	4,089	13,991	760,500	1,108,000	1,225,600
White	117.501320	446,833	1,524	803	2,000	127,819	77,903	154,006
Puyallup	156.247300	2,257,546	1,277	725	1,915	183,303	107,867	264,197
Nisqually	304.088800	941,062	1,575	627	2,788	317,358	158,542	446,000
Skokomish	329.469900	962,167	1,612	843	2,398	342,187	215,528	433,833
Hamma Hamma	346.455700	201,792	149	32	557	41,018	10,509	98,643
Dungeness	221.731600	151,469	678	218	1,077	75,422	36,644	92,683
Elwha	221.731600	151,469	2,402	1,959	3,443	117,928	112,307	126,392

Hatchery Fish Residence Time

PCD RISK 1 essentially treats scenarios of fish co-occurrence as closed populations where removal can only occur due to mortality (Busack et al. 2005). Regional outmigrant fish trapping data indicates that hatchery Chinook and coho salmon generally exhibit directed and rapid outmigrant behavior upon release. However, the rate at which hatchery fish outmigrate from freshwater can vary considerably within a given release group. Thus, there is a high probability the majority of released hatchery fish will quickly migrate to saltwater although a portion of released fish can be expected to 'loiter' in freshwater for several days if not weeks (HSRG 2004; Seiler et al. 2000, 2001, 2002, 2003, 2004; Friesen 2005).

For purposes of this assessment and considering the closed-model limitations, the model input field *Hatchery Fish Residence Time* was considered a function of release location in relation to an average fish movement rate. To address differing rates of outmigration (and therein duration of freshwater residency) multiple model simulations were run for each hatchery program using a distribution of outmigration rates for hatchery fish; in this way 'typical' hatchery fish behavior was simulated while also allowing for both exceptionally rapid and prolonged outmigration scenarios.

Outmigrant trap data from the Skagit River was used to define downstream movement rates for sub-yearling hatchery Chinook salmon. Downstream migrant trapping in the Skagit River was initiated in 1990 and has continued since with the trap located at approximate river mile (RM) 17. With the implementation of mass-marked fish, data from the Skagit River system is somewhat unique in providing estimates on cumulative number of hatchery outmigrants according to three different release groups:

- sub-yearling Chinook salmon volitionally released off-station at Countyline Ponds, RM 89,
- Baker River off-station releases of sub-yearling fall Chinook at RM 57, and
- releases of sub-yearling spring Chinook from Marblemount Hatchery, RM 78.

Annual cumulative catch curve data of Skagit River hatchery releases for years 2001 through 2003 were bracketed into three outmigrant groups where the number of days from initial release to when approximately 50, 75 and 98 percent of the total hatchery catch had occurred was calculated. Hatchery fish swim rates could then be calculated using the number of travel days in relation to distance from point of release to the fish trap.

In essence, 50% of the fish were grouped as 'fast' outmigrants, 25 % as 'moderate' and the remaining 25 % as 'slow' outmigrants. This approach allowed for comparison between nine point estimates per grouped outmigrants (i.e. three years of trapping data multiplied by unique tracking of three different hatchery release-group-locations). Using standard statistical summary methods, analysis within and between hatchery outmigrant groups indicated that swim rates were skewed towards slower swim speeds with the median rate comparable between 'fast' and 'moderate' outmigrants. Given this, for sub-yearling Chinook salmon a 'moderate' and probable swim rate of 3.79 RM/day was established for *PCD RISK 1* modeling purposes. The absolute lowest observed swim rate of 0.68 RM/day was chosen as an input value for a triangular probability distribution. The highest observed swim rate was a far outlier and thus the second highest observed swim rate of 12.20 RM/day was selected to complete the triangular distribution for probable rates of outmigration exhibited by sub-yearling Chinook salmon.

There was little applicable data from the Puget Sound region to define swim rate speeds for yearling Chinook and coho salmon. Numerous studies in the Columbia River system have investigated this and indicate that yearling hatchery Chinook and coho salmon generally outmigrate at a faster rate as compared with sub-yearling hatchery fish. In context of the Puget Sound region, there was caution in considering published estimates from the Columbia River basin given that in most instances fish are required to travel far greater distances prior to reaching salt water as compared to Puget Sound river systems (Table 3). Furthermore, studies from the Columbia River basin strongly suggest a positive correlation between rate of fish movement and distance from saltwater. Because of this, a conservative approach was adopted where overall slower outmigration rates were favored (see Table 3, results from Ward 1994, Zabel 1998, Hockersmith et al. 2003, Friesen 2005). Bracketed within a probabilistic triangular distribution, an overall average outmigration rate of 7.0 RM/day was identified for yearling fish with a maximum rate of 17.0 and a minimum of rate 0.68 RM/day (where the minimum rate was derived from the Skagit River for sub-yearling Chinook salmon). For modeling purposes this meant that on average the swim rate for yearling fish was nearly twice that of sub-yearling hatchery Chinook salmon.

Having established triangular distribution probabilities for swim rates, respective of yearling and sub-yearling fish, the duration of freshwater residency by hatchery fish could be calculated given fluvial distance from point of hatchery releases to river-estuary confluences. Monte Carlo simulations of one thousand replicates per hatchery program provided the average number of days hatchery fish remained in freshwater with associated upper and lower 95% confidence bounds. Simulation results for hatchery programs where fish releases occur within a few miles of the estuary resulted in uppermost resident times of less than two days and in some instances less than one day. In order to run PCD RISK 1 an absolute minimum of at least one day was established for duration of freshwater residence by hatchery fish.

Concerning uppermost residency in freshwater by hatchery fish, a lower-river 'milling' effect, or delayed outmigrant behavior was incorporated. Motivation was due to results from beach seine studies such as in the in the lowermost reaches of the Nisqually River that indicated a significant presence of hatchery fish within the first week following release (Hodgson et al 2005; Ellings 2006; see also Miller and Sadro 2003 and Rowse and Fresh 2003). Because of this an additional four days was added to all uppermost estimates for residence time by hatchery fish. With this modification Monte Carlo simulation results were applied to triangular probability distributions within *PCD RISK 1* to specify *Hatchery Fish Residence Time* for individual hatchery program scenarios.

Table 3. Literature review on reported rates of downstream movement (river miles per day) for outmigrating juvenile chinook and coho salmon of both hatchery and wild origin throughout northwest Oregon and Washington.

			Movement Rate (rm / day)			**Information**	
Salmon Species	**Origin**	**Region**	**Average**	**Median**	**Range**	**Source**	**Comments**
Chinook (sub-yearling)	Hatchery	Skagit River, Washington	7.3 (50%) 4.2 (75%) 1.3 (98%)	4.2 (50%) 3.8 (75%) 1.3 (98%)	2.9 - 18.0 1.4 - 10.3 0.7 - 2.1	Seiler et al. 2001, 2002, 2003	Based upon smolt trap recoveries of marked hatchery fish. Rates calculated using cumulative catch curve data (percent of total outmigration) in relation to days elapsed from release to trap capture (travel distance up to 77 mi.).
Chinook (sub-yearling)	Hatchery	Columbia River	11.6	12.4	3.0 - 22.1	Dawley et al. 1986	Beach seine recoveries of group-branded fall Chinook. Recovery information was combined to calculate overall rates.
Chinook (sub-yearling)	Hatchery and Wild	Columbia River	9.7		0.5 - 31.6	Giorgi et al. 1997	Rates for PIT-tagged salmon between Rock Island Dam and McNary Dam (418 mi reach)
Chinook (sub-yearling)	Wild	Snake River	5.5	4.4	1.1 - 12.4	Connor et al. 2003	Overall rates of PIT tagged salmon traveling between Hells Canyon Dam and Little Goose Dam
Chinook (yearling)	Not specified	Lower Willamette River, Oregon	9.5	6.1	0.0 - 26.0	Ward et al. 1994	Rates for radio-tagged salmon through Portland Harbor (RM 0 - 31)

Salmon Species	Origin	Region	Movement Rate (rm / day) Average	Median	Range	Information Source	Comments
Chinook (yearling)	Hatchery and Wild	Lower Willamette River, Oregon		7.7 (H) 5.2 (W) 7.0 (C)	2.5 - 17.4	Friesen 2005	Rates for radio-tagged salmon of hatchery (H), wild (W) and combined (C) origin. Range values based upon report whisker plot graphs.
Chinook (yearling)	Hatchery and Wild	Columbia River	13.4		0.5 - 80.7	Giorgi et al. 1997	Rates for PIT-tagged salmon between Rock Island Dam and McNary Dam (418 mi. reach)
Chinook (yearling)	Hatchery	Snake and Columbia rivers	15.0 (10%) 10.0 (50%) 6.6 (90%)		13.3 - 17.0 8.9 - 12.9 4.7 - 8.8	Hockersmith et al. 2003	Rates for PIT-tagged salmon between Lower Granite Dam and Bonneville Dam (362 mi. reach). Percentiles indicate rates for cumulative proportions of total fish detected
Chinook (yearling)	Hatchery and Wild	Snake and Columbia rivers	7.3			Zabel et al. 1998	Modeled constant migration rate of PIT-tagged fish over an eight-year period.
Coho (yearling)	Hatchery	Green River, Puget Sound, Washington	4.5 (25%) 2.7 (50%) 1.7 (75%) 0.4 (98%)			Data provided by WDFW for year 2001 smolt trap monitoring	Based upon smolt trap recoveries of marked hatchery fish. Rates calculated using cumulative catch curve data (percent of total outmigration) in relation to days elapsed from

Salmon Species	Origin	Region	Movement Rate (rm / day) Average	Median	Range	Information Source	Comments
							release to trap capture (i.e. river miles traveled per day).
Coho (yearling)	Hatchery	Skagit River, Puget Sound, Washington	11.2		9.6 - 12.9	WDFW HGMPs	Based upon outmigrant trap recoveries of marked hatchery fish. Unable to obtain source data and thus not personally reviewed nor verified.
Coho (yearling)	Unknown	Lower Cowlitz River, Washington	18.3 11.4*	18.0 11.4*	16.3 - 20.9 7.1 - 15.7*	HARZA 1999	Rates for radio-tagged salmon where (*) denotes calculated values that include delayed outmigration due to holding behavior in recovery ponds.
Coho (yearling)	Hatchery and Wild	Lower Willamette River, Oregon		5.1	1.2 - 15.5	Friesen 2005	Rates for radio-tagged salmon. Range values approximated from report whisker plot graphs.
Coho (yearling)	Hatchery	Columbia River	4.8	2.9	1.9 - 16.4	Dawley et al. 1986	Beach seine recoveries of group-branded yearling coho salmon. Recovery information was combined to calculate overall rates.

Hatchery Fish Survival

Outmigrant trap data from the Skagit River was also used to establish modeled rates of survival for hatchery fish. Estimated survival of sub-yearling Chinook salmon released in the Skagit River has ranged between 40 and 70 percent with an overall average of 58 percent for release years 2001 through 2003. The survival period encompassed a range of 47 to 61 days with an approximate average of 54 days (Seiler et al. 2001, 2002 and 2003).

PCD RISK 1 requires parameter input value(s) for *Hatchery Fish Survival Rate* that are used in a daily decay rate function:

$$D_{SR} = S^{(1/t)},$$

where D_{SR} is the daily hatchery fish survival rate, S is the survival rate throughout the period of freshwater residency and t is the hatchery fish residence time in days (Busack et al. 2005). Calculated *PCD RISK 1 Hatchery Fish Residence* times for Skagit River sub-yearling programs were referenced where the most probable averages and uppermost values in days were summed and then averaged. This approach resulted in an average of 34 days (t) and used in the above formula in conjunction with observed minimum, average and maximum rates of survival (S) from the Skagit River studies. A probabilistic rate for daily hatchery fish survival (D_{SR}) was thus calculated and ranged between 0.973 and 0.990 with a triangular peaked average of 0.984. (Figure 2). The survival distribution *0.973_0.984_0.990* was applied to all modeled sub-yearling hatchery programs. Given that essentially no regional information was identified regarding freshwater rates of survival for yearling Chinook and coho salmon, it was assumed yearling fish exhibit an overall higher survival rate due to their larger size (see Connor et al. 2004). Thus, yearling fish programs were assigned an overall higher daily survival rate distribution of *0.973_0.990_0.990*.

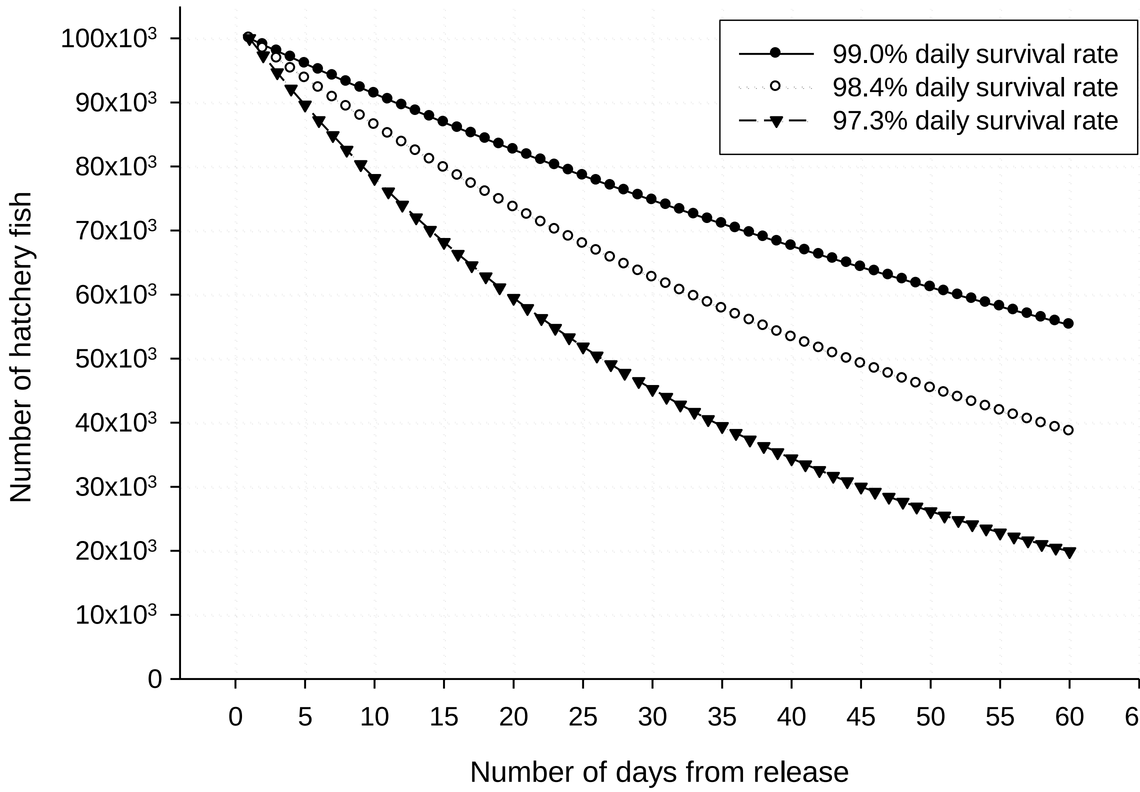

Figure 2. Abundance of hatchery fish over time in relation to specified daily survival rates using the *PCD RISK 1* decay rate function.

Percentage of Population Overlap

The *PCD RISK 1* input variable *Percentage Population Overlap* is treated as the percentage of the natural-origin population available for interaction with hatchery fish due to spatial and temporal overlap (Busack et al 2005). Within modeled scenarios specified separation of the natural-origin population occurs prior to the initial onset of simulated interactions between hatchery and wild fish. In this assessment population overlap was scored according to temporal overlap criteria; separation of fish in a spatial context was not considered. This approach was chosen foremost to avoid confounding logic rules in constructing fish interaction scenarios. To elaborate, for modeled assessments the duration of freshwater residency by hatchery fish was dependent on downstream swim rates in relation to point of release (accounting for spatial considerations). Perhaps more importantly, there was uncertainty concerning how natural juvenile fish are distributed within a watershed at any point in time. In most cases the outmigrant trap data considered for this assessment was from trapping operations located several miles upstream of river-estuary confluences. From a risk-averse point of view it can be argued that natural juvenile Chinook use the lowermost portions of rivers for temporary rearing prior to saltwater entry (see Rowse and Fresh 2003, Hodgson et al. 2005). In an effort to establish consistent logic rules so that hatchery program assessments were comparable, a risk-averse approach was invoked where it was assumed that up to 100 percent overlap could occur between hatchery and natural fish populations. Given this premise it is also defensible that in many instances a significant number of wild fish from a given population will have outmigrated prior to hatchery releases or remain upstream of hatchery release locations. To quantitatively address this, regional outmigrant trapping data was compiled.

Regional downstream trapping data was used to determine the median dates at which an estimated 50% of natural Chinook populations had migrated past respective trap locations (Gray 2006; Griffith et al 2003, 2004, 2005; Nelson and Kelder 2002; Nelson et al. 2003, 2004a,b, 2005a, b; Seiler and Neuhauser 2000; Seiler et al. 2001, 2002, 2003, 2004,a,b; Volkhardt 2005). A total of eighteen data points were identified encompassing five different river systems with monitoring in at least one river system between the years 1999 and 2004 (Figure 3). The collective median date for 50% outmigration of natural juvenile Chinook was March 31 as compared to April 1, the first annual date at which Puget Sound hatchery releases occur (according to program HGMPs). Using the above logic criteria a minimum *Population Percentage Overlap* value of 50 was established. The risk-averse approach thus assumed that between 50 and 100 percent of natural fish populations could co-occur with hatchery releases.

To complete a triangular distribution for *PCD RISK 1* modeling purposes all observed median outmigration dates for natural populations were bracketed within fourteen-day intervals (Figure 4). For a given program, the earliest specified date of hatchery releases were then located within bracketed median outmigration dates for natural-origin populations. The number of observed median outmigration dates bracketed within and following an initial hatchery release were summed and divided by eighteen; this value was the proportion of all observed dates where monitored natural populations had not yet achieved fifty percent outmigration. The proportional value was multiplied by 50 (to scale between fifty and one-hundred percent remaining natural fish) and then added to a minimum population overlap value of fifty percent. To illustrate, a hatchery program releases fish on April 15; referencing Figure 10, this date falls within the April 12 - 26 bracket during which one observed median outmigration date occurred. Adding this to the number of observed median dates following this histogram bin (five date points) equals a total of six. Six divided by eighteen, multiplied by fifty and then added to fifty equals approximately sixty-seven. In *PCD RISK 1*, the *Percentage Population Overlap* for this program would be *50_67_100* with the triangular distribution skewed towards lower population overlap. A program that releases fish in early June would be modeled with a distribution of *50_53_100* whereas an April 1 program release would be *50_78_100.*

An exception to this approach was invoked for the Dungeness River. Outmigrant trap data from this system indicates sustained and significant outmigration of natural-origin juvenile Chinook salmon throughout summer months (Freymond et al. 2001). Given theses trend observations a distribution range of *70_85_100* was established for *Percentage of Population Overlap* for modeled programs in the Dungeness River.

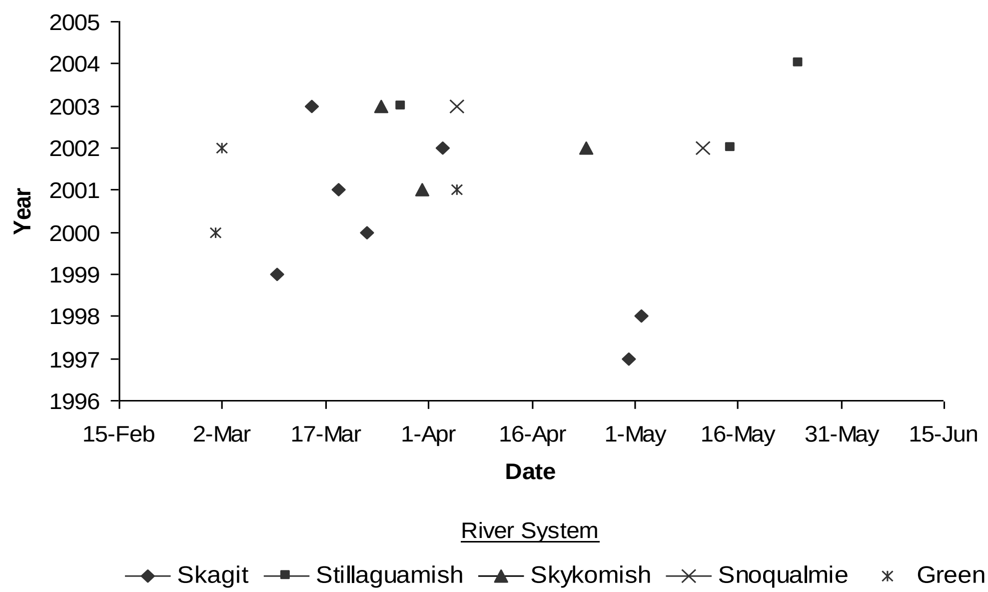

Figure 3. Observed median date at which fifty-percent of populations consisting of natural-origin juvenile Chinook salmon have passed respective trap locations in river basins throughout the Puget Sound, Washington.

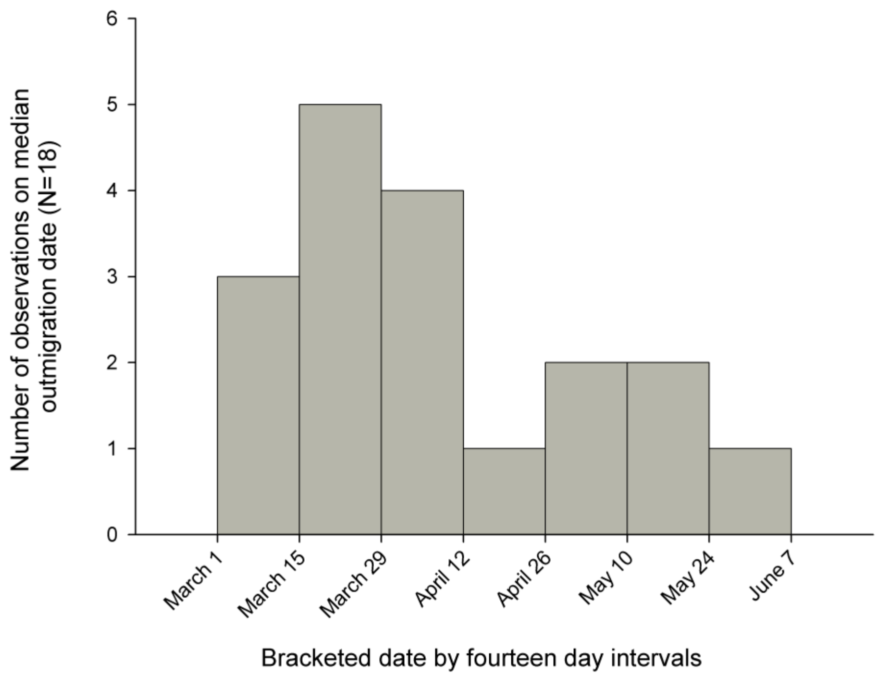

Figure 4. Bracketed observed median dates at which fifty-percent of populations consisting of natural-origin juvenile Chinook salmon have passed respective outmigrant trap locations in river basins throughout the Puget Sound, Washington. Annual data points (*n*) from monitoring in the Skagit (*n*=6), Stillaguamish (*n*=3), Skykomish (*n*=3), Snoqualmie (*n*=2) and Green (*n*=3) rivers.

Percentage Habitat Complexity

Succinct characterization and quantification of 'complex habitat' is contentious at best. Within *PCD PISK 1 Percentage Habitat Complexity* is defined as the amount of habitat that provides protection to natural-origin fish from competitive interactions with hatchery fish. Actual biological attributes can include the amount of in-stream wood, undercut banks, large boulders, etc., that provide visual isolation between co-occurring fish. Although intuitive in concept, consistent quantification of complex habitat within and across river basins for comparable hatchery assessments was a challenge.

Because EDT analysis was completed and available for the majority of watersheds considered in this hatchery assessment, it was decided to apply aspects of the EDT method in quantifying *Percentage Habitat Complexity* for use in *PCD RISK 1*. Broadly, EDT is a watershed approach to quantifying suitability of a river system for salmon production.

EDT analysis quantifies environmental attributes and conditions in relation to existing productivity (the 'patient' template), by life-stage, for a fish species of interest. Analysis is according to habitat reach segments and calendar month. By reach segment, EDT analysis also quantifies the proportional amount of historical 'key' habitat that provides optimal conditions (the diagnosis reference or 'the template') for a specific fish life-stage (e.g. shallow, low velocity pools for salmon fry).

Translation of EDT metrics into the amount of 'complex habitat' for *PCD RISK 1* assessments required identification by individual hatchery programs on timing and point of fish releases. All EDT reaches downstream and to the river-estuary confluence of a specified release location were thus identified. Applicable habitat reaches were proportionally weighted according to respective reach area. Within a given reach, the proportion of 'key' habitat ('template' proportion) was first multiplied by estimated reach-specific productivity ('patient' proportion) and then multiplied by the weighted area of that reach. Calculated scores were then summed across all habitat reaches and multiplied by one hundred to derive a score for *Percentage Habitat Complexity*. Final scores were bracketed within a triangular distribution range of plus or minus five percent to reflect both uncertainty in the scoring method and potential variability across years.

Specification of Remaining Model Input Variables

A subset of input variable fields within *PCD RISK 1* were held equal across all hatchery release programs evaluated for this assessment. These input values are necessary in running modeled scenarios but are not explicitly stated within individual hatchery program profiles presented in Appendices B – E. As a rule, scientific support, model guidelines and recommendations provided by

Busack et al. (2005), the model developers, were heeded in quantifying the following model input variables.

Number of Iterations

In defining parameter input values for assessment of hatchery Chinook and coho salmon programs, a probabilistic approach was typically employed. From a risk perspective, the approach was heavily favored in trying to capture sometimes known or at least suspected variability within dynamic and therein complicated community systems. Invoking general properties of statistical sampling, numerous simulation samples should capture the outcome of both unlikely yet extreme event combinations while suggesting the most centralized and probable trend from a myriad of causal combinations. The computation time required to complete numerous hatchery program assessments somewhat dictated a chosen number of *300* iterations be completed for each program assessment.

Scaling Factor

PCD RISK 1 is a computationally intensive program that depending on the modeled scenario may entail hours up to several weeks to complete multiple simulations and generate analysis results. Because of this, the model allows for the user to scale, or sub-sample at a specified proportion from the 'actual' abundance of hatchery and wild fish. Preliminary evaluations were conducted to investigate potential bias in model results due to varying factors of scale, for what was otherwise static hatchery release scenarios. Based upon insights from this exercise, a 'scaling rule' was invoked where on any given program / model iteration a minimum of 3,000 fish of either hatchery or natural origin would be sampled from respective populations; thus, for each program assessment, the lowest possible abundance from either the hatchery or wild population was divided by 3,000 to determine the appropriate *Scaling Factor*.

Dominance Mode

A *Dominance Mode* value of *2* was used in all assessed hatchery programs with the premise that for a given paired interaction between a hatchery and wild fish, the probability that the wild fish will be dominated is dependant upon the relative difference in fish size (Table 4).

Table 4. From Busack et al (2005), hypothetical percentages of fish dominance over wild fish assuming *Dominance Mode = 2*. Difference in fish size is expressed as a relative difference and dominance is expressed as the percentage of interactions that hatchery-origin fish dominate natural-origin fish. Scenarios assume that natural fish have prior residence.

PCD RISK 1

Dominance Mode = 2

Scenario: more aggressive hatchery fish	**Difference in size (hatchery fish size relative to wild fish size)**						
	< -25	-25 to -15	-15 to -5	- 5 to 5	5 to 15	15 to 25	>25
percentage of hatchery fish dominance over wild fish	10	20	30	70	90	95	100

Probability Dominance Results in Body Weight Loss

This input variable is defined as the probability that a fish that is dominated will have a *Body Weight Loss* (see below) that is equal to one day of no feeding (e.g., the proportion of body weight loss that occurs from being dominated). This value was set at a deterministic value of *0.10*.

Percentage of Body Weight Loss Causing Death

This model parameter input is defined as the percentage of body mass lost due to competitive encounters (with hatchery fish) that will cause death (natural-origin fish mortality). Based upon controlled laboratory studies, Busack et al. (2005) hypothesize a value range between 46 and 76 percent; for this assessment, the input variable was set at fifty percent. Thus, a given wild fish that incurs five days of no feeding due to competitive dominance by hatchery fish will result in wild fish mortality, or termed '*Competition Mortality'*. Because individual fish histories are tracked within the model for a given simulation, model output results also provide a metric termed *'Competition Equivalence*' which is the sum total of all hatchery-wild fish interactions that resulted in a body weight loss of ten percent to wild fish and ultimately divided by five; five being the number of encounters necessary per an individual fish to result in mortality. While this is the mechanistic model structure, it is important to caution that model output results are best considered as risk indices rather than actual mortality rates per se (see below on *Maximum Daily Encounters per Hatchery Fish*).

Maximum Daily Encounters per Hatchery Fish

An individualistic-based model, the inclusion of a counter for the maximum number of encounters a hatchery fish can have per day was a programming necessity in order to signal the end of a simulation day. While this parameter has an inferred relation to system carrying capacity (fish densities), the actual basis for quantification is both problematic and rather speculative at multiple watershed scales. Considering this and computer computation loads required for this assessment, the input variable was set at a maximum of *three* encounters a hatchery fish can have per day (i.e. interact with up to three wild fish on a given day). While this parameter input value could be considered contentious it is important to stress that the assessment approach was designed to provide a relative comparison of impact risks between hatchery programs.

Piscivory Rate

Modeled *Piscivory Rate* is treated as the proportion of hatchery-origin fish that will feed on natural-origin 'target' fish. *PCD RISK 1* treats *Piscivory Rate* as the proportion of hatchery fish that are allowed to consume natural-origin fish up to the point of daily satiation (based upon programmed fish bioenergetics criteria); the remaining proportion of hatchery fish are not allowed to consume any natural-origin fish.

Busack et al. (2005) provide a compilation of published rates of predation by juvenile hatchery salmonids on wild juvenile Chinook. The majority of reviewed studies have investigated predation by yearling releases of coho salmon and steelhead and in general indicate relatively low rates of predation. However, from the Feather River, California, Sholes and Hallock reported high rates of predation by hatchery Chinook salmon, but is somewhat questionable due to extrapolation from small sample sizes. Additionally, Hawkins and Tipping (1999) reported high rates of predation by hatchery coho salmon and steelhead in the Lewis River, Washington. In reviewing this study, results from Hawkins and Tipping (1999) could be considered as an extreme worse case scenario and were also not included in defining modeled predation rates. Considering all other published studies presented in Busack et al. (2005), *Piscivory Rate* was modeled within a triangular probability distribution of *0.001_0.002_0.050*; invoking a risk-averse approach, it was always assumed that a proportion of hatchery fish would act as predators although dependent upon the model pathway criteria that a hatchery fish be at least twice the size of a paired wild fish (i.e. physiologically capable of consumption). Input interpretation is that for every 1,000 hatchery fish that are of size to be predators, between one and fifty will actually act as predators with the model selection probability heavily skewed towards one predatory fish.

Disease Mortality

While the model also allows for incorporation of simulated mortality on natural-origin fish due to disease agents, the scientific basis to model actual population impacts remains largely undeveloped.

Induced and elevated mortality of natural fish through disease agents as a result of hatchery releases is most certainly a perceived risk and should be addressed. However, due to the general lack of empirical insight and therein a high degree of uncertainty, disease considerations were not incorporated in this assessment. Input model values concerning disease mortality rates were set at *0*.

RESULTS AND DISCUSSION

Assessed competition and predation impacts on natural Chinook salmon populations encompassed eleven major Puget Sound watersheds and twenty ESA listed populations of Chinook salmon. Given that risk assessments were conducted as part of the Chinook Hatchery EIS, modeled fish interaction scenarios were evaluated according to current hatchery production levels with a portion of these programs also evaluated according to proposed alternatives for increased and decreased levels of fish production. Under current hatchery management, a total of thirty Chinook salmon programs were assessed (twenty-one programs releasing fish at the sub-yearling stage and the remaining nine releasing fish as yearlings). Considering current hatchery production of coho salmon, a total of fourteen programs were modeled all of which release fish as yearlings. For hatchery Chinook salmon programs an additional eighteen scenarios were evaluated of which fourteen proposed decreased fish production levels and four program scenarios with an increase from current hatchery production levels. Proposed EIS scenarios dictated that an additional seventeen coho salmon hatchery programs be assessed of which thirteen entailed a reduction in the number of fish released and four programs with an increase in the number of coho released. Thus, in total, seventy-nine hatchery production scenarios were assessed using *PCD RISK 1*.

PCD RISK 1 assessments resulted in scored indices of risk to natural Chinook salmon populations according to modeled ecological mechanisms of fish interactions. Assessed impacts by releases of hatchery fish were categorically attributed to mechanisms of either predation or competition. In terms of competition, only model output results for *'Competition Equivalence'* were considered. This metric is the total number of hatchery-wild fish interactions in which given a paired hatchery-wild fish interaction resulted in a wild fish incurring a ten percent loss in bodyweight, where the sum total is divided by five. The division by five is the number of dominant encounters incurred by a wild fish that results in mortality.

Output from PCD RISK 1 also provides competition impacts in terms of *'Competition Mortality'*, interpreted as the 'true' and total number of wild fish mortalities due to each individual fish actually incurring a fifty-percent loss in body weight due to dominant encounters with hatchery fish. For all hatchery programs considered, simulated impacts scored zero according to '*Competition Mortality*' model criteria. This is not to say that actual natural fish mortality doesn't occur due to competition with hatchery fish, but rather to illustrate why *PCD RISK 1* assessment results are to be treated as risk index scores. Furthermore, this in part is rationale for considering modeled competition and predation hatchery impacts separately, i.e. different modeled mechanisms.

Current Hatchery Management – Yearling vs. Sub-Yearling Releases

Consideration of fish release stage for individual hatchery programs is important in interpreting model results. Using averaged model scores under current hatchery management, assessment results indicate that competition impacts by the majority yearling release programs is essentially null (Figure 5, plotted points along the x-axis). However, for these same yearling release programs, levels of risk for predation impacts on wild Chinook salmon populations is significantly elevated above an index score of zero. Model interpretation is that yearling programs release fish of such a large size as compared to wild fish that the modeled mechanism for fish interactions is almost exclusively predation. In a similar context, results for several program releases of sub-yearling hatchery fish indicate that these fish are predominantly too small to act as predators and thus impact risks are largely through mechanisms of competition (Figure 5, plotted points along or near the y-axis). In all other instances, releases of sub-yearling fish impose impact risks to wild populations through direct mechanisms of both predation and competition.

Relative comparison of averaged index scores for predation and competition under current hatchery management suggest 'risk guilds' in assessing program releases of hatchery Chinook and coho salmon (Figure 5). All hatchery programs combined, 82 percent resulted in an indexed competition score of five or less, with the remaining percentile and associated higher index scores attributable to hatchery Chinook salmon programs. In terms of predation, approximately half of all current hatchery programs considered resulted in an impact index score of five or less, with eighteen percent of all programs scoring between five and ten, and the remaining thirty-percent scoring above an index impact score of ten; of the coho hatchery production programs, seven of the fourteen programs had a predation impact score above ten (Table 5).

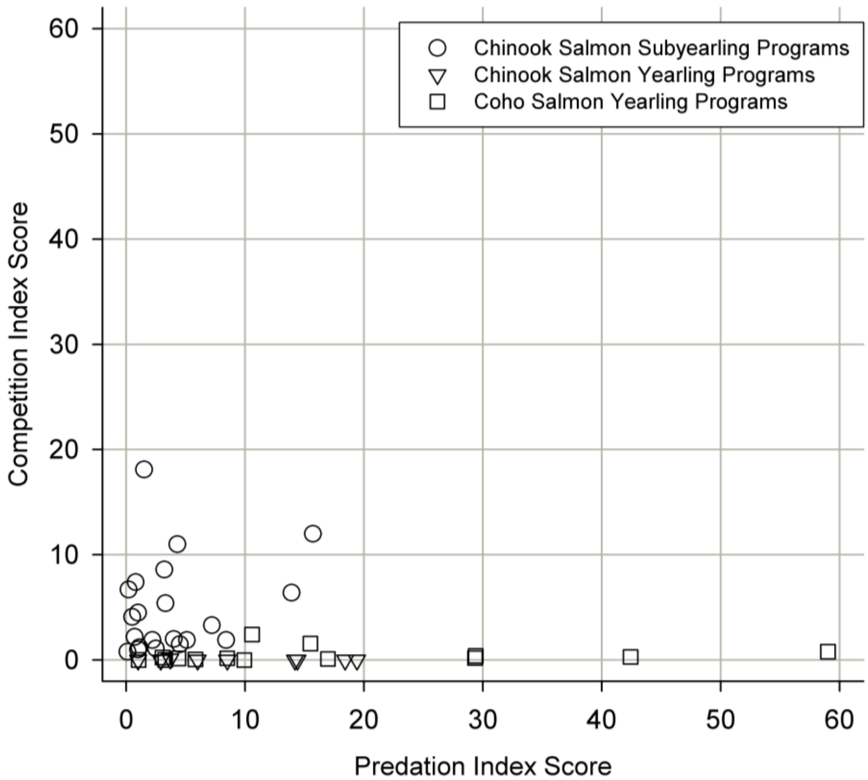

Figure 5. Relationship between average index scores for predation and competition using *PCD RISK 1* analysis to evaluate impacts on natural juvenile Chinook salmon populations by hatchery releases of Chinook and coho salmon throughout Puget Sound, Hood Canal and Strait of Juan de Fuca freshwater basins. Index scores according to current hatchery production levels.

Table 5. Bracketed index scores according to PCD RISK 1 simulation results to assess competition and predation impacts on natural Chinook salmon populations throughout the greater Puget Sound region by hatchery releases of Chinook and coho salmon. Averaged index scores are for fish interactions in the freshwater environment under current hatchery management practices.

PCD RISK 1	**Hatchery Chinook Salmon Programs (N= 30)**		**Hatchery Coho Salmon Programs (N=14)**		**Hatchery Programs Combined (N=44)**	
Averaged Index Score	n	n/N*100	n	n/N*100	n	n/N*100
Competition (Comp)						
Comp ≤ 5	22	73 %	14	100 %	36	82 %
5 < Comp ≤ 10	5	17 %	0	0 %	5	11 %
Comp > 10	3	10 %	0	0 %	3	7 %
Predation (Pred)						
Pred ≤ 5	19	63 %	4	29 %	23	52 %
5 < Pred ≤ 10	5	17 %	3	21 %	8	18 %
Pred > 10	6	20 %	7	50 %	13	30 %

A key initial consideration in interpreting model scores is the ratio of hatchery to wild fish abundances. Although the number of hatchery fish released may seem relatively small for a given program, the degree for 'impact potential' is correlated to the abundance of the wild fish population within the receiving environment. This relationship was particularly strong in terms of predation impacts on wild Chinook salmon populations in scenarios with hatchery releases of yearling fish (Figure 6). Exceptions to this relationship (Figure 6, the two far-right points) were two coho hatchery programs in the Elwha and Dungeness rivers, Strait of Juan de Fuca, which both had the highest proportion of hatchery to wild fish abundances. In both program instances fish are released in May and June, respectively, and approximately three miles from the estuary confluence (see Appendix D and E). Thus, the potential for predation impacts on wild fish is mitigated by both timing and location of hatchery releases.

In terms of modeled impact scores considering sub-yearling releases of hatchery fish (Chinook salmon only), the correlation between predation impacts and proportional abundances of hatchery versus wild fish was less apparent (Figure 7). Risk assessment results indicated that hatchery releases of sub-yearling Chinook salmon could, in some program scenarios, result in 'significant' impacts to wild Chinook populations through mechanisms of both predation and competition. Given sub-yearling hatchery fish, the proportion of fish that are of sufficient size to act as predators is not as directly related to the number of hatchery fish released (i.e. hatchery and wild fish are of a more similar size).

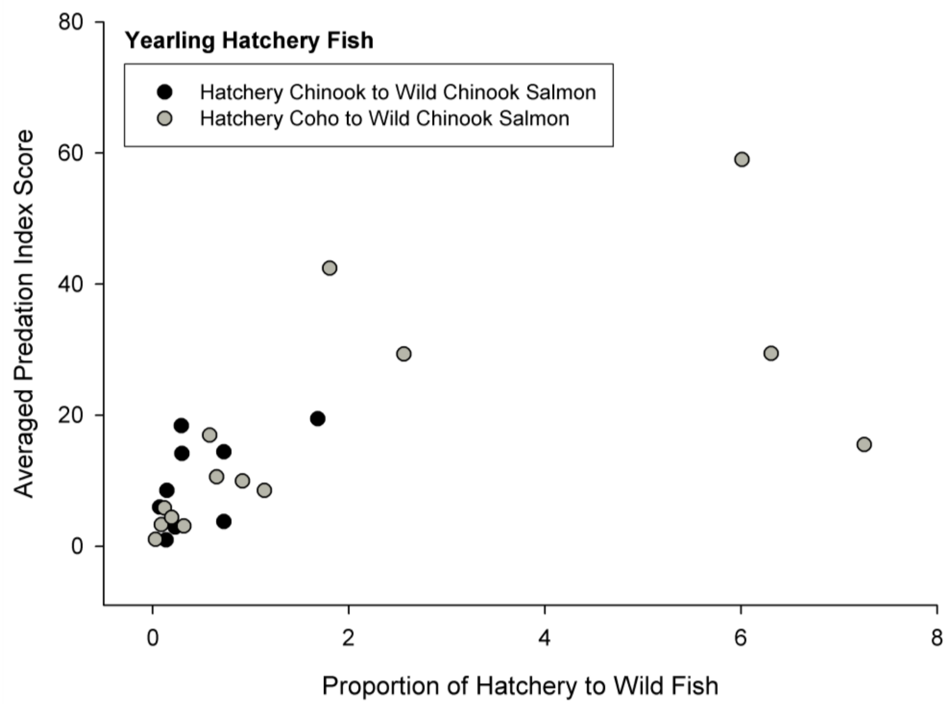

Figure 6. Relationship between the proportion of yearling releases of hatchery Chinook and coho salmon to wild juvenile Chinook salmon versus PCD RISK 1 modeled index scores for predation impacts on wild fish populations. Populations encompass freshwater basins within the greater Puget Sound region under current hatchery management practices.

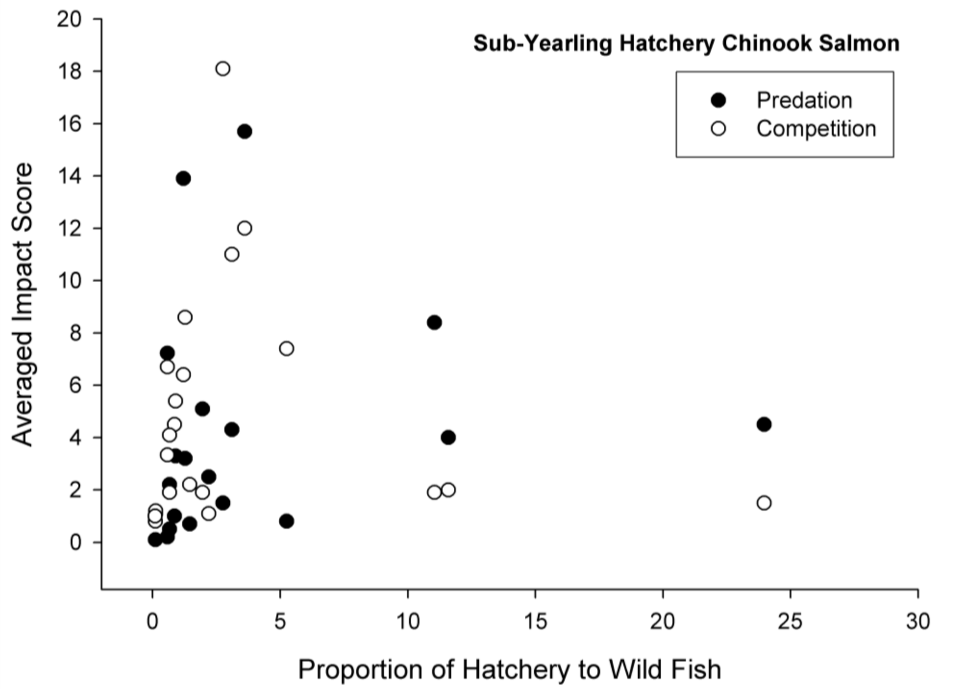

Figure 7. Relationship between the proportion of sub-yearling releases of hatchery Chinook salmon to wild juvenile Chinook salmon versus PCD RISK 1 modeled index scores for predation and competition impacts on wild fish populations. Populations encompass freshwater basins within the greater Puget Sound region under current hatchery management practices.

This may, in part, explain the relatively poor predictive relationship to models scores for predation impacts. The model mechanism for competition, given that hatchery fish are not of size to act as predators, is largely a function of the number of days hatchery and wild fish co-occur. To elaborate, within the model on a given simulation day, if a wild fish encounters and is dominated by a hatchery fish, the wild fish incurs a ten percent loss in body weight (one '*Competition Equivalent*') and is removed for that day from the simulation-fish interaction-environment. A potential result of this, is that for a given simulation day within the *PCD RISK 1* model, if the number of hatchery fish is of a magnitude greater than the number of wild fish, the vast majority of wild fish could incur a dominant encounter and be 'ineligible' for further interactions with hatchery fish for that day. Under this scenario premise, if fish co-occur for only a few days then potential impacts due to competition are minimized. Contrast this to the model mechanism for predation, where a pre-determined proportion of hatchery fish, if of size, will act as predators and on a given simulation day will attempt to encounter and consume wild fish up to the point of bioenergetic satiation or a maximum of three wild fish encounters per day (three encounters per day for competition mechanisms as well). Either a fish is eaten on a given encounter or remains eligible for additional encounters on that simulation day. Thus, the potential for impacts due to predation are less constrained by days of fish co-occurrence.

In general, there was a positive relationship between the number of days sub-yearling hatchery and wild Chinook salmon co-occurred versus averaged model scores of competition impacts ('*Competition Equivalence*'; Figure 8). For predation scores, the relationship was less definitive, likely due to reasons discussed above. Average days of fish co-occurrence reflect hatchery release locations (i.e. time necessary for hatchery fish to outmigrate from freshwater). In examining Figure 8, the three data points to the far right and near the x-axis, are respective paired points for competition and predation impacts per a given program, and all represent program releases of hatchery fish within the Skagit River. These three Skagit River hatchery programs release fish between approximate river miles 57 and 91 throughout the month of June. Unlike the release location, the release date reduces potential impact risks to natural Chinook salmon populations due to the likelihood that a large portion of wild fish will have outmigrated from freshwater. Foremost however, model results are a reflection of population status in terms of overall abundance of wild Chinook salmon in relation to the number of hatchery releases (at least seven times as many wild fish as compared to the number of fish released per hatchery program; see Appendix B and C). This serves to illustrate that interpretation of assessment results by hatchery program, to certain degrees scenario attributes as a whole need to be considered (e.g. relative fish abundances, hatchery fish size at release, time at hatchery release, point of hatchery releases, etc.).

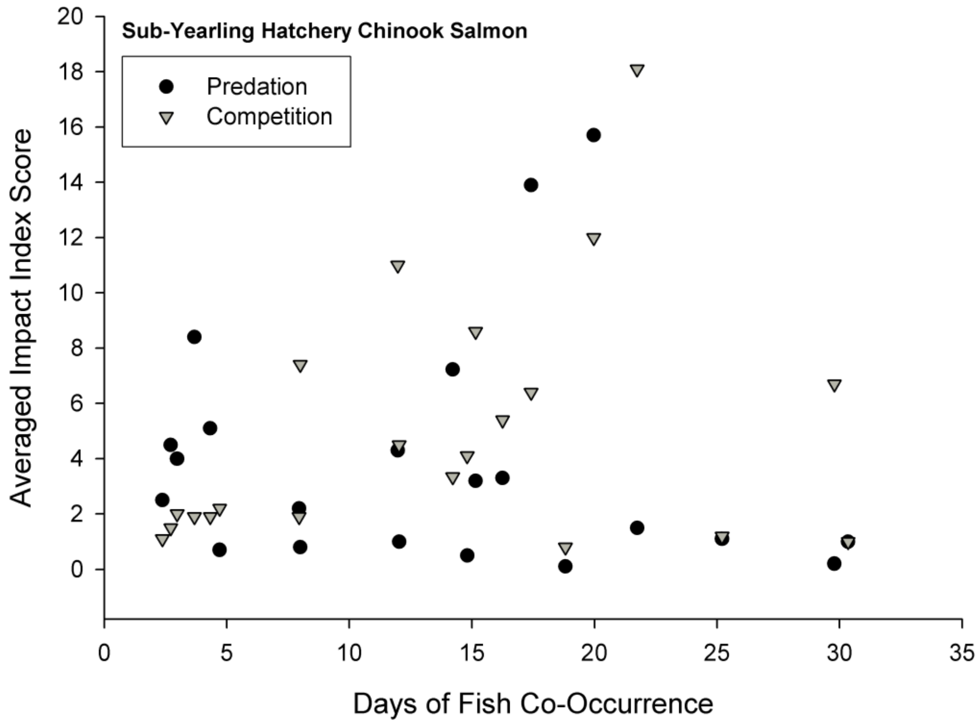

Figure 8. Modeled scores for impacts on natural juvenile Chinook salmon populations due to competition or predation by hatchery releases of sub-yearling Chinook salmon in relation to simulated days of fish co-occurrence. Populations encompass freshwater basins within the greater Puget Sound region under current hatchery management practices.

An attractive feature of *PCD RISK 1* is the ability to incorporate probability distributions in specifying parameter inputs. Substantial efforts were made to establish a consistent methodology in defining fish interaction scenarios. Such an approach was critical in ultimately being able to evaluate hatchery programs at both a programmatic and regional level. Specified distributions for model parameter inputs incorporate known empirical variability as well as uncertainty. Uncertainty stems from a large degree of speculation in how numerous environmental attributes interact in producing outcomes of interest. Therein is the utility of using distribution probabilities and multiple model scenario simulations. Figures 9 – 12 show individual hatchery program results by averaged index scores of impact and associated one standard deviation. Examination of these figures indicate that as index scores for predation and competition impacts increase, associated deviation correspondingly increases.

The range of deviation suggests the likelihood and potential range, or degree of impacts to natural Chinook salmon populations. More directly, how the combination of modeled scenario attributes interact to ultimately result in population impacts is reflected in deviation around averaged point values. For example, given a hatchery program of interest, out of 300 model simulation runs, several simulation results may result in relatively low impact levels. Environmental interpretation is that the deviation around overall averaged scores reflects annual environmental variability. For example, a portion of relatively 'low' model scores could be interpreted to reflect annual conditions where theoretically there could be above average adult returns and juvenile offspring, favorable high flow conditions at time of hatchery releases thus resulting in rapid hatchery fish outmigration and reduced susceptibility of wild fish to negative hatchery fish encounters due to larger than average natural fish size (i.e. favorable in-river conditions for juvenile growth). Contrary to the above scenario, it is also reasonable to expect that in some years environmental conditions are quite the opposite, and though maybe infrequent, exacerbate hatchery impacts on wild fish populations. Such environmental scenarios, and the combination of attributes that do or don't culminate in elevated population impacts are ultimately reflected in simulated deviation around averaged model results.

The above considerations are reflected in considering model output results for hatchery programs that release yearling Chinook salmon in the Dungeness River. Modeled hatchery program profiles for Dungeness and Hurd Creek yearling releases are near identical with the exception of time and location of release where Dungeness program fish are released in mid-April at river mile 10.5 as compared to Hurd Creek which releases fish in early June at river mile 3 (see Appendix B and C). These considerations dictate different model inputs as to duration of fish co-occurrence, percentage of population overlap between hatchery and wild fish and size of wild fish at time of hatchery releases. Thus, resulting index scores reflect these differences where predation impacts scored significantly higher for the Dungeness Hatchery program due to longer periods of fish occurrence (release location), increased population overlap between hatchery and wild fish (earlier release time) and smaller relative size of wild fish due to a reduced duration for fish growth (Figures 9 – 11, Program ID SJF_2A_Y and SJF_2B_Y). This example provides some inference in terms of model sensitivity to varying parameter inputs.

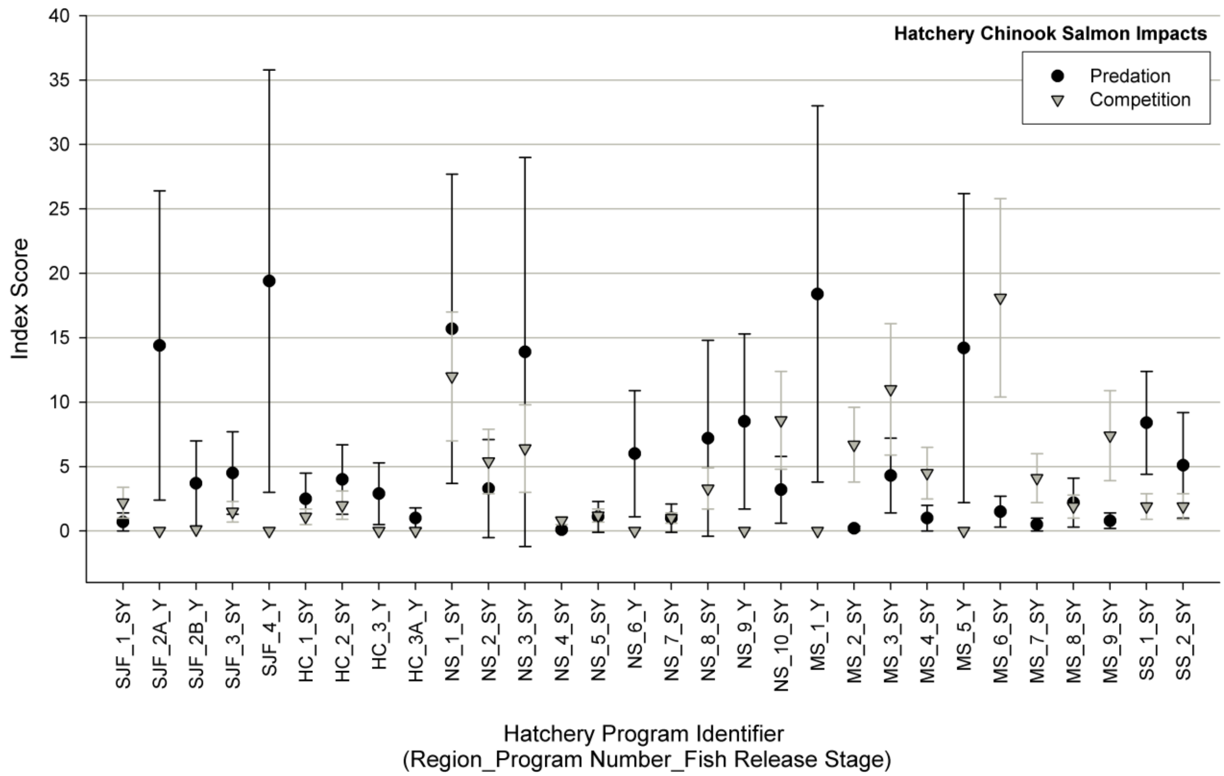

Figure 9. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation and competition impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait if Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to current hatchery management practices. See Appendix B and C for hatchery program identifiers and modeled interaction scenarios.

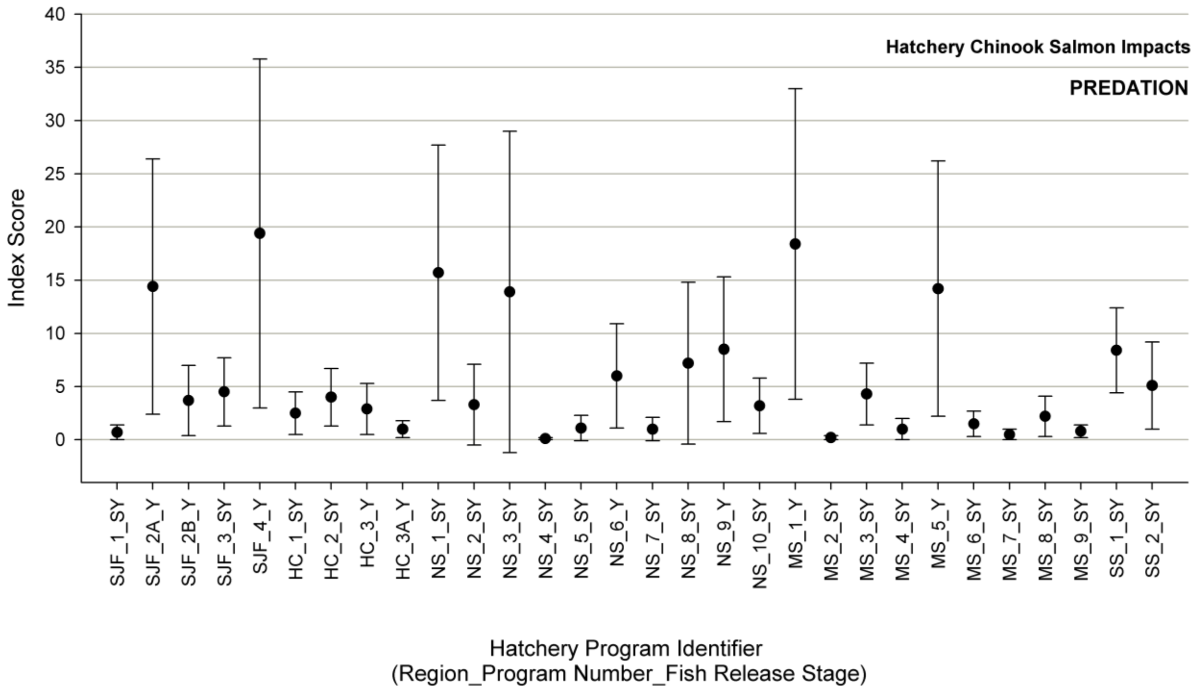

Figure 10. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait of Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to current hatchery management practices. See Appendix B and C for hatchery program identifiers and modeled interaction scenarios.

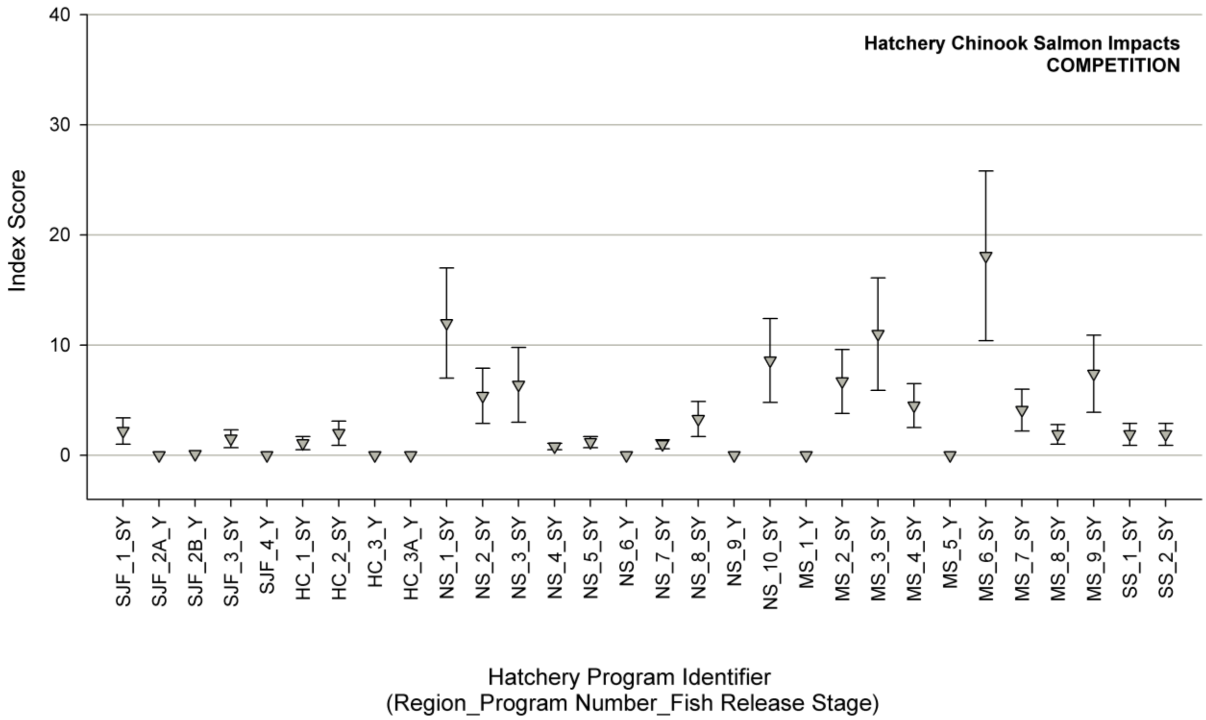

Figure 11. *PCD RISK 1* simulated index scores (and associated one standard deviation) for competition impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait of Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to current hatchery management practices. See Appendix B and C for hatchery program identifiers and modeled interaction scenarios.

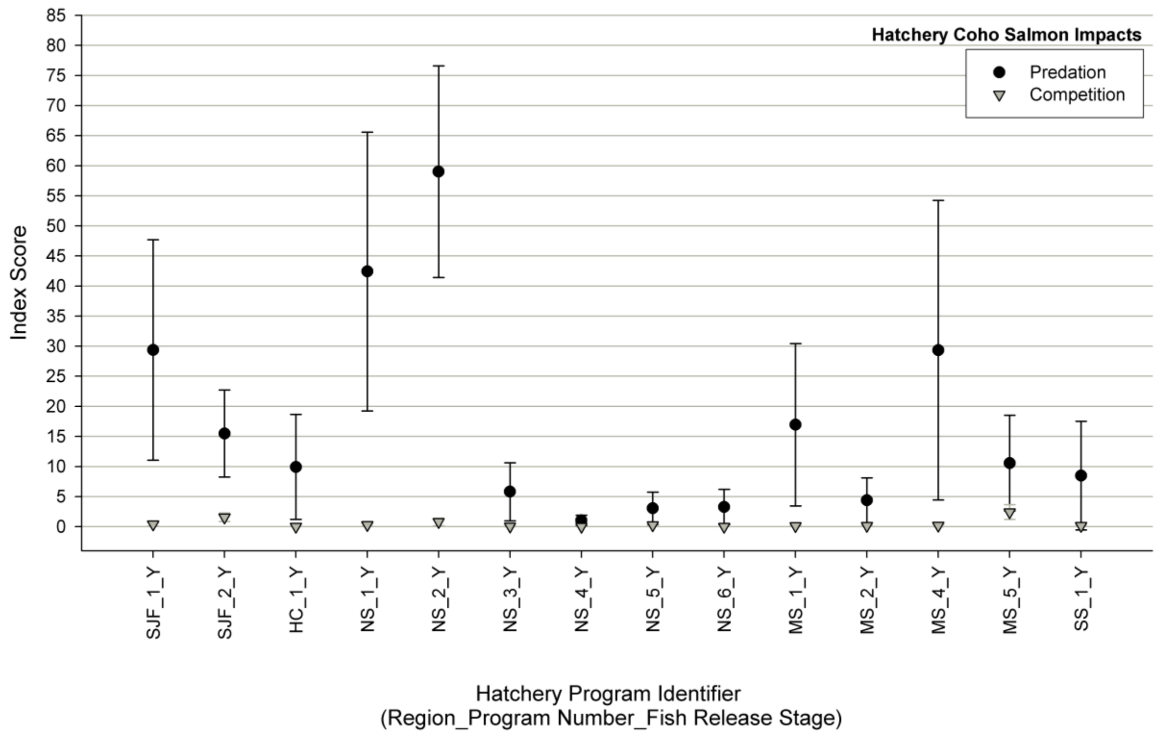

Figure 12. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation and competition impacts on natural juvenile Chinook salmon populations by hatchery releases of yearling (Y) coho salmon throughout Strait if Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to current hatchery management practices. See Appendix D and E for hatchery program identifiers and modeled interaction scenarios.

Alternative Hatchery Production Scenarios

As part of the Hatchery EIS process, a number of hatchery production programs were also assessed under proposed scenarios in which levels of fish production were increased and/or decreased. In these instances, model scenarios were identical to current production scenarios except for the number of hatchery fish released. As a general rule production alternatives entailed a two-fold increase and/or reduction by half from current fish production levels (See Appendix C and E).

Assessment results for program production alternatives suggested in general, a positive linear relationship between the magnitude of proposed programmatic releases and assessment scores under current hatchery management. For example, in instances where proposed production is doubled, model index scores for hatchery impacts also doubled, assuming assessment scores under current conditions were not at or essentially zero (e.g. impacts by yearling fish were in the form of predation and not competition and thus essentially no increased impact due to competition). It is important to again note increasing deviation with increasing averaged index scores (Figures 13 – 15). Thus, the likelihood and degree to which perceived risks could be realized is in relation to the range of uncertainty around point averages. From a risk-averse perspective this has important implications. In managing threatened Chinook salmon populations, even low likelihood for catastrophic population impacts is of serious and real concern. While exact translation from *PCD RISK 1* model results to actual population impacts is unattainable, index scores suggest degrees to which wild Chinook salmon populations are susceptible to negative impacts by releases of hatchery fish. Ideally an extension of this assessment would accompany a robust model sensitivity analysis. Such an approach could more explicitly identify individual model parameters and attribute combinations that significantly contribute to elevated hatchery impacts, i.e. elevated risks to natural populations. If it is decided that risk containment and reduction is the desired and necessary management action, then assessment tools such as *PCD RISK 1* could be used to examine scenarios that foremost involve alterations in the number of hatchery fish that are released, time at release, fish size at release and location of hatchery releases. Such an approach should be accompanied with empirical research monitoring.

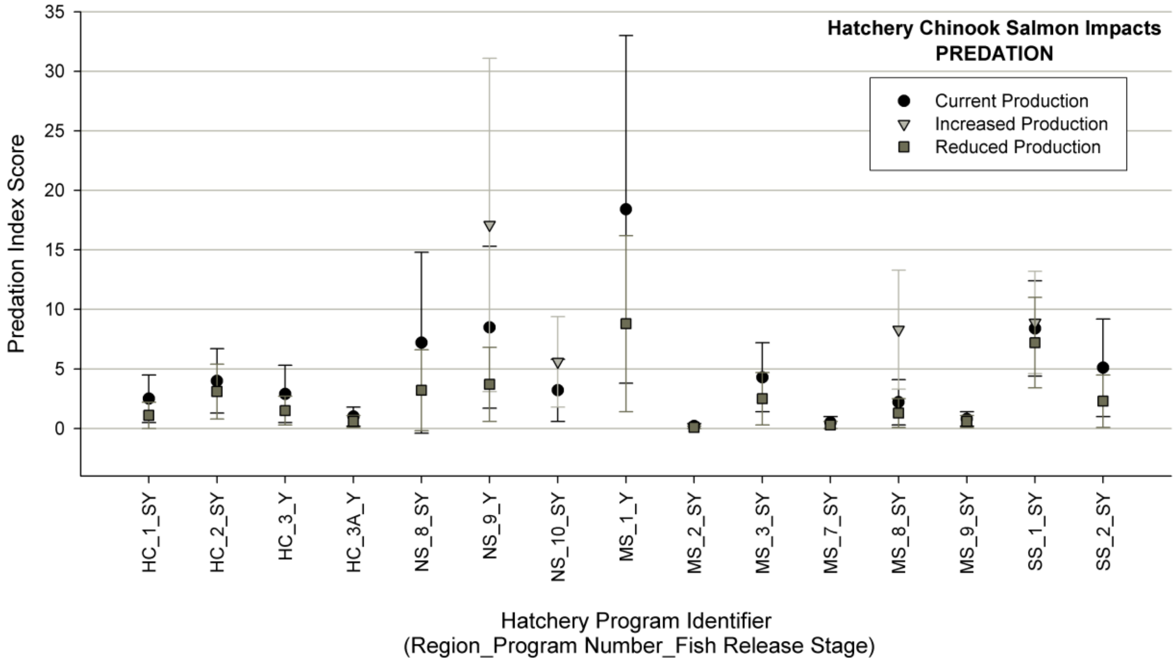

Figure 13. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait of Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to alternative hatchery production levels considered under the Hatchery Environmental Impact Statement. See Appendix B and C for hatchery program identifiers and modeled interaction scenarios.

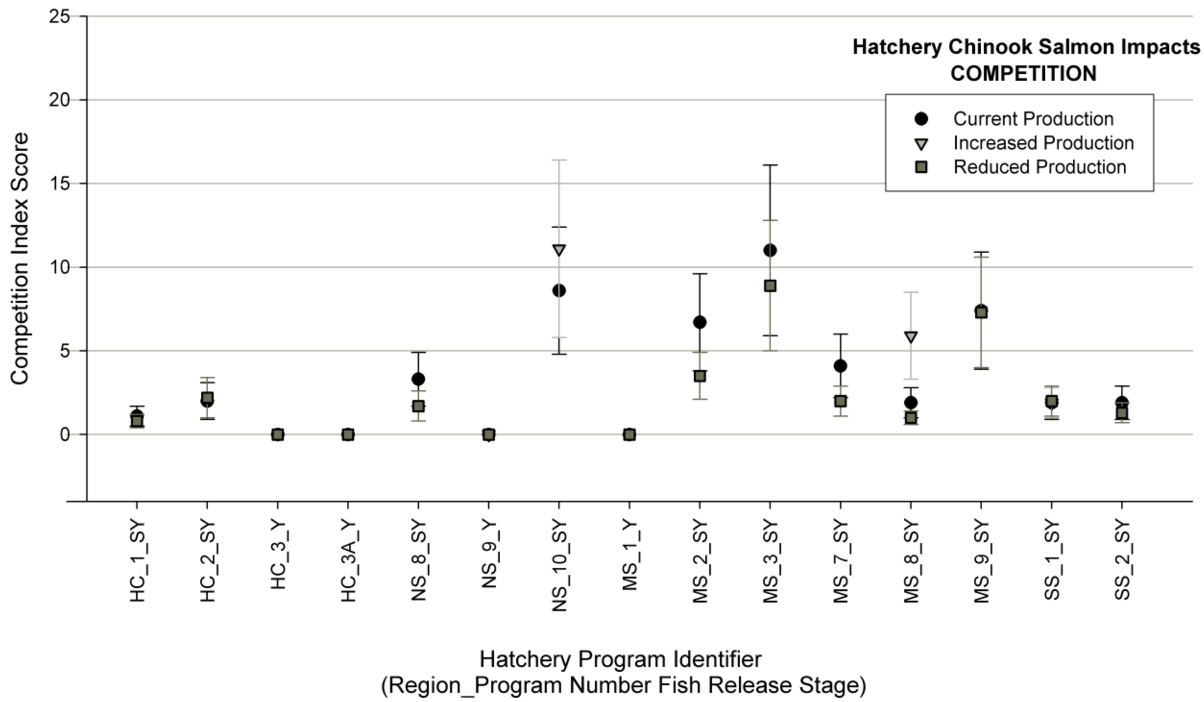

Figure 14. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait of Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to alternative hatchery production levels considered under the Hatchery Environmental Impact Statement. See Appendix B and C for hatchery program identifiers and modeled interaction scenarios.

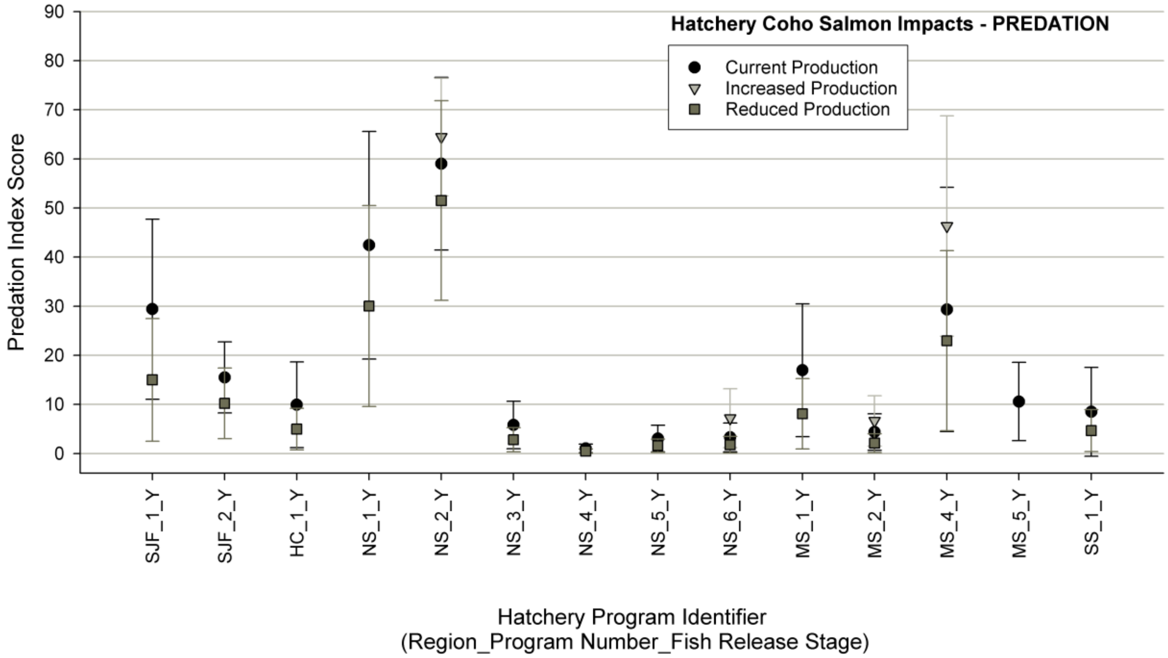

Figure 15. *PCD RISK 1* simulated index scores (and associated one standard deviation) for predation impacts on natural juvenile Chinook salmon populations by hatchery releases of sub-yearling (SY) and yearling (Y) Chinook throughout Strait of Juan de Fuca, Hood Canal and Puget Sound freshwater basins, Washington. Index scores according to alternative hatchery production levels considered under the Hatchery Environmental Impact Statement. See Appendix D and E for hatchery program identifiers and modeled interaction scenarios.

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APPENDIX A

Size Attributes at Time of Outmigration for Juvenile Chinook Salmon, of Natural Origin, Throughout the Puget Sound Region

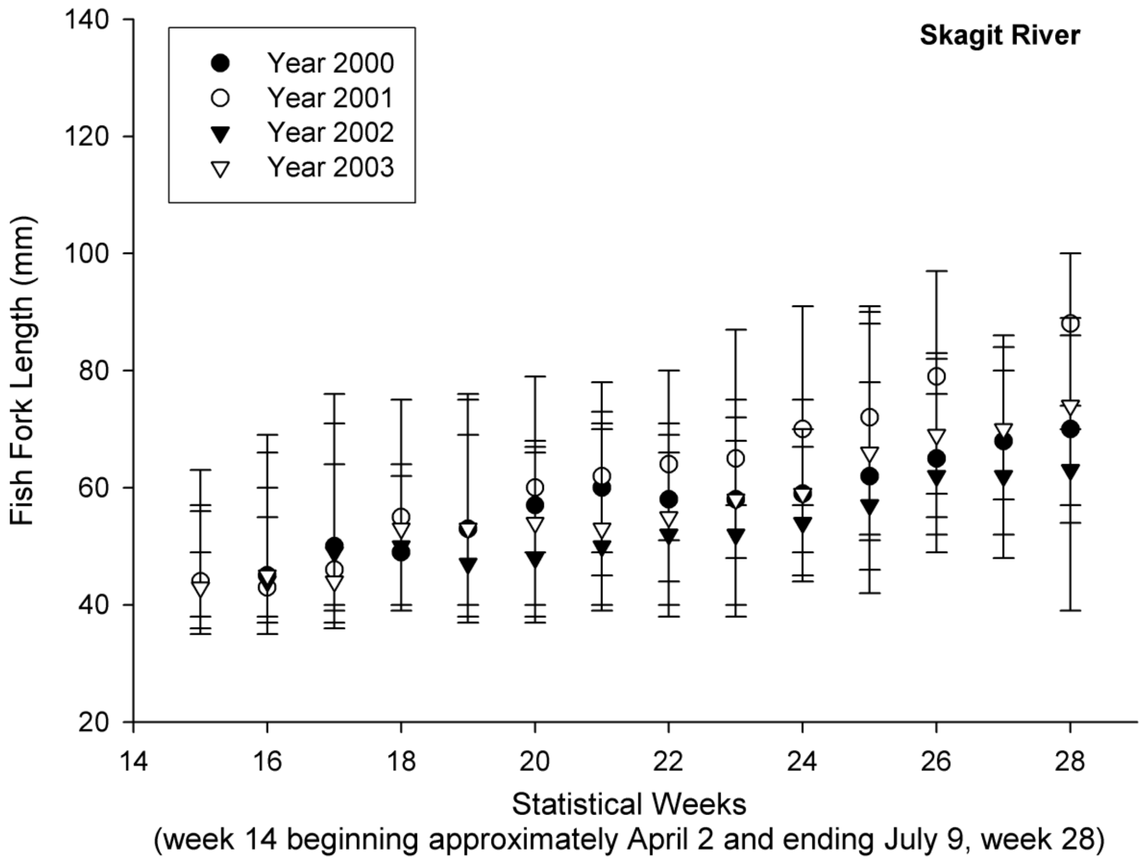

Figure A.1. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week and year for outmigrating natural juvenile Chinook salmon captured by an inclined plane trap in the Skagit River, Washington. Data from Seiler et al. 2000, 2001, 2002, 2003 and 2004.

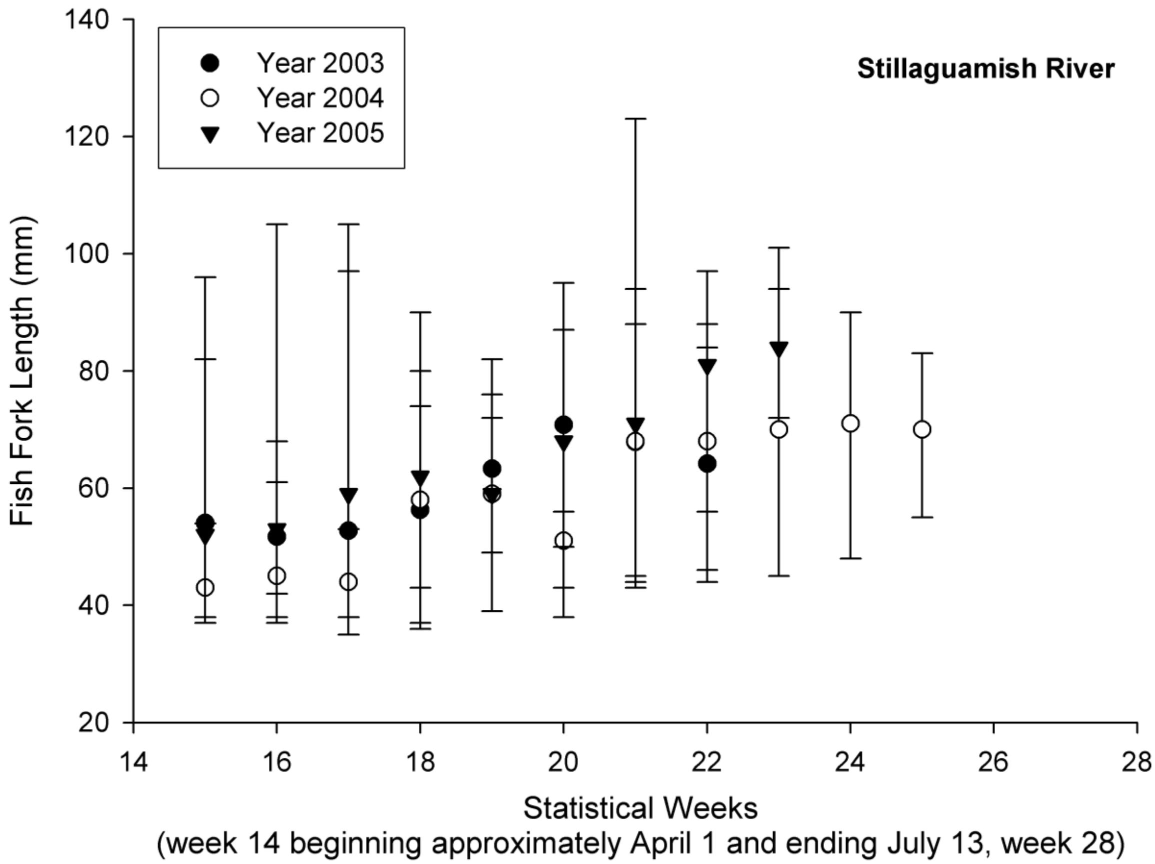

Figure A.2. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week and year for outmigrating natural juvenile Chinook salmon captured by a rotary screw trap in the Stillaguamish River, Washington. Data from Griffith et al. 2003, 2004 and 2005.

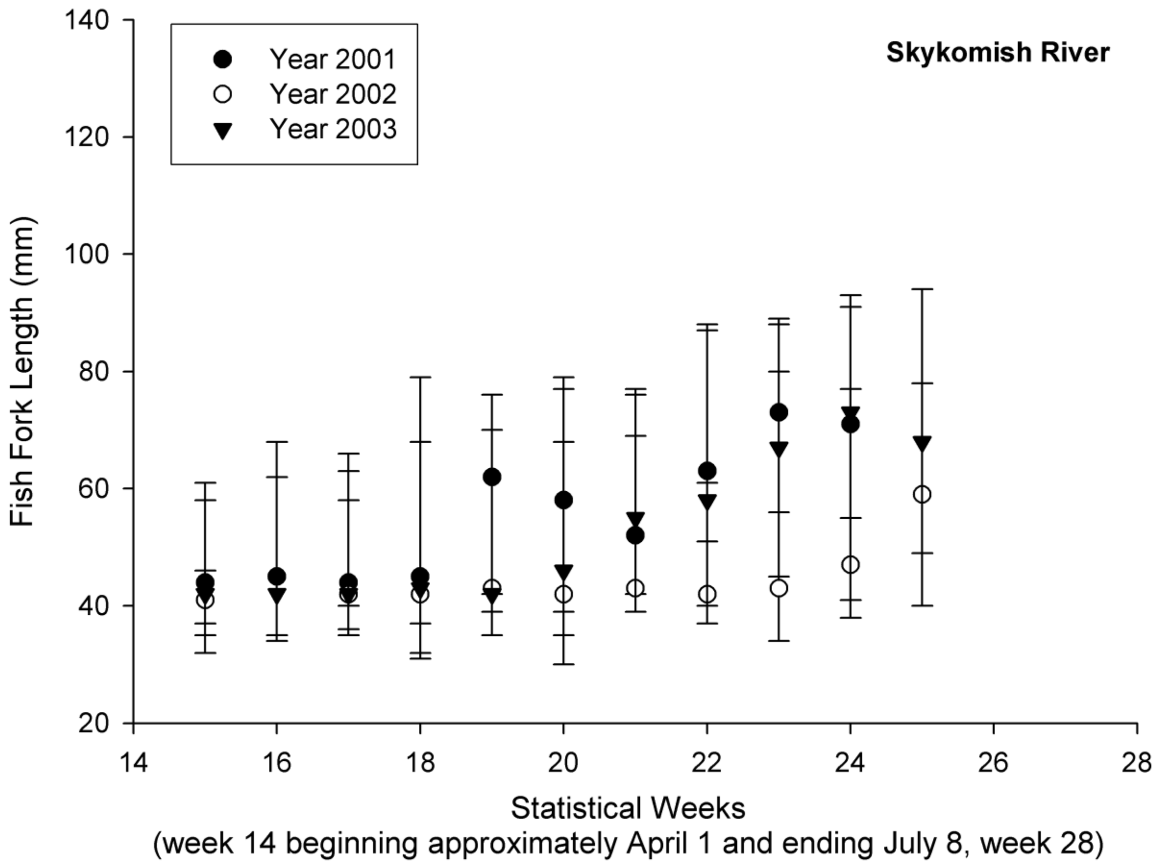

Figure A.3. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week and year for outmigrating natural juvenile Chinook salmon captured by a rotary screw trap in the Skykomish River, Washington. Note: fish size criteria were used to delineate presumed yearling Chinook salmon which are not presented on this graph. Data from Nelson et al. 2003, Nelson and Kelder 2005(a,b).

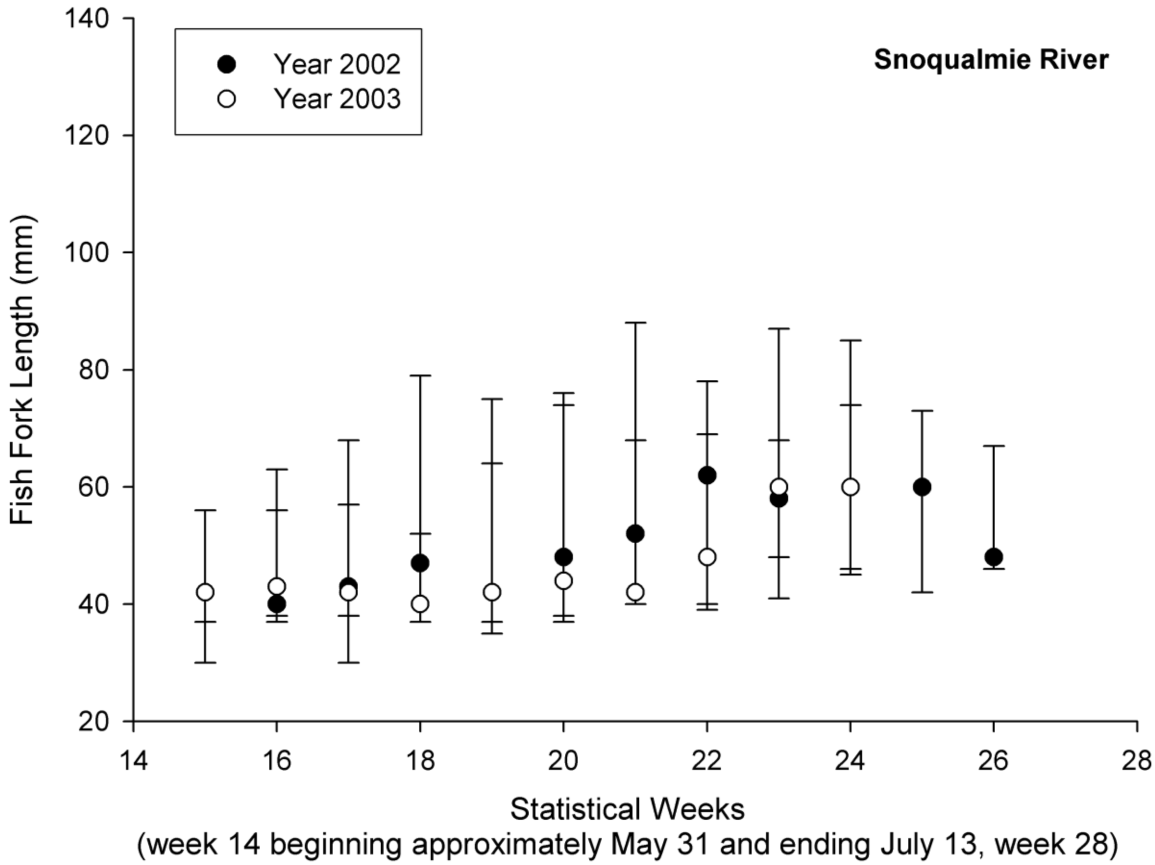

Figure A.4. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week and year for outmigrating natural juvenile Chinook salmon captured by a rotary screw trap in the Snoqualmie River, Washington. Note: fish size criteria were used to delineate presumed yearling Chinook salmon which are not presented on this graph. Data from Nelson and Kelder 2004 (a,b).

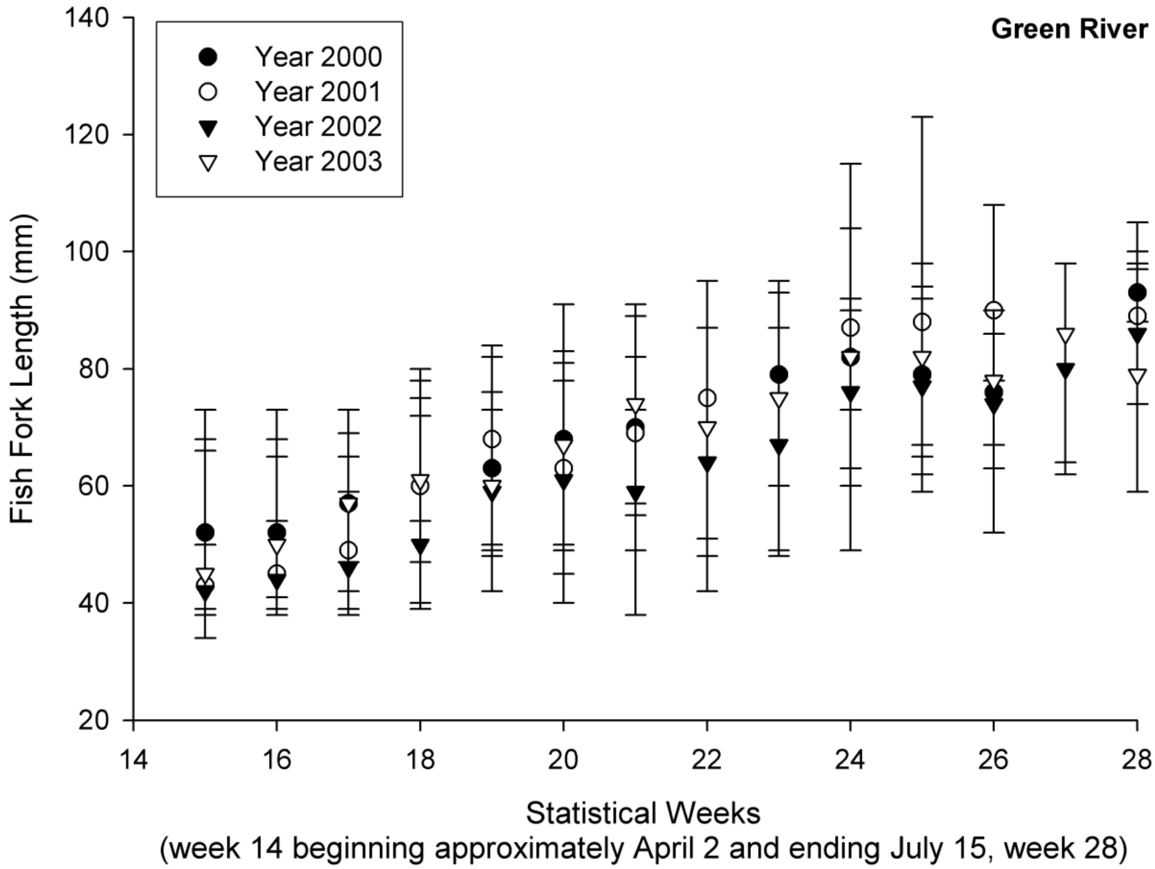

Figure A.5. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week and year for natural juvenile Chinook salmon captured by an outmigrant trap in the Green River, Washington. Data from Seiler et al. 2002a, 2004a, 2004b and Volkhardt et al. 2005.

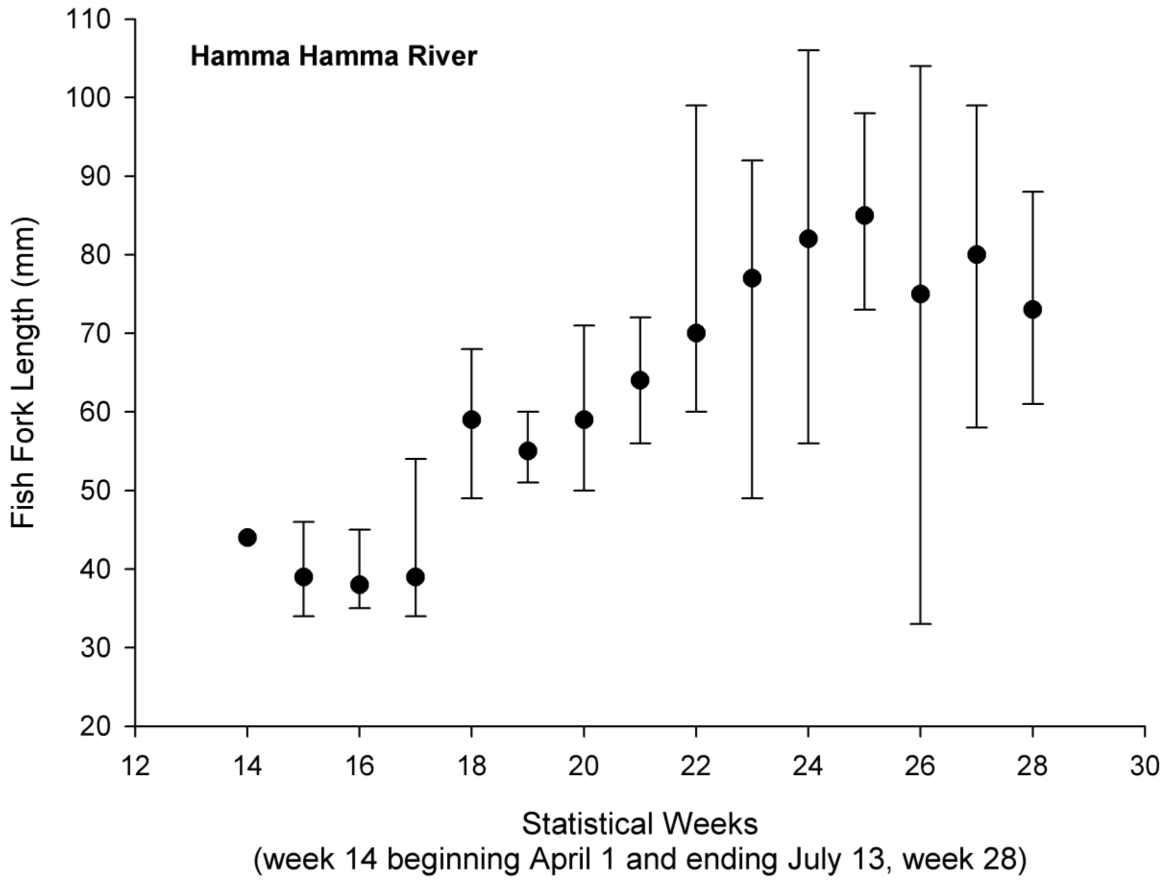

Figure A.6. Average fish fork lengths with associated observed minimum and maximum lengths by statistical week for outmigrating natural juvenile Chinook salmon captured by a rotary screw trap in the Hamma Hamma River, Washington. Unpublished data from Cynthia Gray, Port Gamble S'Klallam Tribe, research years 2002 - 2005.

APPENDIX B

***PCD RISK 1* Assessments: Identification of Hatchery Release Programs for Chinook Salmon in the Greater Puget Sound Region ('Hatchery Program Identifiers')**

Appendix B. Chinook salmon hatchery production programs in Western Washington that were assessed for freshwater ecological impacts on wild salmon populations using *PCD RISK 1*. Under 'Program ID', 'Y' denotes yearling fish release stage and 'SY' sub-yearling fish release stage.

PCD RISK 1 Program ID	Region	Program	Release Watershed	Numbers Released	Release Date
SJF_1_SY	Strait of Juan de Fuca	Dungeness Chinook	Dungeness	100 K	First group early May; second group early June
SJF_2A_Y	Strait of Juan de Fuca	Dungeness Chinook	Dungeness	50 K	April 15
SJF_2B_Y	Strait of Juan de Fuca	Dungeness Chinook	Dungeness	50 K	June 1
SJF_3_SY	Strait of Juan de Fuca	Elwha Chinook	Elwha	2.85 M	mid - June
SJF_4_Y	Strait of Juan de Fuca	Elwha Chinook	Elwha	200 K	April
HC_1_SY	Hood Canal	Hamma Hamma summer/fall Chinook	Hamma Hamma	110 K	May
HC_2_SY	Hood Canal	George Adams summer/fall Chinook	Skokomish	3.8 M	mid May - mid June
HC_3_Y	Hood Canal	Ricks Pond summer/fall Chinook	Skokomish	75K	April 15
HC_3A_Y	Hood Canal	Ricks Pond summer/fall Chinook	Skokomish	45K	June 1
NS_1_SY	North Sound	Kendall Ck spring Chinook	Nooksack	600 K	May - June 1
NS_2_SY	North Sound	Kendall Ck spring chinook, on-stat	Nooksack	150 K	May - June 1

PCD RISK 1 Program ID	Region	Program	Release Watershed	Numbers Released	Release Date
NS_3_SY	North Sound	Skookum Creek Chinook	Nooksack	200 K	May
NS_4_SY	North Sound	Marblemount fall Chinook	Skagit	222 K	June 10 - 20
NS_5_SY	North Sound	Marblemount spring Chinook	Skagit	250 K	June 1 - 15
NS_6_Y	North Sound	Marblemount spring Chinook	Skagit	150 K	April
NS_7_SY	North Sound	Marblemount summer Chinook	Skagit	200 K	June
NS_8_SY	North Sound	Snohomish summer Chinook	Snohomish	1.0 M	June 1 -7
NS_9_Y	North Sound	Snohomish summer Chinook	Snohomish	250 K	April
NS_10_SY	North Sound	Stillaguamish summer Chinook	Stillaguamish	220 K	May 1 - 30
MS_1_Y	Mid Sound	Icy Creek summer/fall Chinook	Green	300 K	April 1
MS_2_SY	Mid Sound	Keta Creek ummer/fall Chinook	Green	600 K	May 15 - 30
MS_3_SY	Mid Sound	Soos Creek summer/fall Chinook	Green	3.2 M	early June
MS_4_SY	Mid Sound	White River spring Chinook (on station releases)	White	260 K	late May - early June
MS_5_Y	Mid Sound	White River spring Chinook (on station releases)	White	90 K	April 1 - May 1
MS_6_SY	Mid Sound	White River spring Chinook	White	840 K	end May - early June

PCD RISK 1 Program ID	Region	Program	Release Watershed	Numbers Released	Release Date
		(off station acclimated releases)			
MS_7_SY	Mid Sound	Acclimation Ponds summer/fall Chinook (initially reared at Clarks Creek)	Puyallup	200 K	late May - early June
MS_8_SY	Mid Sound	Diru Creek summer/fall Chinook (reared at Clarks Creek Hatchery)	Puyallup	200 K	late April - early May
MS_9_SY	Mid Sound	Voights Creek summer/fall Chinook	Puyallup	1.6 M	mid May - early June
SS_1_SY	South Sound	Clear Creek summer/fall Chinook	Nisqually	3.4 M	May 7 - June 4
SS_2_SY	South Sound	Kalama Creek summer/fall Chinook	Nisqually	600 K	May 23 - June 6

APPENDIX C

Program Profiles for Assessed Hatchery Releases of Chinook Salmon:

***PCD RISK 1* Parameter Input Values**

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery and/or Watershed	Dungeness	
Program Description	Gray Wolf acclimation site releases of sub-yearling Chinook salmon	
Program ID Code	SJF_1_SY	
Program Details		
Release Date	early May and early June	HGMP
Point of Release (river miles from estuary)	16	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	100,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	97	HGMP
Min. Fish Fork Length (mm)	87	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_2_11	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	36,700	
Average	75,500	
Maximum	93,000	
Age-0 Ocean Type		Freymond et al. 2001
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	70_80	
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population		
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	4_9_14	MJS - EDT
Percentage Population Overlap	70_85_100	Freymond et al. 2001
River Temperature (°C)	7_10_13	WDOE online data

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery and/or Watershed	Dungeness Hatchery	
Program Description	On-station release of yearling Chinook salmon	HGMP
Program ID Code	SJF_2A_Y	
Program Details		
Release Date	April 15	HGMP
Point of Release (river miles from estuary)	10.5	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	50,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	176_188_188	HGMP
Min. Fish Fork Length (mm)	158	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	1_2_9	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	36,700	
Average	76,000	
Maximum	93,000	
Age-0 Ocean Type		Freymond et al. 2001
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	40_50	
Min. Fish Fork Length (mm)	30	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	3_8_13	MJS - EDT
Percentage Population Overlap	70_85_100	Freymond et al. 2001
River Temperature (°C)	5_7_9	WDOE online data

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery and/or Watershed	Hurd Creek Hatchery, Dungeness	
Program Description	On-station release of yearling Chinook salmon	HGMP
Program ID Code	SJF_2B_Y	
Program Details		
Release Date	June 1	HGMP
Point of Release (river miles from estuary)	RM 3	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	50,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	176_188_188	HGMP
Min. Fish Fork Length (mm)	158	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	36,700	
Average	76,000	
Maximum	93,000	
Age-0 Ocean Type		Freymond et al. 2001
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	78	
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	9_14_19	MJS - EDT
Percentage Population Overlap	70_85_100	Freymond et al. 2001
River Temperature (°C)	7_10_13	WDOE online data

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery	Elwha Hatchery	
Program Description	On-station release of sub-yearling Chinook	HGMP
Program ID Code	SJF_3_SY	
Program Details		
Release Date	mid - June	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	2,850,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	87_97_97	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_1_6	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006; Note EDT values adopted from Dungeness analysis
Minimum	112,300	
Average	117,900	
Maximum	126,400	
Age-0 Ocean Type		
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	60_70_80	Mike McHenry, unpub. data.
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	28_33_38	Score derived from Nisqually River MJS - EDT analysis/output (Kalama Creek Chinook program)
Percentage Population Overlap	50_53_100	
River Temperature (°C)	9_11_13	Mike McHenry, unpub data

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery	Elwha Hatchery	
Program Description	On-station release of yearling Chinook salmon	HGMP
Program ID Code	SJF_4_Y	
Program Details		
Release Date	April	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	188	HGMP
Min. Fish Fork Length (mm)	169	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006; Note EDT values adopted from Dungeness analysis
Minimum	112,300	
Average	117,900	
Maximum	126,400	
Age-0 Ocean Type		
Proportion of Population	1.0	CMPPSC
Mean Fish Fork Length (mm)	50_55_60	Mike McHenry, unpub. data
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	28_33_38	Score derived from Nisqually MJS - EDT analysis/output (Kalama Creek Chinook program)
Percentage Population Overlap	50_78_100	
River Temperature (°C)	8_10_12	Mike McHenry, unpub. data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Kendall Creek, Nooksack River	
Program Description	Unacclimated releases of sub-yearling spring Chinook salmon from Excelsior and Deadhorse Ponds	HGMP
Program ID Code	NS_1_SY	
Program Details		
Release Date	May - June	HGMP
Point of Release (river miles from estuary)	63.5 and 65	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	600,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	82_97_97	HGMP
Min. Fish Fork Length (mm)	74	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	6_15_40	
Natural Fish Details		
Number of Natural Fish		
Triangular Distribution		MJS-EDT; PSC 2005
Minimum	103,000	
Average	169,000	
Maximum	227,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_70	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70_90	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	18_23_28	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	7_11_15	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Kendall Creek Hatchery, Nooksack	
Program Description	On-station release of sub-yearling Chinook salmon	HGMP
Program ID Code	NS_2_SY	
Program Details		
Release Date	May - June	HGMP
Point of Release (river miles from estuary)	46	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	150,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	82	HGMP
Min. Fish Fork Length (mm)	74	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	4_11_33	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	103,000	
Average	169,000	
Maximum	227,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_70	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70_90	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	19_24_29	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	7_11_15	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Skookum Creek Hatchery, Nooksack	
Program Description	On-station release of sub-yearling Chinook salmon	HGMP
Program ID Code	NS_3_SY	
Program Details		
Release Date	May	HGMP
Point of Release (river miles from estuary)	50.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	85_92_92	HGMP
Min. Fish Fork Length (mm)	77	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	5_12__35	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	103,000	
Average	169,000	
Maximum	227,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	40_70	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70_90	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	20_25_30	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	7_11_15	WDOE online data

		Information Reference
Region	North Puget sound	
Hatchery and/or Watershed	Marblemount Hatchery, Skagit River	
Program Description	Off-station release of sub-yearling fall Chinook salmon	HGMP
Program ID Code	NS_4_SY	
Program Details		
Release Date	June 10 - 20	HGMP
Point of Release (river miles from estuary)	56.5	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	222,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	71	HGMP
Min. Fish Fork Length (mm)	64	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	5_13_39	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_68	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	38	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_50_100	
River Temperature (°C)	8_12_15	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Marblemount Hatchery, Skagit River	
Program Description	On-station release of sub-yearling spring Chinook salmon	HGMP
Program ID Code	NS_5_SY	
Program Details		
Release Date	June 1 - 15	HGMP
Point of Release (river miles from estuary)	78	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	250,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	86	HGMP
Min. Fish Fork Length (mm)	77	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	8_18_51	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_68	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Min. Fish Fork Length (mm)	38	Skagit River: Seiler et al. 2000, 2001 ,2002, 2003, 2004
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	8_12_15	WDOE online data

		Information Reference
Region	North Puget sound	
Hatchery and/or Watershed	Marblemount Hatchery, Skagit River	
Program Description	On-station release of yearling spring Chinook salmon	HGMP
Program ID Code	NS_6_Y	
Program Details		
Release Date	April	HGMP
Point of Release (river miles from estuary)	78	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	150,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	176	HGMP
Min. Fish Fork Length (mm)	158	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	5_12_37	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	44_55	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	34	Seiler et al. 2000,2001,2002,2003
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	17_22_27	MJS - EDT
Percentage Population Overlap	50_78_100	
River Temperature (°C)	7_9_12	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Marblemount Hatchery, Skagit River	
Program Description	County Line Ponds off-station release of sub-yearling summer Chinook salmon	HGMP
Program ID Code	NS_7_SY	
Program Details		
Release Date	June	HGMP
Point of Release (river miles from estuary)	91	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	90	HGMP
Min. Fish Fork Length (mm)	81	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	9_21_61	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_60_74	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	85	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	19_24_29	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	8_11_14	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Wallace Hatchery, Skykomish - Snohomish	
Program Description	On-station release of sub-yearling summer Chinook salmon	HGMP
Program ID Code	NS_8_SY_CP ; NS_8_SY_RP	
Program Details		
Release Date	June 1 - 7	HGMP
Point of Release (river miles from estuary)	60.2	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	1,000,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	500,000	
Mean Fish Fork Length (mm)	92	HGMP
Min. Fish Fork Length (mm)	83	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	6_14_41	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,150,000	
Average	1,668,000	
Maximum	2,317,000	
Age-0 Ocean Type		Nelson and Kelder 2002, 2004(a,b), 2005(a, b); Nelson et al. 2003
Proportion of Population	0.93_0.95_0.97	
Mean Fish Fork Length (mm)	40_60_70	
Min. Fish Fork Length (mm)	36	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		Nelson and Kelder 2002, 2004(a,b), 2005(a, b); Nelson et al. 2003
Proportion of Population	0.03_0.05_0.07	
Mean Fish Fork Length (mm)	90_100	
Fish Length CV (%)	10	
Percentage Habitat Complexity	23_28_33	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	10_14_18	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Wallace Hatchery, Skykomish - Snohomish	
Program Description	On-station release of yearling summer Chinook	HGMP
Program ID Code	NS_9_Y_CP ; NS_9_Y InP ; NS_9_Y_RP	
Program Details		
Release Date	April 1 - 7	HGMP
Point of Release (river miles from estuary)	60.2	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	250,000	HGMP
Increased Production Alternative	500,000	
Reduced Production Alternative	125,000	
Mean Fish Fork Length (mm)	188	HGMP
Min. Fish Fork Length (mm)	169	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	4_9_29	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,150,000	
Average	1,668,000	
Maximum	2,317,000	
Age-0 Ocean Type		Nelson and Kelder 2002, 2004(a,b), 2005(a,b); Nelson et al. 2003
Proportion of Population	0.93_0.95_0.97	
Mean Fish Fork Length (mm)	43	
Min. Fish Fork Length (mm)	30	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		Nelson and Kelder 2002, 2004(a,b), 2005(a,b); Nelson et al. 2003
Proportion of Population	0.03_0.05_0.07	
Mean Fish Fork Length (mm)	60_70	
Fish Length CV (%)	10	
Percentage Habitat Complexity	24_29_34	MJS - EDT
Percentage Population Overlap	50_78_100	
River Temperature (°C)	6_8_9	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Stillaguamish River	
Program Description	Release of sub-yearling summer Chinook salmon from Whitehorse Ponds	HGMP
Program ID Code	NS_10_SY_CP ; NS_10_SY_InP	
Program Details		
Release Date	May 1 - 30	HGMP
Point of Release (river miles from estuary)	45.8	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	220,000	HGMP
Increased Production Alternative	420,000	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	85_92_92	HGMP
Min. Fish Fork Length (mm)	79	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	4_10_32	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	128,000	
Average	170,000	
Maximum	217,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	58_64_75	Griffith et al. 2003, 2004, 2005
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	85	Griffith et al. 2003, 2004, 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	26_31_36	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	9_13_18	Griffith et al. 2003, 2004, 2005

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	Icy Creek Hatchery, Green - Duwamish River	
Program Description	On-station release of yearling summer/fall Chinook salmon	HGMP
Program ID Code	MS_1_Y_CP ; MS_1_Y_RP	
Program Details		
Release Date	April 1	HGMP
Point of Release (river miles from estuary)	48.3	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	300,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	150,000	
Mean Fish Fork Length (mm)	176	HGMP
Min. Fish Fork Length (mm)	158	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	3_7_25	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Minimum	760,500	
Average	1,108,000	
Maximum	1,225,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	42_52	Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Min. Fish Fork Length (mm)	34	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70	
Fish Length CV (%)	10	
Percentage Habitat Complexity	10_15_20	Adopted from MJS - EDT analysis/output for the White River
Percentage Population Overlap	50_78_100	
River Temperature (°C)	8_9_11	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	Keta Creek Hatchery, Green-Duwamish	
Program Description	Off-station plantings of summer/fall sub-yearling Chinook salmon	HGMP
Program ID Code	MS_2_SY_CP ; MS_2_SY_RP	
Program Details		
Release Date	May 15 - 30	HGMP
Point of Release (river miles from estuary)	89	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	600,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	300,000	
Mean Fish Fork Length (mm)	71	HGMP
Min. Fish Fork Length (mm)	64	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	8_21_60	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Minimum	760,500	
Average	1,108,000	
Maximum	1,225,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	58_70	Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	80	
Fish Length CV (%)	10	
Percentage Habitat Complexity	13_18_23	Adopted from MJS - EDT analysis for the White River
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	Soos Creek Hatchery, Green - Duwamish	
Program Description	On-station release of sub-yearling summer/fall Chinook salmon	HGMP
Program ID Code	MS_3_SY_CP ; MS_3_SY_RP	
Program Details		
Release Date	early June	HGMP
Point of Release (river miles from estuary)	33.7	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	3,200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	1,600,000	
Mean Fish Fork Length (mm)	87	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	3_8_25	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Minimum	760,500	
Average	1,108,000	
Maximum	1,225,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	58_70	Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	80	
Fish Length CV (%)	10	
Percentage Habitat Complexity	12_17_22	Adopted from MJS - EDT analysis for the White River
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	White River Hatchery, White-Puyallup	
Program Description	On-station release of sub-yearling spring Chinook salmon	HGMP
Program ID Code	MS_4_SY	
Program Details		
Release Date	late May - early June	HGMP
Point of Release (river miles from estuary)	33.7	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	260,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	87_104_104	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	3_8_25	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70_80	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	95	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	White River Hatchery, White - Puyallup	
Program Description	On-station release of yearling spring Chinook salmon	HGMP
Program ID Code	MS_5_Y	
Program Details		
Release Date	April 1 - May 1	HGMP
Point of Release (river miles from estuary)	33.7	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	90,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	188	HGMP
Min. Fish Fork Length (mm)	179	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	2_5_18	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	45_55	Berger and Williamson 2005
Min. Fish Fork Length (mm)	36	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	17_22_27	MJS - EDT
Percentage Population Overlap	50_78_100	
River Temperature (°C)	7_9_11	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	White River	
Program Description	Off-station acclimation releases of sub-yearling Chinook salmon	HGMP
Program ID Code	MS_6_SY	
Program Details		
Release Date	late May - early June	HGMP
Point of Release (river miles from estuary)	63.5 (uppermost accl. site)	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	840,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	86_92_92	HGMP
Min. Fish Fork Length (mm)	77	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	6_15_44	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70_80	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	95	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	13_18_23	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	Puyallup	
Program Description	Acclimation releases of sub-yearling summer/fall Chinook salmon (Rushingwater, Mowich, Cowskull ponds)	HGMP
Program ID Code	MS_7_SY_CP ; MS_7_SY_RP	
Program Details		
Release Date	late May - early June	HGMP
Point of Release (river miles from estuary)	44.8 (uppermost accl. site)	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	100,000	
Mean Fish Fork Length (mm)	87_97_97	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	4_10_30	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70_80	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	95	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	9_14_19	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget sound	
Hatchery and/or Watershed	Diru / Clarks Creek Hatchery, Puyallup	
Program Description	On-station (Diru Creek) release of sub-yearling summer/fall Chinook salmon	HGMP
Program ID Code	MS_8_SY_CP ; MS_8_SY_InP ; MS_8_SY_RP	
Program Details		
Release Date	late April - early May	HGMP
Point of Release (river miles from estuary)	5.8	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	800,000	
Reduced Production Alternative	100,000	
Mean Fish Fork Length (mm)	97_111_111	HGMP
Min. Fish Fork Length (mm)	87	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	2_5_17	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	65_72	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	90	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	8_13_18	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	9_11_15	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery and/or Watershed	Voights Creek Hatchery, Puyallup	
Program Description	Off-station release of sub-yearling summer/fall Chinook salmon	HGMP
Program ID Code	MS_9_SY_CP ; MS_9_SY_RP	
Program Details		
Release Date	mid May - early June	HGMP
Point of Release (river miles from estuary)	21.8	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	1,600,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	805,000	
Mean Fish Fork Length (mm)	87	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	2_5_17	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70_80	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	95	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	7_12_17	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Hood Canal	
Hatchery and/or Watershed	Hamma Hamma	
Program Description	Release of sub-yearling summer/fall Chinook salmon from John Creek conservancy site	HGMP
Program ID Code	HC_1_SY_CP ; HC_1_SY_RP	
Program Details		
Release Date	May	HGMP
Point of Release (river miles from estuary)	1.4	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	110,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	55,000	
Mean Fish Fork Length (mm)	85_92_92	HGMP
Min. Fish Fork Length (mm)	77	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	10,500	
Average	41,000	
Maximum	98,600	
Age-0 Ocean Type		
Proportion of Population	0.98	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	58_62_68	Cynthia Gray, unpubl. data
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	80_90	
Fish Length CV (%)	10	
Percentage Habitat Complexity	27_32_37	MJS - EDT
Percentage Population Overlap	50_64_100	Cynthia Gray, unpubl. data
River Temperature (°C)	7_8_11	Cynthia Gray, unpubl. data

		Information Reference
Region	Hood Canal	
Hatchery and/or Watershed	George Adams Hatchery, Skokomish River	
Program Description	On-station release of sub-yearling summer/fall Chinook salmon	HGMP
Program ID Code	HC_2_SY_CP ; HC_2_SY_RP	
Program Details		
Release Date	mid May - mid June	HGMP
Point of Release (river miles from estuary)	4.1	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	3,800,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	1,900,000	
Mean Fish Fork Length (mm)	87_97_97	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_1_7	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	215,500	
Average	342,200	
Maximum	433,800	
Age-0 Ocean Type		
Proportion of Population	0.98	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	60_65_80	Cynthia Gray, unpubl. data
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	90_100	
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_86_100	
River Temperature (°C)	9_10_15	WDOE online data

		Information Reference
Region	Hood Canal	
Hatchery and/or Watershed	Skokomish River	
Program Description	Release of yearling summer/fall Chinook salmon from Rick's Pond	HGMP
Program ID Code	HC_3_Y_CP ; HC_3_Y_RP	
Program Details		
Release Date	April 15	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	75,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	37,500	
Mean Fish Fork Length (mm)	188	HGMP
Min. Fish Fork Length (mm)	169	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	215,500	
Average	342,200	
Maximum	433,800	
Age-0 Ocean Type		
Proportion of Population	0.98	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	38_42	Cynthia Gray, unpubl. data
Min. Fish Fork Length (mm)	30	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	60	
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_67_100	
River Temperature (°C)	6_7_11	WDOE online data

		Information Reference
Region	Hood Canal	
Hatchery and/or Watershed	Skokomish River	
Program Description	Release of yearling summer/fall Chinook salmon from Rick's Pond	HGMP
Program ID Code	HC_3A_Y_CP ; HC_3A_Y_RP	
Program Details		
Release Date	June 1	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	45,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	22,500	
Mean Fish Fork Length (mm)	188	HGMP
Min. Fish Fork Length (mm)	169	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990 (yearling fish rate)	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	215,500	
Average	342,200	
Maximum	433,800	
Age-0 Ocean Type		
Proportion of Population	0.98	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	60_65_80	
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	90_100	
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	11_13_15	WDOE online data

		Information Reference
Region	South Puget Sound	
Hatchery and/or Watershed	Clear Creek Hatchery, Nisqually River	
Program Description	On-station release of summer/fall sub-yearling Chinook salmon	
Program ID Code	SS_1_SY_CP ; SS_1_SY_InP ; SS_1_SY_RP	
Program Details		
Release Date	May 7 - June 4	HGMP
Point of Release (river miles from estuary)	6.3	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	3,400,000	HGMP
Increased Production Alternative	3,800,000	
Reduced Production Alternative	1,700,000	
Mean Fish Fork Length (mm)	87_97_97	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_2_8	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	158,500	
Average	317,400	
Maximum	446,000	
Age-0 Ocean Type		
Proportion of Population	1.0	CMPPSC Nisqually River
Mean Fish Fork Length (mm)	60_60_70	Ellings 2006
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	28_33_38	MJS - EDT
Percentage Population Overlap	50_59_100	
River Temperature (°C)	8_9_12	Ellings 2006

		Information Reference
Region	South Puget Sound	
Hatchery and/or Watershed	Kalama Creek Hatchery, Nisqually River	
Program Description	On-station release of summer/fall Chinook sub-yearling salmon	
Program ID Code	SS_2_SY_CP ; SS_2_SY_RP	
Program Details		
Release Date	May 23 - June 6	HGMP
Point of Release (river miles from estuary)	9.2	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	600,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	300,000	
Mean Fish Fork Length (mm)	87_111_111	HGMP
Min. Fish Fork Length (mm)	78	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.984_0.990	
Residence Time (days)	1_2_10	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	158,500	
Average	317,400	
Maximum	446,000	
Age-0 Ocean Type		
Proportion of Population	1.0	CMPPSC Nisqually River
Mean Fish Fork Length (mm)	60_70_70	Ellings 2006
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	29_34_39	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	8_9_12	Ellings 2006

APPENDIX D

***PCD RISK 1* Assessments: Identification of Hatchery Release Programs for Coho Salmon in the Greater Puget Sound Region ('Hatchery Program Identifiers')**

Appendix D. Coho salmon hatchery production programs in Western Washington that were assessed for freshwater ecological impacts on wild salmon populations using *PCD RISK 1*. Under 'Program ID', 'Y' denotes yearling fish release stage.

PCD RISK 1 Program ID	Region	Program	Release Watershed	Numbers Released	Release Date
SJF_1_Y	Strait of Juan de Fuca	Lower Elwha Coho	Lower Elwha River	750 K	May 1 - 30
SJF_2_Y	Strait of Juan de Fuca	Dungeness Coho	Dungeness River	500 K	After June 1
HC_1_Y	Hood Canal	George Adams Coho	Skokomish River	300 K	After April 15
NS_1_Y	North Sound	Kendall Creek Coho	Nooksack River	300 K	May 15 - 30
NS_2_Y	North Sound	Skookum Creek Coho	South Fork Nooksack River	1 M	May 15 - June 15
NS_3_Y	North Sound	Marblemount Coho	Skagit River	250 K	June
NS_4_Y	North Sound	Baker Lake Coho	Skagit River / Baker Lake	120 K	June
NS_5_Y	North Sound	Harvey Creek Coho	Stillaguamish River	53.5 K	May 1 - 15
NS_6_Y	North Sound	Wallace River Coho	Skykomish River	150 K	May
MS_1_Y	Mid Sound	Soos Creek Coho	Green River	600 K	Late April
MS_2_Y	Mid Sound	Crisp Creek Yearling Coho	Green River	600 K	May 15
MS_3_SY**	Mid Sound	Crisp Creek Coho Fry	Green River	550 K	April - May

PCD RISK 1 Program ID	Region	Program	Release Watershed	Numbers Released	Release Date
MS_4_Y	Mid Sound	Voights Creek Coho	Puyallup River	780 K	April 10
MS_5_Y	Mid Sound	Puyallup Tribe Coho Acclimation Site Releases	Puyallup River	200 K	Late April - Mid May
SS_1_Y	South Sound	Kalama Creek Coho	Lower Nisqually River	350 K	April 1 - May 1

APPENDIX E

Program Profiles for Assessed Hatchery Releases of Coho Salmon:

***PCD RISK 1* Parameter Input Values**

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery / Watershed	Lower Elwha Hatchery / Lower Elwha River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	SJF_1_Y_CP SJF_1_Y_RP	
Program Details		
Release Date	May 1 - 30	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	750,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	375,000	
Mean Fish Fork Length (mm)	143	HGMP
Min. Fish Fork Length (mm)	129	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006; Note EDT values adopted from Dungeness analysis
Minimum	112,300	
Average	117,900	
Maximum	126,400	
Age-0 Ocean Type		
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	55_60_75	Mike McHenry, unpub. data.
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	28_33_38	Score derived from Nisqually River MJS - EDT analysis/output (Kalama Creek Chinook program)
Percentage Population Overlap	50_64_100	
River Temperature (°C)	9_10_12	Mike McHenry, unpub data

		Information Reference
Region	Strait of Juan de Fuca	
Hatchery / Watershed	Dungeness Hatchery / Dungeness River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	SJF_2_Y_CP SJF_2_Y_RP	
Program Details		
Release Date	After June 1	HGMP
Point of Release (river miles from estuary)	RM 3	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	500,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	250,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	36,700	
Average	76,000	
Maximum	93,000	
Age-0 Ocean Type		Freymond et al. 2001
Proportion of Population	1.0	
Mean Fish Fork Length (mm)	78	
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	9_14_19	MJS - EDT
Percentage Population Overlap	70_85_100	Freymond et al. 2001
River Temperature (°C)	7_10_13	WDOE online data

		Information Reference
Region	Hood Canal	
Hatchery / Watershed	George Adams / Skokomish River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	HC_1_Y_CP HC_1_Y_RP	
Program Details		
Release Date	After April 15	HGMP
Point of Release (river miles from estuary)	2.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	300,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	150,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_1_5	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	215,500	
Average	342,200	
Maximum	433,800	
Age-0 Ocean Type		
Proportion of Population	0.98	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	38_42_55	Cynthia Gray, unpubl. data
Min. Fish Fork Length (mm)	30	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02	CMPPSC Skokomish River
Mean Fish Fork Length (mm)	60	
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_67_100	
River Temperature (°C)	6_7_11	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery / Watershed	Kendall Creek Hatchery / Nooksack River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	NS_1_Y_CP NS_1_Y_RP	
Program Details		
Release Date	May 15 - 30	HGMP
Point of Release (river miles from estuary)	46	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	300,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	150,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	3_7_24	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	103,000	
Average	169,000	
Maximum	227,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	48_58	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70_80	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	19_24_29	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	8_10_14	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery / Watershed	Skookum Creek Hatchery / South Fork Nooksack River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	NS_2_CP NS_2_InP NS_2_RP	
Program Details		
Release Date	May 15 - June 15	HGMP
Point of Release (river miles from estuary)	50.9	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	1,000,000	HGMP
Increased Production Alternative	2,000,000	
Reduced Production Alternative	500,000	
Mean Fish Fork Length (mm)	133_143	HGMP
Min. Fish Fork Length (mm)	120	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	3_8_26	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	103,000	
Average	169,000	
Maximum	227,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_58_60	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70_80	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	20_25_30	MJS - EDT
Percentage Population Overlap	50_58_100	
River Temperature (°C)	8_11_15	WDOE online data

		Information Reference
Region	North Puget sound	
Hatchery / Watershed	Marblemount Hatchery / Skagit River	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	NS_3_Y_CP NS_3_Y_RP	
Program Details		
Release Date	June	HGMP
Point of Release (river miles from estuary)	78	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	250,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	125,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	5_12_39	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_58_62	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Min. Fish Fork Length (mm)	38	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70	Skagit River: Seiler et al. 2000, 2001,2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	8_12_15	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery and/or Watershed	Baker Lake Coho / Skagit River	
Program Description	Off-station release of yearling coho salmon	HGMP
Program ID Code	NS_4_Y_CP NS_4_Y_RP	
Program Details		
Release Date	June	HGMP
Point of Release (river miles from estuary)	56.5	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	60,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	30,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	4_9_29	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,609,400	
Average	2,235,400	
Maximum	2,415,000	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC ; PSSRP 2005
Mean Fish Fork Length (mm)	50_58_64	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Min. Fish Fork Length (mm)	38	Skagit River: Seiler et al. 2000, 2001 ,2002, 2003, 2004
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	70	Skagit River: Seiler et al. 2000, 2001, 2002, 2003, 2004
Fish Length CV (%)	10	
Percentage Habitat Complexity	16_21_26	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	8_12_15	WDOE online data

		Information Reference
Region	North Puget Sound	
Hatchery / Watershed	Harvey and Johnson creek Hatchery / Stillaguamish River	
Program Description	On station release of yearling coho salmon	HGMP
Program ID Code	NS_5_Y_CP NS_5_Y_RP	
Program Details		
Release Date	May 1 - 15	HGMP
Point of Release (river miles from estuary)	Approx. 19	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	55,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	27,000	
Mean Fish Fork Length (mm)	133_137	HGMP
Min. Fish Fork Length (mm)	120	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_3_12	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	128,000	
Average	170,000	
Maximum	217,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	58_64_75	Griffith et al. 2003, 2004, 2005
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	
Mean Fish Fork Length (mm)	85	Griffith et al. 2003, 2004, 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	26_31_36	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	9_13_18	Griffith et al. 2003, 2004, 2005

		Information Reference
Region	North Puget Sound	
Hatchery / Watershed	Wallace Hatchery / Skykomish - Snohomish	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	NS_6_Y_CP NS_6_Y_InP NS_6_Y_RP	
Program Details		
Release Date	May	HGMP
Point of Release (river miles from estuary)	40	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	150,000	HGMP
Increased Production Alternative	300,000	
Reduced Production Alternative	75,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	3_6_21	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	1,150,000	
Average	1,668,000	
Maximum	2,317,000	
Age-0 Ocean Type		Nelson and Kelder 2002, 2004(a,b), 2005(a, b); Nelson et al. 2003
Proportion of Population	0.93_0.95_0.97	
Mean Fish Fork Length (mm)	40_50_60	
Min. Fish Fork Length (mm)	35	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		Nelson and Kelder 2002, 2004(a,b), 2005(a, b); Nelson et al. 2003
Proportion of Population	0.03_0.05_0.07	
Mean Fish Fork Length (mm)	80_90	
Fish Length CV (%)	10	
Percentage Habitat Complexity	23_28_33	MJS - EDT
Percentage Population Overlap	50_53_100	
River Temperature (°C)	8_10_15	WDOE online data

		Information Reference
Region	Mid Puget Sound	
Hatchery / Watershed	Soos Creek Hatchery, Green - Duwamish	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	MS_1_Y_CP MS_1_Y_RP	
Program Details		
Release Date	April 20	HGMP
Point of Release (river miles from estuary)	33.7	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	600,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	300,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	2_5_18	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Minimum	760,500	
Average	1,108,000	
Maximum	1,225,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	45_55_60	Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	75	
Fish Length CV (%)	10	
Percentage Habitat Complexity	12_17_22	Adopted from MJS - EDT analysis for the White River
Percentage Population Overlap	50_67_100	
River Temperature (°C)	7_9_13	WDOE online data

		Information Reference
Region	Mid Puget Sound	
Hatchery / Watershed	KetaCreek Hatchery (Crisp Creek rearing ponds) / Green - Duwamish	
Program Description	On-station release of yearling coho salmon	HGMP
Program ID Code	MS_2_Y_CP MS_2_Y_InP MS_2_Y_RP	
Program Details		
Release Date	May 15	HGMP
Point of Release (river miles from estuary)	41.2	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	300,000	
Reduced Production Alternative	100,000	
Mean Fish Fork Length (mm)	146	HGMP
Min. Fish Fork Length (mm)	131	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	3_6_22	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Minimum	760,500	
Average	1,108,000	
Maximum	1,225,600	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	58_70	Seiler et al. 2002a, 2004(a,b) 2002a, 2003a; Volkhardt 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	80	
Fish Length CV (%)	10	
Percentage Habitat Complexity	12_17_22	Adopted from MJS - EDT analysis for the White River
Percentage Population Overlap	50_58_100	
River Temperature (°C)	10_14_17	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery / Watershed	Voights Creek Hatchery / Puyallup River	
Program Description	On station release of yearling coho salmon	HGMP
Program ID Code	MS_4_Y_CP MS_4_Y_InP MS_4_Y_RP	
Program Details		
Release Date	April 20	HGMP
Point of Release (river miles from estuary)	21.8	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	780,000	HGMP
Increased Production Alternative	1,180,000	
Reduced Production Alternative	390,000	
Mean Fish Fork Length (mm)	140	HGMP
Min. Fish Fork Length (mm)	126	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_3_14	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	45_60	Berger and Williamson 2005
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	70	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	7_12_17	MJS - EDT
Percentage Population Overlap	50_67_100	
River Temperature (°C)	7_9_11	WDOE online data

		Information Reference
Region	Central Puget Sound	
Hatchery / Watershed	Voights Creek Hatchery (Electron Acclimation Ponds) / Puyallup River	
Program Description	Off-station acclimation releases of yearling coho salmon	HGMP
Program ID Code	MS_5_Y	
Program Details		
Release Date	late April - mid May	HGMP
Point of Release (river miles from estuary)	63.5 (uppermost accl. site)	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	200,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	NA	
Mean Fish Fork Length (mm)	118_138_138	HGMP
Min. Fish Fork Length (mm)	106	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	4_10_33	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	185,800	
Average	311,000	
Maximum	418,200	
Age-0 Ocean Type		
Proportion of Population	0.92_0.95_0.98	CMPPSC Skagit River
Mean Fish Fork Length (mm)	65_75	Berger and Williamson 2005
Min. Fish Fork Length (mm)	40	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.02_0.05_0.08	CMPPSC Skagit River
Mean Fish Fork Length (mm)	90	Berger and Williamson 2005
Fish Length CV (%)	10	
Percentage Habitat Complexity	13_18_23	MJS - EDT
Percentage Population Overlap	50_64_100	
River Temperature (°C)	9_11_15	WDOE online data

		Information Reference
Region	South Puget Sound	
Hatchery / Watershed	Kalama Creek Hatchery / Nisqually River	
Program Description	On-station release of yearling coho salmon	
Program ID Code	SS_1_Y_CP SS_1_Y_RP	
Program Details		
Release Date	April 1 - May 1	HGMP
Point of Release (river miles from estuary)	9.2	HGMP
Hatchery Fish Details		
Number of Hatchery Fish		
Current Production	350,000	HGMP
Increased Production Alternative	NA	
Reduced Production Alternative	175,000	
Mean Fish Fork Length (mm)	135	HGMP
Min. Fish Fork Length (mm)	121	
Fish Length CV (%)	10_11_15	
Survival Rate	0.973_0.990_0.990	
Residence Time (days)	1_1_8	
Natural Fish Details		
Number of Natural Fish Triangular Distribution		MJS-EDT; CMPPSC; PSCCHMP 2005, 2006
Minimum	158,500	
Average	317,400	
Maximum	446,000	
Age-0 Ocean Type		
Proportion of Population	1.0	CMPPSC Nisqually River
Mean Fish Fork Length (mm)	55_65	Ellings 2006
Min. Fish Fork Length (mm)	38	
Fish Length CV (%)	11_14_17	
Age-1 Stream Type		
Proportion of Population	0.0	
Mean Fish Fork Length (mm)		
Fish Length CV (%)		
Percentage Habitat Complexity	29_34_39	MJS - EDT
Percentage Population Overlap	50_78_100	
River Temperature (°C)	7_9_11	Ellings 2006

Puget Sound Hatcheries Draft EIS

Appendix E

Overview of the All H Analyzer

(Supplement: AHA model runs for Chinook salmon)

OVERVIEW OF THE "ALL H ANALYZER"

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Chapter 1
Overview

The purpose of the analysis was to compare the average, long-term effects of different hatchery strategies on conservation and harvest. Conservation of natural populations was assessed in terms of estimated abundance and productivity as well as via an index of the relative magnitude of natural versus artificial selection pressures on individual populations and their potential impacts on fitness. Harvest was assessed by estimating the average number of hatchery- and natural-origin fish taken in various fisheries. The analysis of these factors entailed the integration of habitat in terms of population-specific productivity and capacity parameters, harvest rates for hatchery- and natural-origin fish in all applicable fisheries, hydrosystem survival for adults and juveniles, and hatchery operations, with special emphasis on broodstock and escapement management and hatchery stray rates. The calculations entailed by these goals were simple in concept, but involved the simultaneous tracking of many populations and their interactions.

The approach used in this analysis involved an accounting for natural and hatchery reproduction, natural survival, and the fate of fish that survived to be caught the marine fishery or to return to the Columbia River. In turn, the fate of adults returning to the Columbia River was assessed in terms of homing fidelity, the composition of spawning escapement, relative reproductive success, relative contribution to the conservation of Evolutionarily Significant Units (ESUs) in the Columbia River Basin, and relative contributions to harvest by fishery.

1.1 Analysis Tool

The AHA tool is a Microsoft Excel-based application to evaluate salmon management options in the context of the four "Hs"—**H**abitat, passage through a **H**ydroelectric system (when appropriate), **H**arvest, and **H**atcheries. The AHA calculator integrates the four "Hs" using the methods to estimate equilibrium natural escapement, broodstock requirements, and harvest by fishery for natural- and hatchery-origin fish.

Most importantly, AHA estimates reflect a measure of hatchery influence on natural populations that is a function of both the percent hatchery-origin spawners in the natural escapement and the percent of natural-origin broodstock incorporated into the hatchery program. The assumptions underlying these fitness impacts are based on recently published work (Ford 2002, Lynch and O'Hely, 2001) and further development of these ideas by D. Campton (USFWS), C. Busack (WDFW), and K. Currens (NWIFC).

The AHA tool consists of a battery of interconnected modules for each H incorporating the equations described previously to estimate total recruits, escapement, and harvest for populations and hatchery programs. A critical feature of the analytical tool is the distribution of hatchery recruits to harvest, those recovered back at the point of release, and those straying to spawn in natural populations. In turn, the number of strays to natural populations affects the degree of hatchery influence in all natural populations receiving strays, and thus the fitness, abundance, and harvest potential for each population.

The purpose of the AHA tool is to allow managers to explore the implications of alternative ways of balancing hatcheries, harvest, habitat, and hydrosystem constraints. This tool is not used to make decisions nor to judge the "correctness" of management policies. Rather, it illustrates the implications of alternative ways of balancing the four "Hs" so that informed decisions can be made.

AHA should not be viewed as a new tool to predict habitat, harvest, or hydro effects to populations, but rather as a platform for integrating existing analyses. AHA makes relatively few new assumptions; instead, it brings together the results of other models. It does not replace these other models but instead relies on them for input. AHA is thus a relatively simple aid to regional decision making which, by incorporating the results of other models, can rapidly explore the impacts of very detailed scenarios relating to one or more of the "Hs".

Chapter 2
Analytical Methods

This rest of this paper describes the analytical methods embedded in the AHA tool. Methods, which depend upon a variety of information, include:

- The basic Beverton-Holt survival function which was assumed to describe recruitment for all fish spawning in nature
- Calculations of broodstock composition in terms of hatchery- and natural-origin adults, survival of hatchery fish by life stage in nature and in the hatchery, and the fate of returning hatchery adults
- Calculations of the mean number of fish taken in each of four fisheries
- Computations of ecological and genetic interactions between natural- and hatchery-origin fish reproducing in the natural environment

The analysis does not attempt to estimate what might happen in any particular year; rather, it projects the average outcome after many generations. The analysis tracked each hatchery and natural population component over 100 generations.

The methods compute survival and number of recruits of natural and hatchery production. Survival in nature depends on:

- Quantity and quality of habitat used by the population
- Fish passage survival through migration corridors
- Estuarine and ocean survival conditions
- Fitness of the natural population
- Relative ability of hatchery fish to spawn and their progeny to survive in nature

Survival of hatchery production depends on:

- Number broodstock collected and spawned
- Pre-spawn survival, fecundity, and sex ratio of the broodstock
- Survival in the hatchery to time of release, including culling
- Post-release survival of hatchery fish

The analysis recognizes and accounts for ecological and genetic interactions between natural and hatchery production. Ecological interactions occur via competition in nature, whereas genetic interactions are expressed in terms of gene flow between the production groups.

Ecological interactions depend on:

- Composition of the naturally spawning population
- Ability of hatchery fish to spawn successfully and the survival of their progeny in nature
- Number of hatchery fish spawning in nature

Genetic interactions depend on:

- Composition of the hatchery broodstock
- Percentage of the hatchery return recovered at the point of release and that spawn in nature
- Composition of the naturally spawning population
- Ability of hatchery fish to spawn successfully and survival of their progeny in nature
- Differences in selection pressure between the natural and hatchery environments

2.1 Natural Production

The abundance of natural progeny from adults spawning in nature is computed using the multi-stage, Beverton-Holt (B-H) survival function (Beverton and Holt 1957; Moussalli and Hilborn 1986). The survival function is based on life parameters for productivity (density-independent survival) and capacity (maximum number of fish that can survive). The two-parameter B-H survival function was assumed for each of the following life stages:

1. Spawning to emergent fry
2. Emergent fry to juveniles leaving the subbasin (smolts)
3. Juvenile mainstem migration in the Snake and Columbia rivers and ocean rearing
4. Adults entering the Columbia River and migration to the mouth of the subbasin
5. Pre-spawning adults, i.e. fish from the point of subbasin entry to the initiation of spawning

The B-H survival function assumed for each life stage was as follows:

$$N_{i+1} = \frac{N_i \cdot p_i}{1 + \frac{N_i \cdot p_i}{c_i}} \qquad (1)$$

where:

N_i = Number of fish alive at the beginning of life stage i
N_{i+1} = Number of fish alive at end of life stage $i+1$
p_i = Density-independent survival of life stage i
c_i = Capacity of life stage i (maxium number fish survive in life stage)

Abundance of hatchery-origin fish spawning in nature and their off-spring were adjusted to include the relative reproductive success of hatchery fish in nature, such that the total number of spawners, N_i, was:

$$N_i = N_{i,Nat} + N_{i,Hatch} \cdot Rel\_Surv_{i,Hatch} \qquad (2)$$

where:

$N_{i,Nat}$ = Number of progeny from natural-origin spawners in life stage i

$N_{i,Hatch}$ = Number of progeny from hatchery-origin spawners in life stage i

$Rel\_Surv_{i,Hatch}$ = An estimate of the phenotypic impact of hatchery rearing on life stage productivity in nature for life stage i

More specifically, Rel_Survi,Hatch is a user-provided estimate of the phenotypic depression of the reproductive success of hatchery spawners in nature.

The B-H productivity and capacity[1] parameters were adjusted for the relative fitness, F, of the natural population over the complete (adult-to-adult) life cycle. The formulas used to estimate fitness of the natural population are described in Section 2.4.3 of this appendix. The fitness multiplier was apportioned over each life stage i as follows:

$$f_i = F^{Rel\_Loss_i} \quad (3)$$

where:

f_i = Life-stage specific fitness

Rel_Loss_i = Assumed proportion of the total fitness effect occuring in life stage i

The overall survival function for life stage *i* was as follows:

$$N_{i+1} = \frac{p_i \cdot f_i \cdot (N_{i,Nat} + N_{i,Hatch} \cdot Rel\_Surv_{i,Hatch})}{1 + \frac{p_i \cdot f_i \cdot (N_{i,Nat} + N_{i,Hatch} \cdot Rel\_Surv_{i,Hatch})}{c_i \cdot f_i}} \quad (4)$$

Cumulative productivity and capacity for a population included an assumed average smolt-to-adult return rate (SAR), calculated at the mouth of the subbasin of origin. Productivity and capacity parameters were adjusted as necessary to ensure that predicted SARs equaled the latest observed SAR by means of the following adjustment:

$$P_{Adj} = P_{Base} \cdot \left(SAR_{Obs} / SAR_{Base} \right) \quad (5)$$

where:

P_{Adj} = Adjusted Spawner-Spawner Productivity

P_{Base} = Baseline period Spawner-Spawner Productivity

SAR_{Obs} = Latest observed subbasin-to-subbasin SAR

SAR_{Base} = SAR assumed in baseline estimate of Productivity

[1] Capacity is affected by both the quantity of key habitat and productivity by the equation:

$$C_i = p_i / \left(1/C_{i-1} + p_i / c_i \right).$$

A comparable adjustment for spawner-to-spawner capacity made use of the multi-stage B-H equation (Moussalli and Hilborn 1986) as follows:

$$C_{Adj} = \frac{p_{Smolt} \cdot SAR_{Obs} \cdot p_{Prespawn}}{\left(\frac{1}{c_{Spawn}} + \frac{p_{Smolt}}{c_{Smolt}} + \frac{p_{Smolt} \cdot SAR_{Obs} \cdot p_{Prespawn}}{c_{Prespawn}} \right)} \tag{6}$$

where:

C_{adj} = Adjusted Spawner-Spawner Capacity

p_{smolt} = Productivity for the period emergent fry to smolt leaving the subbasin

$p_{prespawn}$ = Productivity for the period adult entering subbasin to spawning

c_{spawn} = Life stage capacity from spawner to emegerent fry (relative index)

c_{smolt} = Life stage capacity from emergent fry to smolt leaving subbasin

$c_{prespawn}$ = Life stage capacity from adult entering subbasin to spawning

Productivity and capacity for the pre-spawn and spawner-to-fry life stages were user-supplied input variables. Given these values, productivity (P_{Smolt}) and capacity (c_{Smolt}) for the fry-to-smolt life stage was calculated as follows:

$$p_{Smolt} = \frac{P}{p_{Egg-fry} \cdot SAR_{Obs} \cdot p_{Pre-spawn}} \tag{7}$$

and

$$c_{Smolt} = \frac{1}{\left[\left(p_{Pre-spawn} \cdot SAR_{Obs} \right) \cdot \left(\frac{1}{C} - \frac{1}{c_{Pre-spawn}} \right) \right]} \tag{8}$$

Finally, productivity and capacity of the population from spawner to smolt leaving the subbasin was computed to provide a means of reporting and validating cumulative productivity and capacity parameters and life stage parameters used in the analysis.

Productivity from spawn to smolt was computed by the following expression:

$$p_{Spawn-smolt} = \frac{P}{SAR_{Obs} \cdot p_{Pre-spawn}} \tag{9}$$

Capacity for the spawner-to-smolt life stage ($c_{Spawn\text{-}smolt}$) was computed as follows:

$$c_{spawn-smolt} = \frac{C}{\left[\left(SAR_{Obs} \cdot p_{Pre-spawn} \right) \cdot \left(1 - \frac{C}{c_{Pre-spawn}} \right) - \frac{1}{\left(p_{Spawn-smolt} \cdot c_{Spawn-egg} \right)} \right]} \tag{10}$$

Data sources

The cumulative B-H productivity (P) and capacity (C) parameters define the maximum adult recruitment rate (density-independent recruitment) and maximum number of spawners (adult "carrying capacity") for a population over the complete life cycle (spawner to spawner). The specific parameters used in analyses can come from a variety of sources, depending on the population. Habitat-based models like Ecosystem Diagnosis and Treatment (EDT) can be used to estimate productivity and capacity, or these parameters can be estimated by fitting a B-H function to observed abundance data. It is also possible to estimate these parameters were from a time series of dam counts, with a subsequent allocation of returns to populations based on the relative quantity and quality of habitat in spawning tributaries above the reference dam.

Life stage specific parameters can be obtained from fish passage survival models, ESU recovery plans, and hatchery managers.

2.2 Hatchery Production

Hatchery production was evaluated in terms of whether a given hatchery program was segregated or integrated. A hatchery program was considered segregated if the management intent was to create a distinct population that is reproductively isolated from naturally spawning populations. A hatchery program was considered to be integrated if the management intent was to create a composite hatchery/natural population for which the dominant selective pressure was the natural environment. The concepts underlying the computation of net natural vs. artificial selection in integrated programs and the impact of net selective pressure on genetic fitness of the natural population are described in more detail in Section 2.4. In some cases, more than one release strategy was used in a program; for example, some programs release both late summer subyearling parr and spring yearling smolts. In such cases, information was required for both release groups. The combined number of hatchery juveniles produced (H_{Rel}) was computed as follows:

$$H_{Rel} = \sum_{a} BS_{HOB} \cdot S_{Spawn-egg} \cdot S_{Egg-rel,a} + BS_{NOB} \cdot S_{Spawn-egg} \cdot S_{Egg-rel,a} \cdot Rel\_Surv_{NOB} \quad (11)$$

where:

$$S_{Spawn-egg} = S_{Pre-spawn} \cdot Fecundity \cdot \%Females \cdot \left(1 - \%EggsCulled\right)$$

and:

BS_{NOB} = Number of natural-origin adults in broodstock (integrated programs)

BS_{HOB} = Number of hatchery-origin adults in broodstock (local and imported)

$S_{Spawn-rel,a}$ = Survival from egg to release for release group a

$\%R_a$ = Proportion of release comprised of juveniles from release group a

$S_{Pre-spawn}$ = Survival in hatchery of broodstock adults

$Fecundity$ = Average number of eggs per female in broodstock

$\%Females$ = Percent females in broodstock

$\%Culled$ = Percent of eggs in broodstock destroyed, typically for disease management

Survival from release to adult was based on total recruits per hatchery spawner (R/S). Recruits per spawner for hatchery fish (R/S_{Hatch}) is analogous to the productivity value for the natural population. Sometimes called the hatchery return rate, it represents the mean number of hatchery-origin recruits (HORs) produced (harvest plus escapement) per hatchery spawner. Hatchery spawners are the number of adults collected to meet broodstock needs before pre-spawn mortality and culling. The hatchery recruits per spawner value was usually computed from coded wire tag data or other hatchery information and was a user-supplied input variable.

The combined recruits per spawner value (R/S_{Hatch}) for programs that included more than one release strategy was calculated as follows:

$$R/S_{Hatch} = \frac{R/S_{\text{R}1} \cdot \%R_1 \cdot S_{\text{R}2\_egg-rel} + R/S_{\text{R}2} \cdot \%R_2 \cdot S_{\text{R}1\_egg-rel}}{\%R_1 \cdot S_{\text{R}2\_egg-rel} + \%R_2 \cdot S_{\text{R}1\_egg-rel}} \qquad (12)$$

where:

R/S_{R1} & R/S_{R2} = Recruits per spawner for release groups 1 and 2

$S_{R1\_egg-rel}$ = Egg to release survival of hatchery juveniles for group 1, includes eggs culled

$S_{R2\_egg-rel}$ = Egg to release survival of hatchery juveniles for group 2, includes eggs culled

$\%R_1$ & $\%R_2$ = Proportion of program release comprised of release groups 1 and 2

Survival of hatchery fish from release to adult recruitment was computed to provide a means of reporting and validating hatchery inputs for recruit per spawner and in-hatchery survival to release. SAR_{Hat} was calculated by the following expression:

$$SAR_{Hatch} = \frac{R/S_{Hatch}}{\left(S_{Spawn-rel,R1} \cdot \%R_1 + S_{Spawn-rel,R2} \cdot \%R_2\right) \cdot S_{Spawn-egg}} \qquad (13)$$

Finally, SAR_{Hat} was adjusted as necessary to ensure that predicted hatchery SAR equaled the latest observed SAR by means of the following adjustment:

$$SAR_{Hat\_Adj} = SAR_{Hat} \cdot \left(SAR_{Obs} / SAR_{Base} \right) \qquad (14)$$

where SAR_{Obs} and SAR_{Base} are as previously defined in Equation 5.

In the analysis, hatchery recruits included strays, fish taken in the harvest, fish recovered at the point of release, fish recovered at an adult in-river weir, and fish that spawned in nature. Methods to calculate the number of fish harvested are described in more detail in Section 2.3. The following section describes how the escapement, i.e. fish that were not harvested, was distributed.

The number of hatchery adults recovered at the point of release ($\#Hatch$) was calculated by the following expression:

$$\#Hatch = H_{Rel} \cdot SAR_{Hat\_Adj} \cdot \left(1 - TotalExploitation\right) \cdot \%Hatch \qquad (15)$$

where:

$TotalExploitation$ = Total exploitation rate across all fisheries

$\%Hatch$ = Percent hatchery origin escapement recovered and/or that died at the point of release.

The analysis estimated hatchery surplus as the number of hatchery adults collected at the hatchery and other locations such as weirs *(%Weir*), but not used for broodstock. Hatchery surplus was calculated as follows:

$$Surplus_{Hatch} = H_{Rel} \cdot SAR_{Hat\_Adj} \cdot \left(1 - TotalExploitation\right) \cdot \%Weir \cdot \%Hatch - BS_{HOB} \quad (16)$$

The number of hatchery returns surviving to spawn in nature (N_{hat}) was calculated as follows:

$$N_{Hatch} = H_{Rel} \cdot SAR_{Hat\_Adj} \cdot \left(1 - TotalExploitation\right) \cdot \left(1 - \%Hatch\right) \quad (17)$$

The number of hatchery adults spawning in a particular natural population is calculated as follows:

$$N_{Hatch} = \sum_{p=1}^{P} N_{Hatch,p} \cdot \left(1 - \%Weir\right) \quad (18)$$

In the previous equation hatchery fish are assumed to originate from one or more hatchery programs *p*. Methods to distribute hatchery fish spawning in nature to natural populations will be described in detail in the Interaction section of this appendix.

Data Sources

Hatchery Genetic Management Plans (HGMPs) are a good source of information for hatchery programs. Although HGMPs vary in completeness and quality, comprehensive HGMPs include information on a wide range of parameters including:

- Hatchery type (Segregated/Integrated)
- Broodstock target (number of fish) and hatchery/natural composition in the broodstock
- Broodstock collection procedures
- Contribution of hatchery fish to natural escapement
- Proportion of broodstock imported and/or exported
- Smolt release size and life stage
- Hatchery survival by life stage
- Hatchery return rates
- Hatchery stray rates

2.3 Harvest

Harvest analysis in the methods was relatively simple. Harvest was estimated for major fisheries (defined by harvest area) as a function of user-supplied harvest rates and the estimated number of HOR and NOR fish available in each fishery. Mark-selective fisheries on hatchery fish were analyzed by imposing differential harvest rates on NORs and HORs. Harvest analysis does not incorporate age-specific harvest rates; harvest rates represent total harvest on a brood over all ages.

The number of natural fish surviving to marine fisheries (NMar, Nat) was calculated as follows:

$$N_{Mar,Nat} = N_{Smolt} \cdot S_{Juv} \tag{19}$$

where:

N_{Smolt} = Estimated number of natural-origin juveniles leaving subbasin.
S_{Juv} = Survival of natural fish during juvenile mainstem passage and in the ocean.

The number of *hatchery* fish surviving to marine fisheries ($N_{Mar,\,Hat}$) was calculated by a similar expression:

$$N_{Mar,Hatch} = H_{Rel} \cdot S_{Juv,Hatch} \tag{20}$$

where:

H_{Rel} = Number of hatchery fish released.
$S_{Juv,Hatch}$ = Survival of hatchery fish during juvenile mainstem passage and in the ocean.

The number of fish harvested was calculated sequentially, beginning with the number of fish harvested in marine fisheries ($Harv_{Mar,\,i}$):

$$Harv_{Mar,i} = N_{Mar,i} \cdot HR_{Mar,i} \tag{21}$$

where:

$N_{Mar,i}$ = Number of fish surviving to enter marine fisheries for production type *i*.
$\mathrm{HR}_{Mar,i}$ = Marine harvest rate on adults for production type *i*.

The number of fish harvested in the lower reaches of a major river and in fisheries further upstream entail sequential calculations in which each successive harvest makes use of the fish remaining after previous harvests.

Data Sources

Harvest rate is the number of fish harvested divided by the total number of fish available to the fishery. Harvest rates are taken from recent brood year averages or from target harvest rates described in management plans. Future harvest rates applied to the analysis came from proposed harvest plans or recommendations.

2.4 Interactions – (Ecological and Genetic)

The analytical methods evaluated interactions between hatchery and natural fish in two ways: 1) through ecological interactions between progeny of naturally spawning hatchery and natural-origin parents and 2) through long-term genetic interactions resulting from hatchery adults spawning with natural fish. The methods to compute effects of these interactions for each of these ways are described in the following sections. The sections describe the quantitative assessment of ecological and genetic interactions in the analysis. First, however, an overview of methods to compute the number of hatchery fish spawning in nature and their distribution among natural populations is presented, followed by descriptions of methods to compute effects of ecological and genetic interactions.

2.4.1 Distribution of Hatchery Adults Spawning in Nature

Hatchery returns may be recovered at the point of release, at a weir, on the spawning grounds within the subbasin of origin, on spawning grounds outside the subbasin of origin, or they may die after escaping the fisheries, but before spawning. The analytical methods included assumptions about the fate of all hatchery return escaping fisheries. The procedure tracked the eventual fate of all returning hatchery adults from every population/program.

All hatchery adults not recovered in fisheries or at hatchery racks or weirs at their point of release are considered strays. Strays were allocated to a natural population within their respective basin of origin (within-basin strays), to natural populations outside of the originating basin (out-of-basin strays), or designated as adults returning to areas with no spawning populations. The purpose of the straying component in the analysis is to account for the effect of reproductive interactions between natural populations ("recipient populations") and hatchery programs ("donor populations").

The proportion and source of hatchery strays in the natural spawning escapement is used to estimate relative genetic fitness (see following section) of recipient natural populations. Recall from equation 17, the number of hatchery strays (N_{Hatch}) spawning in nature from the donor population p was calculated as follows:

$$N_{Hatch} = H_{Rel} \cdot SAR_{Hatch} \cdot \left(1 - TotalExploitation\right) \cdot \left(1 - \%Hatch\right) \qquad (22)$$

The number of strays from donor hatchery p to a particular recipient natural population was calculated as follows:

$$Recip_{Hatch,p} = N_{Hatch,p} \cdot \%Recip \qquad (23)$$

where *%Recip* is an estimate of the proportion of the adults that stray to the recipient natural population.

Generally the *%Recip* would sum to 100% for a donor population, i.e. all strays were assumed to spawn with a natural population. However, information suggested that, in some cases, a portion of the hatchery return not recovered at the hatchery does not attempt to spawn with a natural population (e.g., programs that release fish a long distance away from natural populations).

The actual number of hatchery fish spawning in a recipient natural population is the sum of hatchery fish from all donor populations:

$$Strays_{Hatch} = \sum_{p=1}^{P} Recip_{Hatch,p} \cdot \left(1 - \%Weir\right) \qquad (24)$$

where *%Weir* is the proportion of the hatchery adults destined to spawn with the natural population, but are recovered at an adult weir either below the population or within the boundaries of the natural population.

Data Sources

Assumptions regarding strays can often be obtained from hatchery managers. Such data typically consists of a time series of coded wire tagged releases from the originating hatchery and adult recoveries at the originating hatchery adult trap, at hatchery adult traps other than the originating hatchery, and from spawning ground surveys. Recoveries of hatchery adults at hatchery traps other than the release hatchery can be used to provide a measure of straying outside of the basin of origin. Observations of the number of hatchery adults on the spawning grounds or at weirs can be used to validate or revise default assumptions.

2.4.2 Ecological Interactions

The analysis considered the effect of hatchery fish in nature on survival of natural fish through competitive interactions (reviewed in Kostow 2008). While the number of hatchery fish that "effectively" interbreed may be low, the census number of fish present may be very large and may have a significant ecological effect (Kostow 2003, Kostow 2004, Kostow and Zhou 2006). The concern is that hatchery fish may compete effectively at the juvenile stage, but have inferior reproductive success.

The analytical approach computed an adjusted survival of progeny of natural-origin spawners based on estimates of productivity and competition factors for hatchery fish relative to natural-origin fish.

The number of fish from natural-origin parents surviving to the next life stage was adjusted based on the quantity of fish from hatchery-origin parents. In other words, Equation 4 described previously was modified to account for competition between the progeny of hatchery and natural spawners in nature. The following equation was used to compute number of fish surviving to the next life stage from natural-origin parents ($N_{i,Nat}$):

$$N_{i+1,Nat} = \frac{p_i \cdot f_i \cdot N_{i,Nat}}{1 + \dfrac{p_i \cdot f_i \cdot (N_{i,Nat} + N_{i,Hatch} \cdot Rel\_Surv_{i,Hatch} \cdot Rel\_Comp_{i,Hatch})}{c_i \cdot f_i}} \quad (25)$$

The number of fish surviving to the next life stage from hatchery-origin parents ($N_{i,Hatch}$) was computed by the following:

$$N_{i+1,Hatch} = \frac{p_i \cdot f_i \cdot Rel\_Surv_{i,Hatch} \cdot N_{i,Hatch}}{1 + \dfrac{p_i \cdot f_i \cdot (N_{i,Hatch} \cdot Rel\_Surv_{i,Hatch} + N_{i,Nat})}{c_i \cdot f_i}} \quad (26)$$

In the previous equations, $N_{i,Nat}$ is the number of natural progeny from natural-origin parents and $N_{i,Hatch}$ is the number of natural progeny from hatchery-origin parents. The competition effect of offspring from hatchery spawners may be adjusted based on the $Rel\_Comp_{i,Hatch}$ parameter. A value of 1.0 results in equal competition between the off-spring of hatchery spawners and natural spawners. Values less than 1.0 signify that off-spring from hatchery fish are less competitive in nature.

Hatchery and natural fish can potentially interact after release when returning as pre-spawners and as spawners on the spawning grounds. The analysis considered these potential effects by considering a variety of factors such as the number of fish released, life stages at release, release strategies, and the percent of the natural spawning abundance that is comprised of hatchery-origin fish.

Data Sources

The analysis can incorporate any relative survival value deemed appropriate for the population of interest. Many hatchery releases are outplant programs based on domesticated hatchery stocks. Hatchery fish from such programs make a relatively small direct genetic contribution to the naturally spawning populations because of differences in spawn timing and behavior (Lieder et al. 1984). For example, in the Columbia River, the analysis assumed 11% relative survival of highly domesticated winter steelhead in nature and 18% relative survival of domesticated summer steelhead in nature.

2.4.3 Genetic Interactions

The analysis of genetic interactions comprises the long-term effects on fitness of hatchery adults spawning with natural populations. A more detailed description of the basis for these equations is described in the HSRG white paper on Fitness and Local Adaptation (Appendix B). The application of the Ford (2002) model in the analytical methods is described below.

The Ford model is based on gene flow between hatchery and natural fish. Two parameters represent the mean proportional genetic contributions in each generation of hatchery and natural fish to natural-origin and hatchery-origin progeny. The proportion of hatchery broodstock composed of natural-origin adults (proportion of natural-origin broodstock or pNOB) was calculated as the following:

$$pNOB = \frac{BS_{NOR}}{BS_{NOR} + BS_{HOR}} \qquad (27)$$

The proportion of naturally spawning fish composed of hatchery-origin spawners (proportion of effective hatchery-origin spawners or $pHOS_{Eff}$) was calculated as the following:

$$pHOS_{Eff} = \frac{N_{HOS} \cdot Rel\_Surv_{HOS}}{\left(N_{HOS} \cdot Rel\_Surv_{HOS}\right) + N_{NOS}} \qquad (28)$$

where NHOS and NNOS were the number of natural spawning hatchery and natural adults, respectively. Effective hatchery spawners were those that successfully produced progeny that survived to spawn to the next generation.

The proportional influence of the natural environment on the mean phenotypic values (and genetic constitutions) of natural and hatchery fish is referred to as PNI 2 (proportionate natural influence). An approximate index of PNI for natural and hatchery fish when pNOB and pHOS were both greater than zero was calculated as the following:

[2] The term *proportionate natural influence* (*PNI*) was first coined by C. Busack, Washington Department of Fish and Wildlife, Olympia, WA.

$$PNI_{Approx} = \frac{pNOB}{\left(pNOB + pHOS\right)} \tag{29}$$

When *pHOS* or *pNOB* were zero, the calculated *PNI* depends on assumptions regarding selection intensities and "heritabilities" associated with a specific trait. If *pNOB* = 0 then PNI_{Hatch} = 0 and the following equation was used to calculate PNI_{Nat}:

$$PNI_{Nat} = \frac{h^2 + (1.0 - h^2 + \omega^2) \cdot pNOB}{h^2 + (1.0 - h^2 + \omega^2) \cdot (pNOB + pHOS)} \tag{30}$$

where:

h^2 = Heritability of the trait ≡ proportion of the total phenotypic variance resulting from heritable genetic variance among individuals $(0 < \mathrm{h}^2 < 1.0)$

ω^2 = Variance of the probability distribution of fitness as a function of phenotypic values for individuals in the population

The analysis assumed σ^2 and ω^2 to be equal between natural and hatchery fish. Note that the inverse of ω^2, i.e. $1/\omega^2$, is the intensity selection towards the phenotypic optimum. In other words, as ω^2 increases the selection intensity decreases. According to Ford (2002), $\omega^2 = 10\sigma^2$ is considered "strong selection", whereas $\omega^2 = 100\sigma^2$ would be considered "weak selection".

Fitness is computed for each generation (*g*) in the analysis based on *pHOS* and *pNOB* in the parent generation (*g-1*).

Population fitness in generation *g* is calculated as the following:

$$F_g = e^{-\frac{1}{2} \cdot \left(\frac{\bar{P}_{Nat,g} - \theta_{Nat}}{\omega^2 + \sigma} \right)^2} \tag{31}$$

where:

θ_{Nat} = Phenotypic optimum or expected value (mean) of the phenotypic probability distribution for the natural population

θ_{Hatch} = Phenotypic optimum or expected value (mean) of the phenotypic probability distribution for the hatchery population

σ^2 = Phenotypic variance for the trait in question

$\bar{P}_{Nat,g}$ = Mean phenotypic value of the natural population in generation g

$\bar{\mathrm{P}}_{Nat}$-θ_{Nat} = Deviation from the optimum phenotypic value for the natural environment

The mean phenotypic value of the natural population ($\bar{P}_{Nat,g}$) and hatchery population ($\bar{P}_{Hatch,g}$) in generation *g* is calculated as the following:

$$\bar{P}_{Nat,g} = \left(1 - pHOS_{g-1}\right) \cdot \left[\bar{P}_{Nat,g-1} + \left(\left(\left(\bar{P}_{Nat,g-1} \cdot \omega^2 + \theta_{Nat} \cdot \sigma^2 \right) / \left(\omega^2 + \sigma^2 \right) \right) - \bar{P}_{Nat,g-1} \right) \cdot h^2 \right] + pHOS_{g-1} \cdot \left[\bar{P}_{Hatch,g-1} + \left(\left(\left(\bar{P}_{Hatch,g-1} \cdot \omega^2 + \theta_{Nat} \cdot \sigma^2 \right) / \left(\omega^2 + \sigma^2 \right) \right) - \bar{P}_{Hatch,g-1} \right) \cdot h^2 \right] \quad (32)$$

and:

$$\bar{P}_{Hatch,g} = \left(1 - pNOB_{g-1}\right) \cdot \left[\bar{P}_{Hatch,g-1} + \left(\left(\left(\bar{P}_{Hatch,g-1} \cdot \omega^2 + \theta_{Hatch} \cdot \sigma^2 \right) / \left(\omega^2 + \sigma^2 \right) \right) - \bar{P}_{Hatch,g-1} \right) \cdot h^2 \right] + pNOB_{g-1} \cdot \left[\bar{P}_{Nat,g-1} + \left(\left(\left(\bar{P}_{Nat,g-1} \cdot \omega^2 + \theta_{Hatch} \cdot \sigma^2 \right) / \left(\omega^2 + \sigma^2 \right) \right) - \bar{P}_{Nat,g-1} \right) \cdot h^2 \right] \quad (33)$$

Data sources

The analytical methods applied in this analysis used the following parameter values in all analyses in order to model the long-term genetic effects of the natural population of hatchery-origin fish spawning naturally:

$$\sigma^2_{Nat} = \sigma^2_{Hatch} = 10.0$$
$$\theta_{Hatch} = 80.0$$
$$\theta_{Nat} = 100.0$$
$$h^2_{Nat} = h^2_{Hatch} = 0.5$$
$$\omega^2 = 10 \cdot \sigma^2 = 100.0 \text{ (Strong selection)}$$

The calculations described above are contained within “All H Analyzer” (AHA) analytical tool.

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Supplement to Appendix E

PNI and pHOS results from AHA Model runs for Chinook salmon for the Puget Sound Hatcheries Draft Environmental Impact Statement

(Model runs performed by WDFW in 2006-2007[1])

Hatchery program (release watershed)	Species	Hatchery program type[2]: - Integrated - Isolated	Fish release number[3]	EIS alternative: 1: No action 2: Proposed action 3: Reduced production 4: Increased production	PNI[4]	pHOS[5]
Glennwood Springs Hatchery (San Juan Islands, Orcas Island)	Fall Chinook	Isolated	sub-300,000 yrlg-250,000	Alternative 1	NA[6]	100%
			sub-300,000 yrlg-250,000	Alternative 2	NA	100%
			sub-300,000 yrlg-250,000	Alternative 3	NA	100%
			sub-300,000 yrlg-250,000	Alternative 4	NA	100%
Kendall Creek Hatchery (NF Nooksack River)	Spring Chinook	Integrated	sub-750,000	Alternative 1	0.12	71%
			sub-750,000	Alternative 2	0.12	71%
			sub-750,000	Alternative 3	0.12	71%
			sub-750,000	Alternative 4	0.12	71%
Skookum Creek Hatchery (SF Nooksack River)	Spring Chinook	Integrated (short-term program)	sub-200,000	Alternative 1	Unk[7]	NA
			sub-200,000	Alternative 2	Unk	NA
			sub-200,000	Alternative 3	Unk	NA
			sub-200,000	Alternative 4	Unk	NA
Samish Hatchery (Samish River)	Fall Chinook	Isolated	sub-4,000,000 yrlg-100,000	Alternative 1	NA	100%
			sub-4,000,000 yrlg-100,000	Alternative 1	NA	100%
			sub-4,000,000 yrlg-100,000	Alternative 1	NA	100%
			sub-4,000,000 yrlg-100,000	Alternative 1	NA	100%

[1] Updated and verified by J. Dixon (WDFW) February 21, 2012.
[2] All are long-term programs unless otherwise noted.
[3] Sub = subyearling and yrlg = yearling.
[4] PNI (proportionate natural influence) applies to integrated hatchery programs.
[5] pHOS (proportion of hatchery-origin spawners) applies to isolated hatchery programs.
[6] NA = not applicable.
[7] Unk (unknown): model results are not available for the program; either the program was not sufficiently initiated at the time of modeling, or needed information is not available to run the model.

Hatchery program (release watershed)	Species	Hatchery program type[2]: - Integrated - Isolated	Fish release number[3]	EIS alternative: 1: No action 2: Proposed action 3: Reduced production 4: Increased production	PNI[4]	pHOS[5]
Marblemount Hatchery (Skagit -Cascade River)	Spring Chinook	Isolated	sub – 250,000 yrlg – 150,000	Alternative 1	NA	2%
			sub – 250,000 yrlg – 150,000	Alternative 2	NA	2%
			sub – 250,000 yrlg – 150,000	Alternative 3	NA	2%
			sub – 250,000 yrlg – 150,000	Alternative 4	NA	2%
Marblemount Hatchery (Skagit River)	Summer Chinook	Integrated	sub-200,000	Alternative 1	0.93	8%
			sub-200,000	Alternative 1	0.93	8%
			sub-200,000	Alternative 1	0.93	8%
			sub-200,000	Alternative 1	0.93	8%
Marblemount Hatchery (Skagit River)	Fall Chinook	Integrated	sub-222,000	Alternative 1	0.84	19%
			sub- 222,000	Alternative 2	0.84	19%
			sub- 222,000	Alternative 3	0.84	19%
			sub- 222,000	Alternative 4	0.84	19%
Whitehorse Springs Hatchery (North Fork Stillaguamish River)	Summer Chinook	Integrated	sub- 200,000	Alternative 1	0.91	10%
			sub - 200,000	Alternative 2	0.91	10%
			sub -200,000	Alternative 3	0.91	10%
			sub - 420,000	Alternative 4	0.79	10%
South Fork Stillaguamish Chinook Natural Stock Restoration) (South Fork Stillaguamish River)	Fall Chinook	Integrated (short-term program)	sub- 45,000	Alternative 1	Unk[7]	NA
			sub - 45,000	Alternative 2	Unk	NA
			sub -45,000	Alternative 3	Unk	NA
			sub -45,000	Alternative 4	Unk	NA
Bernie Kai-Kai Gobin, Tulalip (Snohomish River ; Tulalip Bay)	Summer Chinook	Integrated	sub- 1,700,000	Alternative 1	0.77	NA
			sub -1,700,000	Alternative 2	0.77	NA
			sub -1,700,000	Alternative 3	0.86	NA
			sub -1,700,000	Alternative 4	0.73	NA
Wallace Hatchery (Skykomish River)	Summer Chinook	Integrated	sub - 1,000,000 yrlg – 250,000	Alternative 1	0.77	12%
			sub - 1,000,000 yrlg – 250,000	Alternative 2	0.77	12%
			sub - 500,000 yrlg – 125,000	Alternative 3	0.86	7%
			sub - 1,000,000 yrlg – 500,000	Alternative 4	0.73	15%

Hatchery program (release watershed)	Species	Hatchery program type[2]: - Integrated - Isolated	Fish release number[3]	EIS alternative: 1: No action 2: Proposed action 3: Reduced production 4: Increased production	PNI[4]	pHOS[5]
Issaquah Hatchery (Lake Washington)	Issaquah Fall Chinook	Integrated	sub - 2,000,000	Alternative 1	0.18	74%
			sub - 2,000,000	Alternative 2	0.18	74%
			sub - 2,000,000	Alternative 3	0.18	74%
			sub - 2,000,000	Alternative 4	0.18	74%
Portage Bay Hatchery (Lake Washington)	Portage Bay Fall Chinook	Isolated	Sub-180,000	Alternative 1	NA	100%
			Sub-180,000	Alternative 2	NA	100%
			Sub-180,000	Alternative 3	NA	100%
			Sub-180,000	Alternative 4	NA	100%
Soos Creek, Icy Creek, Keta Creek (Green River)	Fall Chinook	Integrated	Soos sub – 3,200,000 Icy yrlg – 300,000 Keta fing – 600,000	Alternative 1	0.23	30%
			Soos sub – 3,200,000 Icy yrlg – 300,000 Keta fing – 600,000	Alternative 2	0.23	30%
			Soos sub - 1,600,000 Icy yrlg – 150,000 Keta fing – 300,000	Alternative 3	0.36	16%
			Soos sub - 3,200,000 Icy yrlg – 300,000 Keta fing – 600,000	Alternative 4	0.23	30%
Voights and Clarks Creek Hatcheries (Puyallup River)	Fall Chinook	Integrated	sub - 2,000,000	Alternative 1	0.11	82%
			sub - 2,000,000	Alternative 2	0.11	82%
			sub - 1,000,000	Alternative 3	0.16	78%
			sub - 2,600,000	Alternative 4	0.10	86%
White River Hatchery and Puyallup White River Acclimation Sites (White River)	Spring Chinook	Integrated	sub - 1,100,000 yrlg – 90,000	Alternative 1	0.69	11%
			sub -1,100,000 yrlg – 90,000	Alternative 2	0.69	11%
			sub - 1,100,000 yrlg – 90,000	Alternative 3	0.69	11%
			sub - 1,100,000 yrlg – 90,000	Alternative 4	0.69	11%

Hatchery program (release watershed)	Species	Hatchery program type[2]: - Integrated - Isolated	Fish release number[3]	EIS alternative: 1: No action 2: Proposed action 3: Reduced production 4: Increased production	PNI[4]	pHOS[5]
Chambers Creek Hatchery (Chambers Creek)	Fall Chinook	Isolated	sub - 850,000 yrlg – 200,000	Alternative 1	NA	100%
			sub - 850,000 yrlg – 200,000	Alternative 2	NA	100%
			sub - 850,000 yrlg – 200,000	Alternative 3	NA	100%
			sub - 850,000 yrlg – 2,820,000	Alternative 4	NA	100%
Nisqually Hatchery at Clear Creek and Kalama Creek (Nisqually River)	Fall Chinook	Isolated	sub - 4,000,000	Alternative 1	NA	19%
			sub - 4,000,000	Alternative 2	NA	19%
			sub - 2,000,000	Alternative 3	NA	10%
			sub - 4,300,000	Alternative 4	NA	20%
Tumwater Falls Hatchery (Deschutes River)	Fall Chinook	Isolated	sub - 3,800,000 yrlg – 200,000	Alternative 1	NA	100%
			sub - 3,800,000 yrlg – 200,000	Alternative 2	NA	100%
			sub - 3,800,000 yrlg – 200,000	Alternative 3	NA	100%
			sub - 5,800,000 yrlg – 200,000	Alternative 4	NA	100%
Minter Creek Hatchery (Minter Creek)	Fall Chinook	Isolated	sub - 1,800,000	Alternative 1	NA	100%
			sub - 1,800,000	Alternative 2	NA	100%
			sub - 1,800,000	Alternative 3	NA	100%
			sub - 1,800,000	Alternative 4	NA	100%
White River, Minter and Hupp Springs Hatcheries (Carr Inlet, South Sound)	Spring Chinook	Isolated	sub - 250,000 yrlg – 85,000	Alternative 1	NA	100%
			sub - 250,000 yrlg – 85,000	Alternative 2	NA	100%
			sub - 250,000 yrlg – 85,000	Alternative 3	NA	100%
			sub - 250,000 yrlg – 85,000	Alternative 4	NA	100%
Grovers Creek Hatchery and Satellite Rearing Ponds (Kitsap Peninsula)	Fall Chinook	Isolated	sub - 2,800,000 yrlg – 150,000	Alternative 1	NA	100%
			sub - 2,800,000 yrlg – 150,000	Alternative 2	NA	100%
			Sub - 2,800,000 Yrlg – 150,00	Alternative 3	NA	100%
			sub - 2,800,000 yrlg – 150,000	Alternative 4	NA	100%

Hatchery program (release watershed)	Species	Hatchery program type[2]: - Integrated - Isolated	Fish release number[3]	EIS alternative: 1: No action 2: Proposed action 3: Reduced production 4: Increased production	PNI[4]	pHOS[5]
George Adams and Rick's Pond (Skokomish River)	Fall Chinook	Integrated	sub - 3,800,000 yrlg – 120,00	Alternative 1	Unk	NA
			sub - 3,800,000 yrlg – 120,00	Alternative 2	Unk	NA
			sub - 1,900,000 yrlg – 60,000	Alternative 3	Unk	NA
			sub - 3,800,000 yrlg – 120,000	Alternative 4	Unk	NA
Hoodsport Hatchery (Finch Creek, west Hood Canal)	Fall Chinook	Isolated	sub - 2,800,000 yrlg – 120,000	Alternative 1	NA	100%
			sub - 2,800,000 yrlg – 120,000	Alternative 2	NA	100%
			sub - 2,800,000 yrlg – 120,000	Alternative 3	NA	100%
			sub - 2,800,000 yrlg – 120,000	Alternative 4	NA	100%
Hamma Hamma Hatchery (Hamma Hamma River, westside Hood Canal)	Fall Chinook	Integrated	sub - 110,000	Alternative 1	0.50	55%
			sub- 110,000	Alternative 2	0.50	55%
			sub - 110,000	Alternative 3	0.50	55%
			sub - 110,000	Alternative 4	0.50	55%
Dungeness Hatchery (Dungeness River)	Spring Chinook	Integrated	sub - 100,000 yrlg – 100,000	Alternative 1	0.08	44%
			sub - 100,000 yrlg – 100,000	Alternative 2	0.08	44%
			sub - 100,000 yrlg – 100,000	Alternative 3	0.08	44%
			sub - 100,000 yrlg – 100,000	Alternative 4	0.08	44%
Elwha Channel Hatchery (Elwha River)	Fall Chinook	Integrated	sub - 2,500,000 yrlg – 400,000	Alternative 1	Unk	NA
			sub - 2,500,000 yrlg – 400,000	Alternative 2	Unk	NA
			sub - 2,500,000 yrlg – 400,000	Alternative 3	Unk	NA
			sub - 2,500,000 yrlg – 400,000	Alternative 4	Unk	NA

Puget Sound Hatcheries Draft EIS

Appendix F

Hatchery Program Viewer (HPV) Analysis

Assessment of Operational Effectiveness of Puget Sound Hatchery Programs (HPV Analysis)

ICF – Jones & Stokes
June 2009

OVERVIEW

The Hatchery Scientific Review Group (HSRG), in collaboration with ICF-Jones & Stokes, developed a standardized procedure to determine the degree to which hatchery programs are operated according to widely accepted best management practices (BMPs). The procedure covers all operational phases of hatchery operation except program size (number of juveniles released) and some aspects of broodstock composition. These elements were excluded from the BMP analysis because their impact on the performance of hatchery programs and associated natural populations is so direct, and because these impacts are evaluated by another assessment tool, the All H Analyzer (AHA).

Employing operational BMPs is clearly a necessary if not a sufficient condition for a meeting an overall hatchery goal. The goal of a hatchery is determined by its *purpose* and *type.* Hatchery purposes are considered to be either the augmentation of harvest, or the conservation of a natural population. Hatchery types are classified either as segregated or integrated. Segregated programs attempt to minimize all interactions between hatchery-reared and natural fish, especially genetic interactions. Adaptations to an artificial spawning and rearing environment are promoted, and every effort is made to exclude natural fish from brood stock and to limit the number of hatchery fish that spawn naturally. According to current genetic theory, one of the most important characteristics of segregated programs is that the proportion of hatchery-origin fish in the natural spawning escapement (pHOS) be five percent or less. Conversely, the focus of integrated programs is the natural population, of which hatchery fish are considered to be a part. The ultimate goal of an integrated program is that the adaptation of the combined hatchery and natural population is driven primarily by the characteristics of the natural environment. This goal implies that the proportion of natural-origin fish in the broodstock (pNOB) must, on average, exceed pHOS, the proportion of hatchery-origin spawners in nature (Ford 2002). This fundamental requirement has been quantified by a metric termed the PNI, or the Proportionate Natural Influence[1], which is approximated by pNOB/(pNOB + pHOS). If adaptations are to be driven by the natural environment, PNI must be greater than 0.5.

In terms of the HSRG classification scheme, there are four qualitatively different goals for a hatchery depending on whether it is an Integrated Harvest program, an Integrated Conservation program, a Segregated Harvest program or a Segregated Conservation program. Very broadly, the fundamental goals for these four distinct kinds of hatcheries are as follows. Integrated harvest programs should increase harvest opportunity by

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[1] The term *proportionate natural influence* (*PNI*) was first coined by C. Busack, Washington Department of Fish and Wildlife, Olympia, WA.

increasing the productivity of a composite population that continues to be adapted the characteristics and carrying capacity of the natal watershed. Integrated conservation programs focus exclusively on increasing the viability of a composite population by increasing its overall productivity, abundance, life history diversity and geographic distribution. Segregated harvest programs attempt to breed a hatchery population uniquely suited to a particular fishery and, ideally, incapable of ecological or genetic interactions with natural fish of the same species. Segregated conservation programs are typically used to prevent the extinction of a population whose natal watershed has been severely degraded. Such programs attempt to preserve a population either by sequestering it entirely within a hatchery environment, as in a captive brood stock program, or by marking and releasing fish of known ancestry such that essentially all spawning occurs in the hatchery. These broad goals underlie the scheme developed by the HSRG to evaluate salmon and steelhead hatcheries in terms of the BMPs expected of hatchery programs of a specific type and purpose.

DETAILS OF ANALYSIS

Assessment of Operational Effectiveness

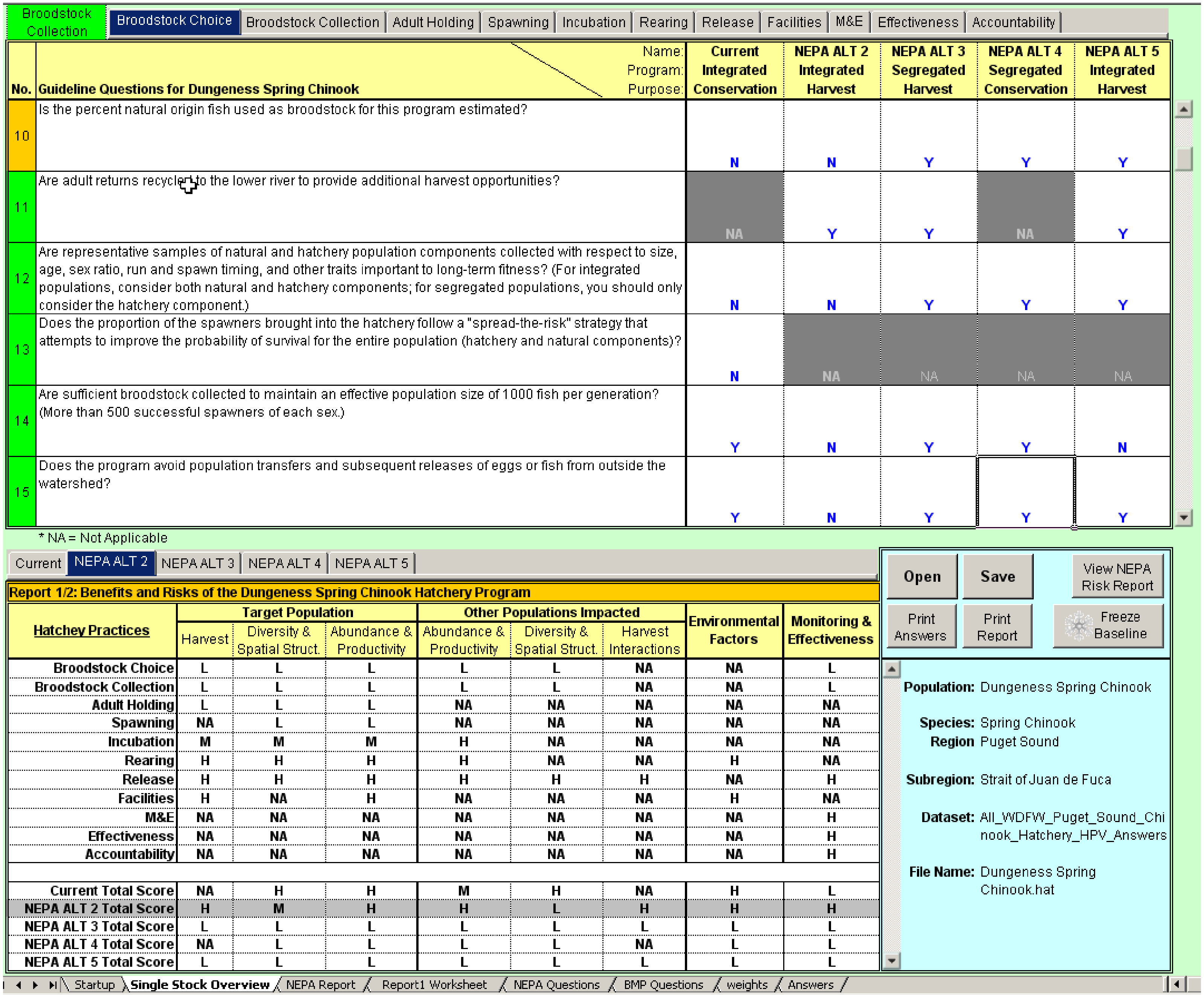
The tool developed by the HSRG to assess operational effectiveness[2] is called the Hatchery Program Viewer (HPV). The HPV is built around a list of 87 questions distributed over 11 operationally distinct hatchery operational components. In order of the sequence in which they typically occur, the 11 hatchery operational components evaluated are: 1) broodstock choice, 2) broodstock collection, 3) adult holding, 4) spawning, 5) incubation, 6) rearing, 7) release, 8) facilities, 9) monitoring, 10) effectiveness and 11) accountability. Each question is tied to effects on one or more of the following impact categories: impacts on the target population[3], impacts on non-target populations, impacts on the environment, or impacts on monitoring and effectiveness. Impact categories for target and non-target populations are, in turn, broken down into impacts on productivity and abundance, impacts on diversity and spatial structure, and impacts on harvest. Answers to these questions generate a total score by impact category for a specific program under four different management scenarios. The HPV is intended to highlight specific benefits and risks associated with each of the hatchery practices covered by the questions, and to identify overall operational deficiencies (or operational effectiveness) by impact category. Ratings take the values of "High operational effectiveness", "Medium operational effectiveness" or "Low operational effectiveness" according to whether the score is, respectively, above 60% of the total possible, between 60 and 40% of the total possible, or less than 40% of the total possible. It should be noted that the 87 questions comprising the HPV are assigned weights between 0 (not

[2] The phrase "operational effectiveness" is to be understood in this document as "the degree to which appropriate Best Management Practices are implemented for a hatchery program of a particular type and purpose".
[3] The phrase "target population" is to be understood as the hatchery population as well as the associated natural population of the same species and race. Sometimes no "associated natural population" exists, as in the case of a segregated harvest fall Chinook program in which smolts are released into a very small tributary that has never been capable of supporting a natural population of fall Chinook. The target population, however, does include a natural component whenever the subbasin of release supports a natural population of the same species and race.

applicable for a specific program type and purpose) to 10 (extremely important for a specific program type and purpose). The weights were the basis for computing an overall BMP score for a particular hatchery operational component. This weighting scheme was developed by ICF Jones & Stokes and several HSRG members, and was intended to reflect the thinking of the HSRG with regard to the importance of each question to programs of a specific purpose and type. Appendix Table 1.1 lists all of the questions included in the HPV analysis as well as the risks and benefits attributed to each BMP. Appendix Table 1.2 provides a full list of citations that were considered in developing the BMPs. Appendix Tables 1.3 through 1.6 shows the weightings assigned to each question for programs that are, respectively, Integrated Harvest, Integrated Conservation, Segregated Harvest or Segregated Conservation programs.

Figure 1 illustrates the matrix of hatchery operations and impact categories as they appear in the HPV “Single Stock Overview”. Although the hatchery program identified in Figure 1 is real, the answers to the operational effectiveness questions are hypothetical. In this hypothetical example, the current program is an integrated conservation program while NEPA alternatives 2 through 5 are, respectively, integrated harvest, segregated harvest, segregated conservation and integrated harvest programs (see the yellow-shaded Name/Program/Purpose headers at top of Figure 1). The six rows in the top half of the Figure represent five Broodstock Collection questions and one Broodstock Choice question, the answers to which appear to the right in columns under the five alternatives. (In the HPV computer application, all 90 questions are viewed and answered in this upper section using the scroll button on the right in Figure 1 to display additional questions). Note that most answers are “Yes/No”, with the correct BMP response usually being “Yes”, although some require a numeric response. The grayed cells in the matrix in the top half of Figure 1 indicate programs for which a particular question is inapplicable. For example, question 11, “Are adult returns recycled to the lower river to provide additional harvest opportunities,” does not apply to conservation programs. Other questions are similarly applicable to some kinds of programs but not to others.

The bottom half of Figure 1 is the operational effectiveness matrix, in which rows are distinct hatchery operations and columns are impact categories. The bottom-most five rows represent the sum of the scores across all operations within a given impact category for a given NEPA alternative. More precisely, the bottom five rows represent the categorical ratings associated with the sum of scores by impact category and alternative. In the computer application, the user clicks on one of the “alternative tabs” at the top of the effectiveness matrix to highlight the overall rating in the appropriate “Total Score” row at the bottom and to display in the upper 11 rows the effects individual hatchery operations have on individual impact categories. In the example shown in Figure 1, “NEPA alternative 2” has been selected and the operation-by-impact category ratings for alternative 2 are displayed in the upper 11 rows.



Broodstock Collection | Broodstock Choice | Broodstock Collection | Adult Holding | Spawning | Incubation | Rearing | Release | Facilities | M&E | Effectiveness | Accountability

No.	Guideline Questions for Dungeness Spring Chinook (Name: / Program: / Purpose:)	Current Integrated Conservation	NEPA ALT 2 Integrated Harvest	NEPA ALT 3 Segregated Harvest	NEPA ALT 4 Segregated Conservation	NEPA ALT 5 Integrated Harvest
10	Is the percent natural origin fish used as broodstock for this program estimated?	N	N	Y	Y	Y
11	Are adult returns recycled to the lower river to provide additional harvest opportunities?	NA	Y	Y	NA	Y
12	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	N	N	Y	Y	Y
13	Does the proportion of the spawners brought into the hatchery follow a "spread-the-risk" strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	N	NA	NA	NA	NA
14	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	Y	N	Y	Y	N
15	Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?	Y	N	Y	Y	Y

* NA = Not Applicable

Current | NEPA ALT 2 | NEPA ALT 3 | NEPA ALT 4 | NEPA ALT 5

Report 1/2: Benefits and Risks of the Dungeness Spring Chinook Hatchery Program

Hatchey Practices	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations Impacted: Abundance & Productivity	Other Populations Impacted: Diversity & Spatial Struct.	Other Populations Impacted: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness
Broodstock Choice	L	L	L	L	L	NA	NA	L
Broodstock Collection	L	L	L	L	L	NA	NA	L
Adult Holding	L	L	L	NA	NA	NA	NA	NA
Spawning	NA	L	L	NA	NA	NA	NA	NA
Incubation	M	M	M	H	NA	NA	NA	NA
Rearing	H	H	H	H	NA	NA	H	NA
Release	H	H	H	H	H	H	NA	H
Facilities	H	NA	H	NA	NA	NA	H	NA
M&E	NA	NA	NA	NA	NA	NA	NA	H
Effectiveness	NA	NA	NA	NA	NA	NA	NA	H
Accountability	NA	NA	NA	NA	NA	NA	NA	H
Current Total Score	NA	H	H	M	H	NA	H	L
NEPA ALT 2 Total Score	H	M	H	H	L	H	H	H
NEPA ALT 3 Total Score	L	L	L	L	L	L	L	L
NEPA ALT 4 Total Score	NA	L	L	L	L	NA	L	L
NEPA ALT 5 Total Score	L	L	L	L	L	L	L	L

Open | Save | View NEPA Risk Report | Print Answers | Print Report | Freeze Baseline

Population: Dungeness Spring Chinook
Species: Spring Chinook
Region Puget Sound
Subregion: Strait of Juan de Fuca
Dataset: All_WDFW_Puget_Sound_Chinook_Hatchery_HPV_Answers
File Name: Dungeness Spring Chinook.hat

Startup | Single Stock Overview | NEPA Report | Report1 Worksheet | NEPA Questions | BMP Questions | weights | Answers

Figure 1. Example of HPV analysis output

The overall rating for target population Diversity and Spatial Structure under alternative 2 is “M”, and this rating is attributable to “L” ratings assigned to Broodstock Choice, Broodstock Collection Adult Holding and Spawning..

Identification of BMP-specific Risks and Benefits

One feature of the HPV analysis should be mentioned in some detail because it provides direction in diagnosing the causes of operational ineffectiveness and in evaluating the nature and severity of the impact of not employing a particular BMP. The HSRG and ICF-Jones & Stokes developed a benefit and a risk statement for each of the 87 questions in the HPV analysis. In the computer application, the user can view the specific benefits and risks associated with every hatchery operation by opening up a benefit/risk sheet in the Workbook. An example of what they see when they do so is shown below.

Excerpt from a Benefit/Risk statements list.

Broodstock Choice

Benefit Statements

Current

This program uses a broodstock representing populations native or adapted to the watershed, which increases the likelihood of long term survival of the stock, helps avoid loss of among population diversity, and reduces the likelihood of unexpected ecological interactions.

Choice of a broodstock with similar morphological and life history traits improves the likelihood of the stock's adaptation to the natural environment.

The broodstock chosen poses no threat to other populations in the watershed from pathogen transmission

Estimating the proportion of natural fish used for broodstock makes it possible to determine whether composition targets have been met and prevents masking of the status of both the hatchery and natural populations.

Risk Statements

Current

None

Broodstock Collection

Benefit Statements

Current

Collection of representative samples of both the natural and hatchery populations reduces the risk of domestication and loss of within population diversity.

The proportion of spawners brought into the hatchery improves the likelihood that the population will survive a catastrophic loss from natural events or hatchery failure.

Risk Statements

Current

Sufficient broodstock are not collected to maintain genetic variation in the population

Stock transfers from outside the watershed pose a risk to local adaptation and increases the risk of pathogen transmission.

Pre-spawning mortality greater than 10% poses a risk to maintaining effective population size and a risk of domestication selection

Lack of established guidelines for acceptable contribution of hatchery origin fish to natural spawning makes program evaluation difficult.

This excerpt shows the benefit/risk tabulation for a hypothetical population and hatchery program. A complete list would cover all hatchery operations, not just Broodstock Choice and Broodstock collection. Whenever the response to a particular question indicates a particular BMP is employed, the benefit of doing so appears in a list. Conversely, risk statements appear only when particular BMPs are not employed. It is particularly useful to managers to scan the risks associated with their program, because they highlight the nature and severity of existing problems and define the objectives for an improvement program.

Appendix Table 1.1 Hatchery Best Management Practices advocated by the HSRG, benefits risks and rationales for each Best Management Practice, and supporting documents from the scientific literature.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Brood Stock Choice	**1**	Does the broodstock chosen represent natural populations native or adapted to the watersheds in which hatchery fish will be released?	Y	Answer is "No" if program is supplemented at any time with out-of-basin broodstock or eggs when egg-take goals are not met by in-basin returns.		This program uses a broodstock representing populations native or adapted to the watershed, which increases the likelihood of long term survival of the stock, helps avoid loss of among population diversity, and reduces the likelihood of unexpected ecological interactions.	Selection of a broodstock not representing populations native or adapted to the watershed poses a risk of loss of among population diversity and may pose additional risks of adverse ecological interactions with non-target stocks.
Brood Stock Choice	**2**	If stock has been extirpated, is the broodstock chosen likely to adapt to the system based on life history and evolutionary history?	Y	Answer "Yes" if not extirpated. Note as much in comments	Not applicable to conservation programs	Choice of a broodstock with a similar life history and evolutionary history to the extirpated stock improves the likelihood of successful re-introduction.	Choice of a broodstock with a dissimilar life history and evolutionary history to the extirpated stock reduces the likelihood of successful re-introduction.
Brood Stock Choice	**3**	Does the broodstock chosen display morphological and life history traits similar to the natural population?	Y	If there's purposeful domestication (run advancement, etc) then answer N even if original brood is indigenous stock. But the answer is "Yes" if program always sustained by returns to watershed even if wild fish are never used as broodstock. For example, the answer would be "Yes" for the Green River Chinook program, which began with endemic fish, but has never since its inception included NORs as broodstock.		Choice of a broodstock with similar morphological and life history traits improves the likelihood of the stock's adaptation to the natural environment.	Choice of a broodstock with dissimilar morphological and life history traits poses a risk that the stock will not adapt well to the natural environment.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Brood Stock Choice	**4**	Does the broodstock chosen have a pathogen history that indicates no threat to other populations in the watershed?	Y	Usually based on use of imported broodstock. If the broodstock represents the natural population -- or reflects conditions inside the targeted watershed -- then answer Yes. Answer Yes (no threat) if broodstock was imported in the distant past, but routine importation has long been discontinued.		The broodstock chosen poses no threat to other populations in the watershed from pathogen transmission	The broodstock chosen poses a risk to other populations in the watershed from pathogen transmission
Brood Stock Choice	**5**	Does the broodstock chosen have the desired life history traits to meet harvest goals? (e.g. timing and migration patterns that result in full recruitment to target fisheries)?	Y	Is the stock known to return at times and in places where it can be harvested effectively and with minimal adverse impacts on commingled non-target stocks?	Applies only to Segregated Harvest programs	The broodstock chosen is likely to have the life history traits to meet harvest goals for the target stocks without adversely impacting other stocks.	The broodstock chosen is unlikely to have the life history traits to successfully meet harvest goals and may contribute to overharvest of comingled stocks.
Brood Stock Choice	**6**	What is the percent natural origin fish in the hatchery broodstock?		Answers to this question trigger subsequent questions.		NA	NA
Brood Stock Choice	**7**	Do natural origin fish make up less than 5% of the broodstock for this program?	Y		Applies only to segregated harvest programs.	Maintaining a hatchery population composed of less than 5% natural fish reduces the risk of loss of among population diversity.	Maintaining a hatchery population composed of more than 5% natural fish increases the risk of loss of among population diversity.
Brood Stock Choice	**10**	Is the percent natural origin fish used as broodstock for this program estimated?	Y			Estimating the proportion of natural fish used for broodstock makes it possible to determine whether composition targets have been met and prevents masking of the status of both the hatchery and natural populations.	Percent wild fish used as broodstock for this program is not accurately estimated . Not estimating of the proportion of natural fish used for broodstock makes it impossible to determine whether composition targets have been met and it masks the status of both the hatchery and natural populations.
Brood Stock Collection	**11**	Are adult returns recycled to the lower river to provide additional harvest opportunities?	N	Answer is "Yes" even if recycling doesn't occur in the "lower river", but to some area supporting a fishery, and even if the HGMP says there is "no directed harvest" on the stock.	Applies only to harvest programs	Not recycling adults to the lower river to provide additional harvest reduces the likelihood of straying and unintended contribution to natural spawning	Recycling adults to provide additional harvest benefits can increase the likelihood of straying and increase the contribution of hatchery fish on the spawning grounds

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Brood Stock Collection	**12**	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	Y	Answer is "No" for integrated programs that do not collect NORs. Answer is "No" even when NORs are collected if the collection occurs only at a hatchery rack, especially if the hatchery is located on a smaller tributary (Chinook programs). The answer is "Yes" only when all fish are stopped by a weir on a lower portion of the main migratory corridor, or brood is collected throughout the watershed, and brood are randomly selected from all available returns.		Collection of representative samples of both the natural and hatchery populations reduces the risk of domestication and loss of within population diversity.	Failure to collect representative samples of both the natural and hatchery populations poses a risk of loss of within population diversity and viability.
Brood Stock Collection	**13**	Does the proportion of the spawners brought into the hatchery follow a “spread-the-risk” strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	Y	A "spread-the-risk" strategy consists of an explicit discussion of relative extinction risk to the natural population as a function of natural productivity, hatchery recruitment rates, and genetic and demographic risks associated with hatchery production.	Applies only to Integrated Conservation programs	The proportion of spawners brought into the hatchery improves the likelihood that the population will survive a catastrophic loss from natural events or hatchery failure.	The proportion of spawners brought into the hatchery increases the risk that the population not will survive a catastrophic loss from natural events or hatchery failure.
Brood Stock Collection	**14**	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	Y	Minimal effective population size is approximately 1000/(mean age of maturity). Therefore minimum population size for Chinook is usually = 1000/4 =250; for Coho = 1000/(2 or 3), or 500/333. Answer is based on the source of the broodstock -- the total number of fish used for broodstock -- and not just the broodstock needed to fulfill a specific program's (or sub-program's) needs.		Sufficient broodstock are collected to maintain genetic variation in the population	Sufficient broodstock are not collected to maintain genetic variation in the population
Brood Stock Collection	**15**	Does the program avoid stock transfers and subsequent releases of eggs or fish from outside the watershed?	Y	Answer "No" even if outside stocks are used very infrequently (e.g., once, 12 years ago).		Avoidance of stock transfers from outside the watershed promotes local adaptation and reduces the risk of pathogen transmission.	Stock transfers from outside the watershed pose a risk to local adaptation and increases the risk of pathogen transmission.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Brood Stock Collection	**16**	Is the broodstock collected and held in a manner that results in less than 10% prespawning mortality?	Y			Maintaining pre-spawning survival higher than 90% maintains effective population size and reduces domestication selection.	Pre-spawning mortality greater than 10% poses a risk to maintaining effective population size and a risk of domestication selection
Brood Stock Collection	**17**	Do you have guidelines for acceptable contribution of hatchery origin fish to natural spawning?	Y	Answer is "No" if explicit guidelines have not been developed. Answer is "No" even if only NORs are passed above the hatchery if HORs are allowed to spawn at will below the hatchery.		Having established guidelines for acceptable contribution of hatchery origin fish to natural spawning provides a clear performance standard for evaluating the program.	Lack of established guidelines for acceptable contribution of hatchery origin fish to natural spawning makes program evaluation difficult.
Brood Stock Collection	**18**	Are guidelines for hatchery contribution to natural spawning met for all affected naturally spawning populations?	Y			The rate of hatchery contribution to natural spawning populations maintains among population diversity and promotes adaptation to the natural environment.	The rate of hatchery contribution to natural spawning populations poses a risk of loss of among population diversity and domestication selection.
Adult Holding	**19**	Is the water source [for adult holding] specific-pathogen free?	Y	Answer is Yes if well or spring water is the only water source. If surface water is the source, need to consider list of specific pathogens, fish presence, etc. Co-Manager's regulated pathogens are IHNV, IPNV, VHSV, and M. cerebralis. Short-cut answers: Well or spring=Y, surface water =N.		Fish health is promoted by the absence of specific pathogens during adult holding.	There is a risk to fish health due to the lack of specific-pathogen free water for adult holding.
Adult Holding	**20**	Does the water used [for adult holding] result in natural water temperature profiles that provide optimum maturation and gamete development?	Y	A 2-part answer: is the temperature profile natural (that of local surface water)? If yes, then, "is the temperature profile suitable"? The answer is "Yes" only if the answers to both questions are affirmative.		Use of water resulting in natural water temperature profiles for adult holding ensures maturation and gamete development synchronous with natural stocks.	Lack of natural water temperature profiles may lead to domestication selection for adult maturation and gamete development.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Adult Holding	**21**	Is the water supply [for adult holding] protected by alarms?	Y	No Answer if the HGMP does not indicate specifically that the adult holding is protected by alarms		Broodstock security is maintained by flow and/or level alarms at the holding ponds.	Absence of flow and/or level alarms at the holding pond may pose a risk to broodstock security.
Adult Holding	**22**	Is the water supply [for adult holding] protected by back-up power generation?	Y	Answer Y if gravity fed. Question is getting at whether hatchery evaluation should be downgraded for not having back-up water supply. Gravity feed = no need for back-up power, therefore Y.		Broodstock security is maintained by back-up power generation for the pumped water supply.	Lack of back-up power generation for the pumped water supply may pose a risk to broodstock security.
Spawning	**23**	Are males and females available for spawning on a given day randomly mated?	Y			Random mating maintains within population diversity.	Non-random mating increases the risk of loss of within population diversity.
Spawning	**24**	Are gametes pooled prior to fertilization?	N	Use of backup males does not = pooled gametes.		Single family pairing increases the effective population size of the hatchery stock.	Pooling of gametes poses a risk to maintaining genetic diversity in the hatchery population.
Spawning	**25**	Are back-up males used in the spawning protocol?	Y	Typical use of back-up males is to spawn one male, wait a minute and then spawn a second male. However, if male gametes are pooled prior to fertilization (#24=Yes), then answer is Yes. Y for 24 not necessarily Y for 25. Only if males are pooled.		Use of back-up males in the spawning protocol increases the likelihood of fertilization of eggs from each female.	Not using of back-up males in the spawning protocol increases the risk of unfertilized eggs and loss of genetic diversity in the broodstock.
Spawning	**26**	Are precocious males (mini-jacks and jacks) used for spawning as a set percentage or in proportion to their contribution to the adult run? (note whether mini-jacks are used in the comment box.)	Y	Answer "no" only if jacks/mini-jacks are not used.		Use of precocious males for spawning as a set percentage or in proportion to their contribution to the adult run promotes within population diversity.	Not using precocious males for spawning as a set percentage or in proportion to their contribution to the adult run increases the risk of loss of within population diversity.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Incubation	**27**	Is the water source [for incubation] pathogen-free?	Y	Answer Yes if spring or well water and No if surface water. If eggs from a program are incubated at multiple facilities, answer "No" even if only one of the incubation facilities is not pathogen-free.	Applies only to Conservation programs	Fish health is promoted by the use of pathogen-free water during incubation.	There is a risk to fish health due to the lack of pathogen-free water for incubation.
Incubation	**28**	Is the water source [for incubation] specific-pathogen free?	Y	Answer is Yes if well or spring water is the only water source. If surface water is the source, need to consider list of specific pathogens, fish presence, etc. Co-Manager's regulated pathogens are IHNV, IPNV, VHSV, and M. cerebralis.	Does not apply to Integrated Conservation programs	Fish health is promoted by the absence of specific pathogens during incubation.	There is a risk to fish health due to the lack of specific-pathogen free water for incubation.
Incubation	**29**	Does the water used [for incubation] provide natural water temperature profiles that result in hatching/emergence timing similar to that of the naturally produced stock?	Y	Answer Yes if the water source provides natural temperature profiles (surface water). Answer No if well or spring water is used.		Use of water resulting in natural water temperature profiles for incubation ensures hatching and emergence timing similar to naturally produced stocks with attendant survival benefits.	Lack of natural water temperature profiles may contribute to domestication selection during incubation.
Incubation	**30**	Can incubation water [for incubation] be heated or chilled to approximate natural water temperature profiles?	Y	Does not apply to the use of heaters or chillers for otolith marking.	Applies only to Conservation programs	The ability to heat or chill incubation water to approximate natural water temperature profiles ensures hatching and emergence timing similar to naturally produced stocks with attendant survival benefits.	The inability to heat or chill incubation water to approximate natural water temperature profiles may contribute to domestication selection during incubation.
Incubation	**31**	Is the water supply [for incubation] protected by flow alarms?	Y	No Answer if the HGMP does not indicate specifically that incubation is protected by alarms.		Security during incubation is maintained by flow alarms at the incubation units.	Absence of flow alarms at the incubation units may pose a risk to the security of incubating eggs and alevin.
Incubation	**32**	Is the water supply [for incubation] protected by back-up power generation?	Y	Answer Y if gravity fed. Question is getting at whether hatchery evaluation should be downgraded for not having back-up water supply. Gravity feed = no need for back-up power, therefore Y.		Security during incubation is maintained by back-up power generation for the pumped water supply.	Absence of back-up power generation for the pumped water supply may pose a risk to the security of incubating eggs and alevin.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Incubation	**33**	Are eggs incubated under conditions that result in equal survival of all segments of the population to ponding? (Does any portion of the eggs derive a survival advantage or disadvantage from incubation procedures? If yes, then mark NO for response)	Y	HGMP almost never answers this question. Refer to Managers for resolution.		Incubation conditions that result in equal survival of all segments of the population reduce the likelihood of domestication selection and loss of genetic variability.	Incubation conditions that result in unequal survival of all segments of the population pose a risk of domestication selection and loss of genetic variability.
Incubation	**34**	Are families incubated individually? (Includes both eying and hatching.)	Y	HGMP almost never answers this question. Refer to Managers for resolution.	Applies only to Conservation programs	Incubating families individually maintains genetic variability during incubation.	Not incubating families individually poses a risk of loss of genetic variability.
Incubation	**35**	Does the program use water sources that result in hatching/emergence timing similar to that of the naturally produced population?	Y	Answer Yes if the water source provides natural temperature profiles (surface water). Answer No if well or spring water is used.		Use of water resulting in natural water temperature profiles for incubation ensures hatching and emergence timing similar to naturally produced stocks.	Lack of natural water temperature profiles may lead to domestication selection during incubation.
Incubation	**36**	Are agency, tribal, or IHOT species-specific incubation recommendations followed for flows?	Y	No Answer if the standards are not specified. Following the guidelines set forth in Piper et al. is not considered YES unless there is a discussion of these guidelines being specifically developed for that particular station's conditions. IHOT does not apply to Puget Sound.		Use of IHOT flow recommendations during incubation promote survival of eggs and alevin and allow for optimum fry development.	Failing to meet IHOT flow recommendations during incubation poses a risk to the survival of eggs and alevin and may not allow for optimum fry development.
Incubation	**37**	Are agency, tribal, or IHOT species-specific incubation recommendations followed for substrate?	Y	No Answer if the standards are not specified. Following the guidelines set forth in Piper et al. is not considered YES unless there is a discussion of these guidelines being specifically developed for that particular station's conditions. IHOT does not apply to Puget Sound.		Use of IHOT recommendations for use of substrate during incubation limits excess alevin movement and promotes energetic efficiently.	Failing to meet IHOT recommendations for using substrate during incubation may allow excess alevin movement and reduces energetic efficiency.
Incubation	**38**	Are agency, tribal, or IHOT species-specific incubation recommendations followed for density parameters?	Y	No Answer if the standards are not specified. Following the guidelines set forth in Piper et al. is not considered YES unless there is a discussion of these guidelines being specifically developed for that particular station's conditions. IHOT does not apply to Puget Sound.		Use of IHOT density recommendations during incubation promote survival of eggs and alevin and allow for optimum fry development.	Failing to meet IHOT density recommendations during incubation poses a risk to the survival of eggs and alevin and may not allow for optimum fry development.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Incubation	**39**	Are disinfection procedures implemented during incubation that prevent pathogen transmission between stocks of fish on site? (Do you have written protocols? If so, describe in the data comment box.)	Y	1998 Co-Managers Fish Health Policy does not provide protocols to address this question. Answer "Yes" if only 1 stock of on site regardless of procedures.		Proper disinfection procedures increase the likelihood of preventing dissemination and amplification of pathogens in the hatchery.	Lack of proper disinfection procedures increase the risk of dissemination and amplification of pathogens in the hatchery.
Incubation	**40**	If eggs are culled, is culling done randomly over all segments of the egg-take?	Y			Random culling of eggs over all segments of the egg-take maintains genetic variability during incubation.	Non-random culling of eggs increases the risk of loss of genetic variability during incubation.
Rearing	**41**	Is the water source [for rearing] specific-pathogen free?	Y	Answer is Yes if well or spring water is the only water source. If surface water is the source, need to consider list of specific pathogens, fish presence, etc. Co-Manager's regulated pathogens are IHNV, IPNV, VHSV, and M. cerebralis but answer to this question derived from water source. Well or spring=Y, surface water =N.		Fish health is promoted by the absence of specific pathogens during rearing.	There is a risk to fish health due to the lack of specific-pathogen free water for rearing.
Rearing	**42**	Does the water used [for rearing] provide natural water temperature profiles that result in fish similar in size to naturally produced fish of the same species?	Y	Answer Yes if the water source provides natural temperature profiles (surface water). Answer No if well or spring water is used.		Use of water resulting in natural water temperature profiles for rearing promotes growth of fish and smoltification synchronous with naturally produced stocks.	Lack of natural water temperature profiles may lead to domestication selection during rearing.
Rearing	**43**	Does the hatchery operate to allow all migrating species of all ages to by-pass or pass through hatchery related structures?	Y	Answer "Yes" if hatchery located at headwater spring. Answer "Yes" if operations pass only NOR fish and retain HOR fish, and passage delay doesn't matter.		Providing upstream and downstream passage of juveniles and adults supports natural distribution and productivity of naturally produced stocks.	Inhibiting upstream and downstream passage of juveniles and adults poses a risk to distribution and productivity of naturally produced stocks.
Rearing	**44**	Is the water supply [for rearing] protected by alarms?	Y	No Answer if the HGMP does not indicate specifically that the adult holding is protected by alarms.		Security during rearing is maintained by flow and/or level alarms at the rearing ponds.	Absence of flow and/or level alarms at rearing ponds may pose a risk to the security of the cultured fish.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Rearing	**45**	Is the water supply [for rearing] protected by back-up power generation?	Y	Answer "Yes" if gravity fed. Question is getting at whether hatchery should be downgraded for not having back up on water supply.		Security during rearing is maintained by back-up power generation for the pumped water supply.	Absence of back-up power generation for the pumped water supply may pose a risk to the security of the cultured fish.
Rearing	**46**	Are fish reared under conditions that result in equal survival of all segments of the population to release? (In other words, does any portion of the population derive a survival advantage or disadvantage from rearing procedures? If yes, then mark NO in box.)	Y	Usually this will have to be resolved by Managers. Answer "No" if spring water used for eggs collected later in season to compensate for rising temperatures in surface water.		Rearing conditions that result in equal survival of all segments of the population reduce the likelihood of domestication selection and loss of genetic variability.	Rearing conditions that result in unequal survival of all segments of the population pose a risk of domestication selection and loss of genetic variability.
Rearing	**47**	If juveniles are culled, is culling done randomly over all segments of the population? (respond yes if juveniles are not culled). Make sure to capture in the comments box the number culled, and the rational for culling.	Y	Note: fry outplanting is juvenile culling.		Random culling of juveniles over all segments of the population maintains genetic variability during rearing.	Non-random culling of juveniles increases the risk of loss of genetic variability during rearing.
Rearing	**48**	Is the correct amount and type of food provided to achieve the desired growth rate?	Y	"No" if HGMP does not specify desired growth rate.		Following proper feeding rates to achieve the desired growth rate improves the likelihood of producing fish that are physiologically fit, properly smolted, and that maintain the age structure of natural populations.	Improper feeding that does not achieve desired growth rate increases the risk of producing fish that are not physiologically fit, that are not properly smolted, and that exhibit an age structure not representative of natural populations.
Rearing	**49**	Is the correct amount and type of food provided to achieve the desired condition factors for the species and life stage being reared?	Y	No Answer if HGMP does not specify desired CF.		Feeding to achieve the desired condition factor is an indicator of proper fish health and physiological smolt quality.	Feeding that does not achieve the desired condition factor may be an indicator of poor fish health and physiological smolt quality.
Rearing	**50**	Does the program use a diet and growth regime that mimics natural seasonal growth patterns? If not, describe the differences in the comment field?	Y	Does the size profile of hatchery fish through time match that of the associated natural stock? HGMPs usually do not discuss.		Use of diet and growth regimes that mimic natural seasonal growth patterns promote proper smoltification and should produce adults that maintain the age structure of the natural population.	Use of diet and growth regimes that do not mimic natural seasonal growth patterns pose a risk to proper smoltification and may alter the age structure of the hatchery population.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Rearing	**51**	Is the program attempting to better mimic the natural stream environment by providing natural or artificial cover?	Y	Answer "No" if no "NATURES" practices implemented (Section 9.2.9), or if a significant effort is not made to replicate natural habitat during rearing.		Providing artificial cover increases the development of appropriate body camouflage and may improve behavioral fitness.	Lack of overhead and in-pond structure does not produce fish with the same cryptic coloration or behavior as do using enhanced environments.
Rearing	**52**	Are fish reared in multiple facilities or with redundant systems to reduce the risk of catastrophic loss?	Y	Answer "Yes" if interim rearing occurs at several facilities but all program fish are then acclimated and released from a single facility.	Applies only to Conservation programs	Maintaining the stock in multiple facilities or with redundant systems reduces the risk of catastrophic loss from facility failure.	Not maintaining the stock in multiple facilities or with redundant systems increases the risk of catastrophic loss from facility failure.
Rearing	**53**	Are agency, tribal, or IHOT juvenile rearing standards followed for loading?	Y	No if the standards are not specified. Following the guidelines set forth in Piper et al. is not considered YES unless there is a discussion of these guidelines being specifically developed for that particular station's conditions. IHOT does not apply to Puget Sound.		Following IHOT standards for juvenile loading maintains proper dissolved oxygen levels promoting fish health, growth and survival, and increases the likelihood of preventing dissemination and amplification of fish pathogens.	Not following IHOT standards for juvenile loading poses a risk to maintaining proper dissolved oxygen levels, compromising fish health and growth and increases the likelihood of dissemination and amplification of fish pathogens.
Rearing	**54**	Are agency, tribal, or IHOT juvenile rearing standards followed for density?	Y	No Answer if the standards are not specified. Following the guidelines set forth in Piper et al. is not considered YES unless there is a discussion of these guidelines being specifically developed for that particular station's conditions. IHOT does not apply to Puget Sound.		Following IHOT standards for juvenile density maintain fish health, growth, and survival, and increases the likelihood of preventing dissemination and amplification of fish pathogens.	Not following IHOT standards for juvenile density poses a risk to maintaining fish health, growth, and survival, and increases the likelihood of dissemination and amplification of fish pathogens.
Rearing	**55**	For captive broodstocks, are fish maintained on natural photoperiod to ensure normal maturation?	Y	If a conservation program, answer "yes" even if not a captive brood program.	Applies only to Conservation programs	Maintaining captive broodstock on natural photoperiods ensures normal maturation.	Maintaining captive broodstock on unnatural photoperiods poses a risk to normal maturation.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Rearing	**56**	For captive broodstocks, are fish maintained reared at 12C to minimize disease?	Y	If a conservation program, answer "yes" even if not a captive brood program.	Applies only to Conservation programs	Maintaining captive broodstock on rearing water below 12ºC reduces the risk of loss from disease.	Maintaining captive broodstock on rearing water above 12ºC increases the risk of loss from disease.
Rearing	**57**	For captive broodstocks, are diets and growth regimes selected that produce potent, fertile gametes and reduce excessive early maturation of fish?	Y	If a conservation program, answer "yes" even if not a captive brood program.	Applies only to Conservation programs	Producing viable gametes and maintaining age structure of the population in captive breeding increases the likelihood of meeting conservation goals.	Failure to produce viable gametes and maintain age structure of the population in captive breeding reduces the likelihood of meeting conservation goals.
Rearing	**58**	For captive broodstocks, are families reared individually to maintain pedigrees?	Y	If a conservation program, answer "yes" even if not a captive brood program.	Applies only to Conservation programs	Rearing families separately for captive broodstock programs maintains pedigrees to reduce the risk of inbreeding depression.	Inability to rear families separately for captive broodstock programs increases the risk of inbreeding depression.
Release	**59**	Are the fish produced qualitatively similar to natural fish in size (fpp and length)?	Y	Send back to Managers unless sizes of natural fish are explicitly compared to hatchery fish. Don't assume answer is "No" for yearling fall chinook programs unless all hatchery fall chinook production is yearling.		Producing fish that are qualitatively similar to natural fish in size may improve performance and reduce adverse ecological interactions.	Producing fish that are not qualitatively similar to natural fish in size may adversely affect performance and increase adverse ecological interactions.
Release	**60**	Are the fish produced qualitatively similar to natural fish in morphology?	Y	Answer "Yes" if NOR are incorporated into the broodstock. Otherwise, answer "No"..	Applies only to Integrated programs	Producing fish that are qualitatively similar to natural fish in morphology may improve performance and reduce adverse ecological interactions.	Producing fish that are not qualitatively similar to natural fish in morphology may adversely affect performance.
Release	**61**	Are the fish produced qualitatively similar to natural fish in behavior?	Y	Question addresses out-migration timing primarily. Answer "Yes" if NATURES rearing applied AND release is volitional. Answer "No" if hatchery releases occur after natural outmigration, regardless of whether the release is "volitional" or not.		Producing fish that are qualitatively similar to natural fish in behavior may improve performance and reduce adverse ecological interactions.	Producing fish that are not qualitatively similar to natural fish in behavior may adversely affect performance and increase adverse ecological interactions.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Release	**62**	Are the fish produced qualitatively similar to natural fish in growth rate?	Y	This question addresses the "size profile" -- the pattern of size through time. But it reduces to the relative sizes of hatchery and natural fish when hatchery fish are released. Therefore, answer "No" if the HOR are larger than the NOR outmigrants.		Producing fish that are qualitatively similar to natural fish in growth rate may improve performance and reduce adverse ecological interactions.	Producing fish that are not qualitatively similar to natural fish in growth rate may adversely affect performance and increase adverse ecological interactions.
Release	**63**	Are the fish produced qualitatively similar to natural fish in physiological status?	Y	Answer Yes if truly volitional releases of smolts occurs. Answer No if forced or quasi-volitional releases without ATPase or other hormonal testing.		Producing fish that are qualitatively similar to natural fish in physiological status may improve performance and reduce adverse ecological interactions.	Producing fish that are not qualitatively similar to natural fish in physiological status may adversely affect performance and increase adverse ecological interactions.
Release	**64**	Are fish released at sizes and life history stages similar to those of natural fish of the same species?	Y	Answer No if the HOR are larger than the NOR outmigrants. Answer No when fish are released at multiple life stages (e.g. fingerlings & yearlings), but the proportion does not match the proportion of those life stages in the natural population.		Releasing fish at sizes and life history stages similar to those of natural fish of the same species may improve performance and reduce adverse ecological interactions.	Releasing fish at sizes and life history stages dissimilar to those of natural fish of the same species may reduce performance and increase the risk of adverse ecological interaction.
Release	**65**	Are volitional releases during natural out-migration timing practiced?	Y	Answer Yes if releases are truly volitional (at least one week), and if they occur during the natural outmigration period.		Volitionally releasing smolts during the natural outmigration timing may improve homing, survival, and reduce adverse ecological interactions.	Failure to volitionally release smolts during the natural outmigration timing may adversely affect homing, survival, and increase risk of adverse ecological interactions.
Release	**66**	Are fish released in a manner that simulates natural seasonal migratory patterns?	Y	Usually leave for managers to answer.	Inapplicable to Integrated Conservation programs	Releasing fish in a manner that simulates natural seasonal migratory patterns improves the likelihood that harvest and conservation goals will be met and may reduce potential adverse ecological impacts.	Failing to release fish in a manner that simulates natural seasonal migratory patterns decreases the likelihood that harvest and conservation goals will be met and may increase the potential for adverse ecological impacts.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Release	**67**	Are fish released in stream reaches within the historic range of that stock?	Y	This question addresses whether or not the fish are being released in a portion of the stream where they could be expected to sustain themselves naturally.; the stock being released is not important.		Releasing fish within the historic range of that stock increases the likelihood that habitat conditions will support the type of fish being released and does not pose new risks of adverse ecological interactions with other stocks.	Releasing fish outside the historic range of that stock poses a risk that habitat conditions will not support the type of fish being released and poses new risks of adverse ecological interactions with other stocks.
Release	**68**	Are fish released in the same subbasin as rearing facility? This question is trying to determine if fish (juveniles) are transported into the subbasin.	Y	Answer this on a watershed scale (e.g. Skokomish River) and not a subbasin scale (e.g. Hood Canal). Answer "No" if hauled out for a portion of the rearing and brought back for release.		Releasing fish in the same subbasin as the rearing facility reduces the risk of dissemination of fish pathogens to the receiving watershed.	Not releasing fish in the same subbasin as the rearing facility increases the risk of dissemination of fish pathogens to the receiving watershed.
Release	**69**	Has the carrying capacity of the subbasin been taken into consideration in sizing this program in regards to determining the number of fish released?	Y	Answer No if PNI<0.5 (Integrated Programs) or if proportion of HOR naturally spawning >5% (Segregated Programs). Do not answer "Yes" unless the relationship between natural carrying capacity and hatchery production is explicitly analyzed and determined to be compatible ecologically and genetically.		Taking the carrying capacity of the subbasin into consideration when sizing the hatchery program increases the likelihood that stock productivity will be high and may limit the limit the risk of adverse ecological and harvest interactions.	Failing to take the carrying capacity of the subbasin into consideration when sizing the hatchery program poses a risk to the productivity of the stock and may increase the risk of adverse ecological and harvest interactions.
Release	**70**	Are 100% of the hatchery fish marked so that they can be distinguished from the natural populations?	Y			Marking 100% of the hatchery population allows them to be distinguished from the natural population and prevents the masking of the status of that population and prevent overharvest of weaker stocks.	Not marking 100% of the hatchery population prevents them from being distinguished from the natural population and may the mask the status of that population and cause over harvest of weaker stocks.
Facilities	**71**	Does hatchery intake screening comply with Integrated Hatchery Operations Team (IHOT), National Marine Fisheries Service, or other agency facility standards?	Y			Compliance with these standards reduces the likelihood that intake structures cause entrapment in hatchery facilities and impingement of migrating or rearing juveniles	Failure to comply with these standards increases the risk of entrapment in hatchery facilities and impingement of migrating or rearing juveniles

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Facilities	**72**	Does the facility operate within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit?	Y	Questions 72 & 72 may be mutually exclusive unless multiple facilities having different NPDES reporting requirements are used: 72 for > 20,000 lbs, 73 for <= 20,000 lbs. If small, usually not answered		Compliance with NDPES discharge limitations maintain water quality in downstream receiving habitat	Hatchery discharge may pose a risk to water quality in downstream receiving habitat
Facilities	**73**	If the production from this facility falls below the minimum production requirement for an NPDES permit, does the facility operate in compliance with state or federal regulations for discharge?	Y	Answer "yes" if the facility is large enough to require NPDES permitting.		Compliance with NDPES discharge limitations maintain water quality in downstream receiving habitat	Hatchery discharge may pose a risk to water quality in downstream receiving habitat
Facilities	**74**	Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?	Y	If HGMP explicitly sates that there is no vulnerability to flooding, then answer "Yes". Otherwise leave blank and allow Manger to answer.		Siting the facility where it is not susceptible to flooding decreases the likelihood of catastrophic loss.	Siting the facility where it is susceptible to flooding increases the likelihood of catastrophic loss.
Facilities	**75**	Is staff notified of emergency situations at the facility through the use of alarms, autodialer, and pagers?	Y	Leave blank unless HGMP specifies.		Notification to staff of emergency situations using alarms, autodialers, and pagers reduces the likelihood of catastrophic loss.	Inability to notify staff of emergency situations using alarms, autodialers, and pagers increases the likelihood of catastrophic loss.
Facilities	**76**	Is the facility continuously staffed to ensure the security of fish stocks on-site?	Y	Leave blank unless HGMP specifies.		Continuous facility staffing reduces the likelihood of catastrophic loss.	Lack of continuous facility staffing increases the likelihood of catastrophic loss.
M&E	**77**	Do you have a numerical goal for total catch in all fisheries?	Y	No Answer if numerical goal not explicitly stated. A goal for a harvest rate does not suffice: need numbers of fish.	Applies only to Harvest programs	This program has a numerical goal for total catch in all fisheries, which makes it possible to evaluate its success and implement information responsive management.	Lack of numerical goals for fishery contributions from this program makes it impossible to define and evaluate its success and difficult to implement information responsive management.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
M&E	**78**	Do you have a goal for broodstock composition (hatchery vs. natural) in the hatchery?	Y	No Answer if numerical goal not explicitly stated.		This program has a specific policy for hatchery broodstock composition (hatchery vs. natural), which makes it possible to monitor and evaluate its effectiveness and to test the validity of the policy.	This program lacks a specific policy for hatchery broodstock composition (hatchery vs. natural), which makes it difficult to monitor and evaluate its effectiveness and to test the validity of the policy.
M&E	**79**	Do you have a goal for spawning escapement composition (hatchery vs. natural) in the wild?	Y	No Answer if numerical goal not explicitly stated.		This program has a specific policy for natural spawning composition (hatchery vs natural), which makes it possible to monitor and evaluate its effectiveness and to test the validity of the policy.	This program lacks a specific policy for natural spawning composition (hatchery vs natural), which makes it difficult to monitor and evaluate its effectiveness and to test the validity of the policy.
M&E	**80**	Do you have a goal for smolt-to-adult return survival?	Y	No Answer if numerical goal not explicitly stated, and a "goal" = to 10-year average is acceptable.		This program has an explicit goal smolt to adult survival, which makes it possible to evaluate success and implement information responsive management.	Programs lacking SAR goals run the risk of becoming inefficient and ultimately “mining” natural fish (integrated programs) just to keep the hatchery in operation.
Effectiveness	**81**	What is the percent hatchery origin fish (first generation) in the natural spawning escapement (for the same species/race)?		Not likely to be answered in HGMP. Return to Managers if can't answer for the watershed of release.		NA	NA
Effectiveness	**82**	Do adults from this program make up less than 5% of the natural spawning escapement (for the species/race) in the subbasin?	-	Answers to 82, 83, and 84 are computed from answer to 81.			
Effectiveness	**83**	Do adults from this program make up between 5 and 30% of the natural spawning escapement (for the species/race) in the subbasin.	-	Answers to 82, 83, and 84 are computed from answer to 81.			Maintaining a natural spawning population composed of greater than 5% hatchery fish increases the risk of loss of among population diversity.
Effectiveness	**84**	Do adults from this program make up more than 30% of the natural spawning escapement (for the species/race) in the subbasin.	-	Answers to 82, 83, and 84 are computed from answer to 81.			Maintaining a natural spawning population composed of greater than 30% hatchery fish increases the risk of loss of among population diversity.

Category	#	Question	Correct Answer	Question Amplification (if needed)	Applicable Program Types and Purposes	Benefit	Risk
Effectiveness	**85**	Is the percent hatchery origin fish (first generation) spawning in the wild estimated?	Y	If not explicitly answered, return to Managers.		Estimating the proportion of hatchery fish spawning in the wild allows evaluation of composition targets and prevents hatchery returns from masking the status of the natural population.	Percent hatchery fish spawning in the wild is not estimated! Not estimating the proportion of hatchery fish spawning in the wild prevents evaluation of composition targets and allows hatchery returns to mask the status of the natural population.
Accountability	**86**	Are standards specified for in-culture performance of hatchery fish?	Y	CV of length can be noted in comments but does not suffice as "YES" if it is the only goal identified. A "Yes" requires goals for survival by life stage as well as release size targets.		Explicit standards for survival, size, condition, etc., make it easier to detect cultural problems before they become impossible to rectify.	The program lacks standards for in-culture performance of hatchery fish, making it difficult to determine causes for program successes and failures.
Accountability	**87**	Are in-culture performance standards met?	Y	Usually will require input from local Managers.			
Accountability	**88**	Are standards specified for post release performance of hatchery fish and their offspring?	Y	"No" unless explicit objectives are stated. 10-yr average SAR can be noted in comments, but does not suffice as YES.			The program lacks specified standards for post release performance of hatchery fish and their offspring., making it difficult to determine success and failures and their causes.
Accountability	**89**	Are post-release performance standards met?	Y	Usually will require input from local Managers.			
Accountability	**90**	Are hatchery programming and operational decisions based on an Adaptive Management Plan? (For example, is an annual report produced describing hatchery operations, results of studies, program changes etc? If a written plan does not exist then the answer is No.)	Y	Typical answer is "No" for harvest programs because there are no structured adaptive management plans in Puget Sound except for a few conservation programs. Existence of Annual Reports alone does not merit a "Yes" unless they specify responses to be taken in the event of adverse/unforeseen developments.			This program lacks an annually updated, written plan describing program goals and operations. This makes it difficult to base hatchery programming and operations on adaptive management principles.

Appendix Table 1.2. Publications used in the development of hatchery Best Management Practices.

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Appendix Table 1.3 Weights assigned to hatchery BMPs for Integrated Harvest Programs. BMPs listed in descending order of importance

Integrated Harvest

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring & Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
69	Has the carrying capacity of the subbasin been taken into consideration in sizing this program in regards to determining the number of fish released?	10	0	10	10	10	10	0	0	50
3	Does the broodstock chosen display morphological and life history traits similar to the natural population?	8	10	8	8	8	0	0	0	42
1	Does the broodstock chosen represent natural populations native or adapted to the watersheds in which hatchery fish will be released?	8	10	8	5	10	0	0	0	41
2	If population has been extirpated, is the broodstock chosen likely to adapt to the system based on life history and evolutionary history?	8	10	8	5	10	0	0	0	41
67	Are fish released in stream reaches within the historic range of that population?	8	10	8	10	0	0	0	0	36
70	Are 100% of the hatchery fish marked so that they can be distinguished from the natural populations?	8	0	8	3	3	3	0	10	35
48	Is the correct amount and type of food provided to achieve the desired growth rate?	8	8	8	10	0	0	0	0	34
49	Is the correct amount and type of food provided to achieve the desired condition factors for the species and life stage being reared?	8	8	8	10	0	0	0	0	34
50	Does the program use a diet and growth regime that mimics natural seasonal growth patterns? If not, describe the differences in the comment field?	8	8	8	10	0	0	0	0	34
62	Are the fish produced qualitatively similar to natural fish in growth rate?	8	8	8	10	0	0	0	0	34
63	Are the fish produced qualitatively similar to natural fish in physiological status?	8	8	8	10	0	0	0	0	34

Integrated Harvest

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring & Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
64	Are fish released at sizes and life history stages similar to those of natural fish of the same species?	8	8	8	10	0	0	0	0	34
65	Are volitional releases during natural out-migration timing practiced?	8	8	8	10	0	0	0	0	34
66	Are fish released in a manner that simulates natural seasonal migratory patterns?	8	8	8	10	0	0	0	0	34
11	Are adult returns recycled to lower to provide additional harvest opportunities?	8	0	8	5	5	0	0	0	26
12	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	0	10	5	5	5	0	0	0	25
42	Does the water used [for rearing] provide natural water temperature profiles that result in fish similar in size to naturally produced fish of the same species?	5	5	5	10	0	0	0	0	25
59	Are the fish produced qualitatively similar to natural fish in size (fpp and length)?	5	5	5	10	0	0	0	0	25
61	Are the fish produced qualitatively similar to natural fish in behavior?	5	5	5	5	0	0	0	0	20
74	Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?	8	0	8	0	0	0	0	0	16
23	Are males and females available for spawning on a given day randomly mated?	0	10	5	0	0	0	0	0	15
24	Are gametes pooled prior to fertilization?	0	10	5	0	0	0	0	0	15

Integrated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness	Sum of Weights
33	Are eggs incubated under conditions that result in equal survival of all segments of the population to ponding? (Does any portion of the eggs derive a survival advantage or disadvantage from incubation procedures? If yes, then mark NO for response)	0	10	5	0	0	0	0	0	15
40	If eggs are culled, is culling done randomly over all segments of the egg-take?	0	10	5	0	0	0	0	0	15
46	Are fish reared under conditions that result in equal survival of all segments of the population to release? (In other words, does any portion of the population derive a survival advantage or disadvantage from rearing procedures? If yes, then mark NO in box.)	0	10	5	0	0	0	0	0	15
47	If juveniles are culled, is culling done randomly over all segments of the population? (respond yes if juveniles are not culled). Make sure to capture in the comments box the number culled, and the rational for culling.	0	10	5	0	0	0	0	0	15
68	Are fish released in the same subbasin as rearing facility? This question is trying to determine if fish (juveniles) are transported into the subbasin.	5	0	5	5	0	0	0	0	15
39	Are disinfection procedures implemented during incubation that prevent pathogen transmission between populations of fish on site? (Do you have written protocols? If so, describe in the data comment box.)	4	0	4	4	0	0	0	0	12
14	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	0	8	3	0	0	0	0	0	11
10	Is the percent natural origin fish used as broodstock for this program estimated?	0	0	0	0	0	0	0	10	10

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness	Sum of Weights
	Integrated Harvest									
17	Do you have guidelines for acceptable contribution of hatchery origin fish to natural spawning?	0	0	0	0	0	0	0	10	10
18	Are guidelines for hatchery contribution to natural spawning met for all affected naturally spawning populations?	0	0	0	0	0	0	0	10	10
21	Is the water supply [for adult holding] protected by alarms?	5	0	5	0	0	0	0	0	10
22	Is the water supply [for adult holding] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
31	Is the water supply [for incubation] protected by flow alarms?	5	0	5	0	0	0	0	0	10
32	Is the water supply [for incubation] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
36	Are agency, tribal, or IHOT species-specific incubation recommendations followed for flows?	5	0	5	0	0	0	0	0	10
37	Are agency, tribal, or IHOT species-specific incubation recommendations followed for substrate?	5	0	5	0	0	0	0	0	10
38	Are agency, tribal, or IHOT species-specific incubation recommendations followed for density parameters?	5	0	5	0	0	0	0	0	10
43	Does the hatchery operate to allow all migrating species of all ages to by-pass or pass through hatchery related structures?	0	0	0	0	0	0	10	0	10
44	Is the water supply [for rearing] protected by alarms?	5	0	5	0	0	0	0	0	10
45	Is the water supply [for rearing] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
53	Are agency, tribal, or IHOT juvenile rearing standards followed for loading?	5	0	5	0	0	0	0	0	10
54	Are agency, tribal, or IHOT juvenile rearing standards followed for density?	5	0	5	0	0	0	0	0	10
75	Is staff notified of emergency situations at the facility through the use of alarms, autodialer, and pagers?	5	0	5	0	0	0	0	0	10

Integrated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness	Sum of Weights
77	Do you have a numerical goal for total catch in all fisheries?	0	0	0	0	0	0	0	10	10
78	Do you have a goal for broodstock composition (hatchery vs. natural) in the hatchery?	0	0	0	0	0	0	0	10	10
79	Do you have a goal for spawning escapement composition (hatchery vs. natural) in the wild?	0	0	0	0	0	0	0	10	10
80	Do you have a goal for smolt-to-adult return survival?	0	0	0	0	0	0	0	10	10
85	Is the percent hatchery origin fish (first generation) spawning in the wild estimated?	0	0	0	0	0	0	0	10	10
86	Are standards specified for in-culture performance of hatchery fish?	0	0	0	0	0	0	0	10	10
87	Are in-culture performance standards met?	0	0	0	0	0	0	0	10	10
88	Are standards specified for post release performance of hatchery fish and their offspring?	0	0	0	0	0	0	0	10	10
89	Are post-release performance standards met?	0	0	0	0	0	0	0	10	10
90	Are hatchery programming and operational decisions based on an Adaptive Management Plan? (For example, is an annual report produced describing hatchery operations, results of studies, program changes etc? If a written plan does not exist then the answer is No.)	0	0	0	0	0	0	0	10	10
51	Is the program attempting to better mimic the natural stream environment by providing natural or artificial cover?	2	0	2	5	0	0	0	0	9
16	Is the broodstock collected and held in a manner that results in less than 10% prespawning mortality?	4	0	4	0	0	0	0	0	8

Integrated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness	Sum of Weights
71	Does hatchery intake screening comply with Integrated Hatchery Operations Team (IHOT), National Marine Fisheries Service, or other agency facility standards?	0	0	0	0	0	0	8	0	8
26	Are precocious males (mini-jacks and jacks) used for spawning as a set percentage or in proportion to their contribution to the adult run? (note whether mini-jacks are used in the comment box.)	0	7	0	0	0	0	0	0	7
19	Is the water source [for adult holding] specific-pathogen free?	3	0	3	0	0	0	0	0	6
20	Does the water used [for adult holding] result in natural water temperature profiles that provide optimum maturation and gamete development?	0	3	3	0	0	0	0	0	6
28	Is the water source [for incubation] specific-pathogen free?	3	0	3	0	0	0	0	0	6
29	Does the water used [for incubation] provide natural water temperature profiles that result in hatching/emergence timing similar to that of the naturally produced population?	0	3	3	0	0	0	0	0	6
41	Is the water source [for rearing] specific-pathogen free?	3	0	3	0	0	0	0	0	6
76	Is the facility continuously staffed to ensure the security of fish populations on-site?	3	0	3	0	0	0	0	0	6
4	Does the broodstock chosen have a pathogen history that indicates no threat to other populations in the watershed?	0	0	0	5	0	0	0	0	5
60	Are the fish produced qualitatively similar to natural fish in morphology?	0	2	3	0	0	0	0	0	5
72	Does the facility operate within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit?	0	0	0	0	0	0	5	0	5
73	If the production from this facility falls below the minimum production requirement for an NPDES permit, does the facility operate in compliance with state or federal regulations for discharge?	0	0	0	0	0	0	5	0	5

Integrated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring & Effectiveness	Sum of Weights
15	Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?	0	1	1	1	1	0	0	0	4
25	Are back-up males used in the spawning protocol?	0	4	0	0	0	0	0	0	4
5	Does the broodstock chosen have the desired life history traits to meet harvest goals? (e.g. timing and migration patterns that result in full recruitment to target fisheries)?	0	0	0	0	0	0	0	0	0
6	What is the percent natural origin fish in the hatchery broodstock?	0	0	0	0	0	0	0	0	0
7	Do natural origin fish make up less than 5% of the broodstock for this program?	0	0	0	0	0	0	0	0	0
13	Does the proportion of the spawners brought into the hatchery follow a “spread-the-risk” strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	0	0	0	0	0	0	0	0	0
27	Is the water source [for incubation] pathogen-free?	0	0	0	0	0	0	0	0	0
30	Can incubation water [for incubation] be heated or chilled to approximate natural water temperature profiles?	0	0	0	0	0	0	0	0	0
34	Are families incubated individually? (Includes both eying and hatching.)	0	0	0	0	0	0	0	0	0
52	Are fish reared in multiple facilities or with redundant systems to reduce the risk of catastrophic loss?	0	0	0	0	0	0	0	0	0
55	For captive broodstocks, are fish maintained on natural photoperiod to ensure normal maturation?	0	0	0	0	0	0	0	0	0
56	For captive broodstocks, are fish maintained reared at 12C to minimize disease?	0	0	0	0	0	0	0	0	0

Integrated Harvest

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring & Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
57	For captive broodstocks, are diets and growth regimes selected that produce potent, fertile gametes and reduce excessive early maturation of fish?	0	0	0	0	0	0	0	0	0
58	For captive broodstocks, are families reared individually to maintain pedigrees?	0	0	0	0	0	0	0	0	0
81	What is the percent hatchery origin fish (first generation) in the natural spawning escapement (for the same species/race)?	0	0	0	0	0	0	0	0	0
82	Do adults from this program make up less than 5% of the natural spawning escapement (for the species/race) in the subbasin?	0	0	0	0	0	0	0	0	0
83	Do adults from this program make up between 5 and 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0
84	Do adults from this program make up more than 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0

Appendix Table 1.4 Weights assigned to hatchery BMPs for Integrated Conservation Programs. BMPs listed in descending order of importance

Integrated Conservation

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
15	Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?	0	7	7	7	7	0	0	0	28
3	Does the broodstock chosen display morphological and life history traits similar to the natural population?	0	10	8	4	4	0	0	0	26
1	Does the broodstock chosen represent natural populations native or adapted to the watersheds in which hatchery fish will be released?	0	10	8	2	5	0	0	0	25
2	If population has been extirpated, is the broodstock chosen likely to adapt to the system based on life history and evolutionary history?	0	10	8	2	5	0	0	0	25
67	Are fish released in stream reaches within the historic range of that population?	0	10	8	5	0	0	0	0	23
12	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	0	10	5	3	3	0	0	0	21
48	Is the correct amount and type of food provided to achieve the desired growth rate?	0	8	8	5	0	0	0	0	21
49	Is the correct amount and type of food provided to achieve the desired condition factors for the species and life stage being reared?	0	8	8	5	0	0	0	0	21
50	Does the program use a diet and growth regime that mimics natural seasonal growth patterns? If not, describe the differences in the comment field?	0	8	8	5	0	0	0	0	21
62	Are the fish produced qualitatively similar to natural fish in growth rate?	0	8	8	5	0	0	0	0	21

Integrated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
63	Are the fish produced qualitatively similar to natural fish in physiological status?	0	8	8	5	0	0	0	0	21
13	Does the proportion of the spawners brought into the hatchery follow a "spread-the-risk" strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	0	10	10	0	0	0	0	0	20
25	Are back-up males used in the spawning protocol?	0	10	10	0	0	0	0	0	20
52	Are fish reared in multiple facilities or with redundant systems to reduce the risk of catastrophic loss?	0	10	10	0	0	0	0	0	20
69	Has the carrying capacity of the subbasin been taken into consideration in sizing this program in regards to determining the number of fish released?	0	0	10	5	5	0	0	0	20
70	Are 100% of the hatchery fish marked so that they can be distinguished from the natural populations?	0	0	8	1	1	0	0	10	20
64	Are fish released at sizes and life history stages similar to those of natural fish of the same species?	0	8	5	5	0	0	0	0	18
65	Are volitional releases during natural out-migration timing practiced?	0	8	5	5	0	0	0	0	18
66	Are fish released in a manner that simulates natural seasonal migratory patterns?	0	8	5	5	0	0	0	0	18
55	For captive broodstocks, are fish maintained on natural photoperiod to ensure normal maturation?	0	8	8	0	0	0	0	0	16
56	For captive broodstocks, are fish maintained reared at 12C to minimize disease?	0	8	8	0	0	0	0	0	16
57	For captive broodstocks, are diets and growth regimes selected that produce potent, fertile gametes and reduce excessive early maturation of fish?	0	8	8	0	0	0	0	0	16

		Integrated Conservation									
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
23	Are males and females available for spawning on a given day randomly mated?	0	10	5	0	0	0	0	0	15
24	Are gametes pooled prior to fertilization?	0	10	5	0	0	0	0	0	15
33	Are eggs incubated under conditions that result in equal survival of all segments of the population to ponding? (Does any portion of the eggs derive a survival advantage or disadvantage from incubation procedures? If yes, then mark NO for response)	0	10	5	0	0	0	0	0	15
34	Are families incubated individually? (Includes both eying and hatching.)	0	10	5	0	0	0	0	0	15
40	If eggs are culled, is culling done randomly over all segments of the egg-take?	0	10	5	0	0	0	0	0	15
42	Does the water used [for rearing] provide natural water temperature profiles that result in fish similar in size to naturally produced fish of the same species?	0	5	5	5	0	0	0	0	15
46	Are fish reared under conditions that result in equal survival of all segments of the population to release? (In other words, does any portion of the population derive a survival advantage or disadvantage from rearing procedures? If yes, then mark NO in box.)	0	10	5	0	0	0	0	0	15
47	If juveniles are culled, is culling done randomly over all segments of the population? (respond yes if juveniles are not culled). Make sure to capture in the comments box the number culled, and the rational for culling.	0	10	5	0	0	0	0	0	15
59	Are the fish produced qualitatively similar to natural fish in size (fpp and length)?	0	5	3	5	0	0	0	0	13
61	Are the fish produced qualitatively similar to natural fish in behavior?	0	5	5	2	0	0	0	0	12

Integrated Conservation											
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
14	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	0	8	3	0	0	0	0	0	11
10	Is the percent natural origin fish used as broodstock for this program estimated?	0	0	0	0	0	0	0	10	10
17	Do you have guidelines for acceptable contribution of hatchery origin fish to natural spawning?	0	0	0	0	0	0	0	10	10
18	Are guidelines for hatchery contribution to natural spawning met for all affected naturally spawning populations?	0	0	0	0	0	0	0	10	10
21	Is the water supply [for adult holding] protected by alarms?	0	0	10	0	0	0	0	0	10
22	Is the water supply [for adult holding] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
26	Are precocious males (mini-jacks and jacks) used for spawning as a set percentage or in proportion to their contribution to the adult run? (note whether mini-jacks are used in the comment box.)	0	10	0	0	0	0	0	0	10
28	Is the water source [for incubation] specific-pathogen free?	0	0	10	0	0	0	0	0	10
31	Is the water supply [for incubation] protected by flow alarms?	0	0	10	0	0	0	0	0	10
32	Is the water supply [for incubation] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
36	Are agency, tribal, or IHOT species-specific incubation recommendations followed for flows?	0	0	10	0	0	0	0	0	10
37	Are agency, tribal, or IHOT species-specific incubation recommendations followed for substrate?	0	0	10	0	0	0	0	0	10
38	Are agency, tribal, or IHOT species-specific incubation recommendations followed for density parameters?	0	0	10	0	0	0	0	0	10

Integrated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
39	Are disinfection procedures implemented during incubation that prevent pathogen transmission between populations of fish on site? (Do you have written protocols? If so, describe in the data comment box.)	0	0	10	0	0	0	0	0	10
41	Is the water source [for rearing] specific-pathogen free?	0	0	10	0	0	0	0	0	10
44	Is the water supply [for rearing] protected by alarms?	0	0	10	0	0	0	0	0	10
45	Is the water supply [for rearing] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
53	Are agency, tribal, or IHOT juvenile rearing standards followed for loading?	0	0	10	0	0	0	0	0	10
54	Are agency, tribal, or IHOT juvenile rearing standards followed for density?	0	0	10	0	0	0	0	0	10
68	Are fish released in the same subbasin as rearing facility? This question is trying to determine if fish (juveniles) are transported into the subbasin.	0	0	5	5	0	0	0	0	10
74	Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?	0	0	10	0	0	0	0	0	10
75	Is staff notified of emergency situations at the facility through the use of alarms, autodialer, and pagers?	0	0	10	0	0	0	0	0	10
76	Is the facility continuously staffed to ensure the security of fish populations on-site?	0	0	10	0	0	0	0	0	10
78	Do you have a goal for broodstock composition (hatchery vs. natural) in the hatchery?	0	0	0	0	0	0	0	10	10
79	Do you have a goal for spawning escapement composition (hatchery vs. natural) in the wild?	0	0	0	0	0	0	0	10	10
80	Do you have a goal for smolt-to-adult return survival?	0	0	0	0	0	0	0	10	10
85	Is the percent hatchery origin fish (first generation) spawning in the wild estimated?	0	0	0	0	0	0	0	10	10
86	Are standards specified for in-culture performance of hatchery fish?	0	0	0	0	0	0	0	10	10

Integrated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
87	Are in-culture performance standards met?	0	0	0	0	0	0	0	10	10
88	Are standards specified for post release performance of hatchery fish and their offspring?	0	0	0	0	0	0	0	10	10
89	Are post-release performance standards met?	0	0	0	0	0	0	0	10	10
90	Are hatchery programming and operational decisions based on an Adaptive Management Plan? (For example, is an annual report produced describing hatchery operations, results of studies, program changes etc? If a written plan does not exist then the answer is No.)	0	0	0	0	0	0	0	10	10
16	Is the broodstock collected and held in a manner that results in less than 10% prespawning mortality?	0	0	8	0	0	0	0	0	8
19	Is the water source [for adult holding] specific-pathogen free?	0	0	8	0	0	0	0	0	8
27	Is the water source [for incubation] pathogen-free?	0	0	8	0	0	0	0	0	8
58	For captive broodstocks, are families reared individually to maintain pedigrees?	0	8	0	0	0	0	0	0	8
71	Does hatchery intake screening comply with Integrated Hatchery Operations Team (IHOT), National Marine Fisheries Service, or other agency facility standards?	0	0	0	0	0	0	8	0	8
51	Is the program attempting to better mimic the natural stream environment by providing natural or artificial cover?	0	2	5	0	0	0	0	0	7
20	Does the water used [for adult holding] result in natural water temperature profiles that provide optimum maturation and gamete development?	0	3	3	0	0	0	0	0	6
29	Does the water used [for incubation] provide natural water temperature profiles that result in hatching/emergence timing similar to that of the naturally produced population?	0	3	3	0	0	0	0	0	6

		Integrated Conservation								
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
30	Can incubation water [for incubation] be heated or chilled to approximate natural water temperature profiles?	0	3	3	0	0	0	0	0	6
4	Does the broodstock chosen have a pathogen history that indicates no threat to other populations in the watershed?	0	0	0	5	0	0	0	0	5
43	Does the hatchery operate to allow all migrating species of all ages to by-pass or pass through hatchery related structures?	0	0	0	0	0	0	5	0	5
60	Are the fish produced qualitatively similar to natural fish in morphology?	0	2	3	0	0	0	0	0	5
72	Does the facility operate within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit?	0	0	0	0	0	0	5	0	5
73	If the production from this facility falls below the minimum production requirement for an NPDES permit, does the facility operate in compliance with state or federal regulations for discharge?	0	0	0	0	0	0	5	0	5
5	Does the broodstock chosen have the desired life history traits to meet harvest goals? (e.g. timing and migration patterns that result in full recruitment to target fisheries)?	0	0	0	0	0	0	0	0	0
6	What is the percent natural origin fish in the hatchery broodstock?	0	0	0	0	0	0	0	0	0
7	Do natural origin fish make up less than 5% of the broodstock for this program?	0	0	0	0	0	0	0	0	0
11	Are adult returns recycled to lower to provide additional harvest opportunities?	0	0	0	0	0	0	0	0	0
77	Do you have a numerical goal for total catch in all fisheries?	0	0	0	0	0	0	0	0	0
81	What is the percent hatchery origin fish (first generation) in the natural spawning escapement (for the same species/race)?	0	0	0	0	0	0	0	0	0

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
	Integrated Conservation									
82	Do adults from this program make up less than 5% of the natural spawning escapement (for the species/race) in the subbasin?	0	0	0	0	0	0	0	0	0
83	Do adults from this program make up between 5 and 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0
84	Do adults from this program make up more than 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0

Appendix Table 1.5 Weights assigned to hatchery BMPs for Segregated Harvest Programs. BMPs listed in descending order of importance

Segregated Harvest											
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
5	Does the broodstock chosen have the desired life history traits to meet harvest goals? (e.g. timing and migration patterns that result in full recruitment to target fisheries)?	10	10	10	8	10	8	0	0	56
12	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	0	10	10	8	10	8	0	0	46
23	Are males and females available for spawning on a given day randomly mated?	0	10	10	8	10	8	0	0	46
69	Has the carrying capacity of the subbasin been taken into consideration in sizing this program in regards to determining the number of fish released?	4	0	4	10	10	10	0	0	38
1	Does the broodstock chosen represent natural populations native or adapted to the watersheds in which hatchery fish will be released?	8	0	8	8	10	0	0	0	34
2	If population has been extirpated, is the broodstock chosen likely to adapt to the system based on life history and evolutionary history?	8	0	8	8	10	0	0	0	34
48	Is the correct amount and type of food provided to achieve the desired growth rate?	8	8	8	10	0	0	0	0	34
49	Is the correct amount and type of food provided to achieve the desired condition factors for the species and life stage being reared?	8	8	8	10	0	0	0	0	34

Segregated Harvest										
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
50	Does the program use a diet and growth regime that mimics natural seasonal growth patterns? If not, describe the differences in the comment field?	8	8	8	10	0	0	0	0	34
62	Are the fish produced qualitatively similar to natural fish in growth rate?	8	8	8	10	0	0	0	0	34
63	Are the fish produced qualitatively similar to natural fish in physiological status?	8	8	8	10	0	0	0	0	34
11	Are adult returns recycled to lower to provide additional harvest opportunities?	8	0	8	8	8	0	0	0	32
15	Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?	6	6	6	0	10	0	0	0	28
67	Are fish released in stream reaches within the historic range of that population?	5	8	5	10	0	0	0	0	28
64	Are fish released at sizes and life history stages similar to those of natural fish of the same species?	5	5	5	10	0	0	0	0	25
3	Does the broodstock chosen display morphological and life history traits similar to the natural population?	0	0	5	8	10	0	0	0	23
70	Are 100% of the hatchery fish marked so that they can be distinguished from the natural populations?	3	0	0	3	3	3	0	10	22
40	If eggs are culled, is culling done randomly over all segments of the egg-take?	0	10	10	0	0	0	0	0	20
47	If juveniles are culled, is culling done randomly over all segments of the population? (respond yes if juveniles are not culled). Make sure to capture in the comments box the number culled, and the rational for culling.	0	10	10	0	0	0	0	0	20

		Target Population			Other Populations					
#	BMP Question	Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
42	Does the water used [for rearing] provide natural water temperature profiles that result in fish similar in size to naturally produced fish of the same species?	3	3	3	10	0	0	0	0	19
59	Are the fish produced qualitatively similar to natural fish in size (fpp and length)?	3	3	3	10	0	0	0	0	19
65	Are volitional releases during natural out-migration timing practiced?	3	3	3	10	0	0	0	0	19
66	Are fish released in a manner that simulates natural seasonal migratory patterns?	3	3	3	10	0	0	0	0	19
7	Do natural origin fish make up less than 5% of the broodstock for this program?	0	10	8	0	0	0	0	0	18
14	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	0	8	8	0	0	0	0	0	16
74	Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?	8	0	8	0	0	0	0	0	16
24	Are gametes pooled prior to fertilization?	0	10	5	0	0	0	0	0	15
61	Are the fish produced qualitatively similar to natural fish in behavior?	3	3	3	5	0	0	0	0	14
68	Are fish released in the same subbasin as rearing facility? This question is trying to determine if fish (juveniles) are transported into the subbasin.	3	0	3	5	0	0	0	0	11
4	Does the broodstock chosen have a pathogen history that indicates no threat to other populations in the watershed?	0	0	0	10	0	0	0	0	10
10	Is the percent natural origin fish used as broodstock for this program estimated?	0	0	0	0	0	0	0	10	10

Segregated Harvest

		Segregated Harvest								
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
17	Do you have guidelines for acceptable contribution of hatchery origin fish to natural spawning?	0	0	0	0	0	0	0	10	10
18	Are guidelines for hatchery contribution to natural spawning met for all affected naturally spawning populations?	0	0	0	0	0	0	0	10	10
21	Is the water supply [for adult holding] protected by alarms?	5	0	5	0	0	0	0	0	10
22	Is the water supply [for adult holding] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
31	Is the water supply [for incubation] protected by flow alarms?	5	0	5	0	0	0	0	0	10
32	Is the water supply [for incubation] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
36	Are agency, tribal, or IHOT species-specific incubation recommendations followed for flows?	5	0	5	0	0	0	0	0	10
37	Are agency, tribal, or IHOT species-specific incubation recommendations followed for substrate?	5	0	5	0	0	0	0	0	10
38	Are agency, tribal, or IHOT species-specific incubation recommendations followed for density parameters?	5	0	5	0	0	0	0	0	10
43	Does the hatchery operate to allow all migrating species of all ages to by-pass or pass through hatchery related structures?	0	0	0	0	0	0	10	0	10
44	Is the water supply [for rearing] protected by alarms?	5	0	5	0	0	0	0	0	10
45	Is the water supply [for rearing] protected by back-up power generation?	5	0	5	0	0	0	0	0	10
53	Are agency, tribal, or IHOT juvenile rearing standards followed for loading?	5	0	5	0	0	0	0	0	10
54	Are agency, tribal, or IHOT juvenile rearing standards followed for density?	5	0	5	0	0	0	0	0	10
75	Is staff notified of emergency situations at the facility through the use of alarms, autodialer, and pagers?	5	0	5	0	0	0	0	0	10

Segregated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
77	Do you have a numerical goal for total catch in all fisheries?	0	0	0	0	0	0	0	10	10
78	Do you have a goal for broodstock composition (hatchery vs. natural) in the hatchery?	0	0	0	0	0	0	0	10	10
79	Do you have a goal for spawning escapement composition (hatchery vs. natural) in the wild?	0	0	0	0	0	0	0	10	10
80	Do you have a goal for smolt-to-adult return survival?	0	0	0	0	0	0	0	10	10
85	Is the percent hatchery origin fish (first generation) spawning in the wild estimated?	0	0	0	0	0	0	0	10	10
86	Are standards specified for in-culture performance of hatchery fish?	0	0	0	0	0	0	0	10	10
87	Are in-culture performance standards met?	0	0	0	0	0	0	0	10	10
88	Are standards specified for post release performance of hatchery fish and their offspring?	0	0	0	0	0	0	0	10	10
89	Are post-release performance standards met?	0	0	0	0	0	0	0	10	10
90	Are hatchery programming and operational decisions based on an Adaptive Management Plan? (For example, is an annual report produced describing hatchery operations, results of studies, program changes etc? If a written plan does not exist then the answer is No.)	0	0	0	0	0	0	0	10	10
51	Is the program attempting to better mimic the natural stream environment by providing natural or artificial cover?	2	0	2	5	0	0	0	0	9
16	Is the broodstock collected and held in a manner that results in less than 10% prespawning mortality?	4	0	4	0	0	0	0	0	8

Segregated Harvest

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
39	Are disinfection procedures implemented during incubation that prevent pathogen transmission between populations of fish on site? (Do you have written protocols? If so, describe in the data comment box.)	4	0	4	0	0	0	0	0	8
71	Does hatchery intake screening comply with Integrated Hatchery Operations Team (IHOT), National Marine Fisheries Service, or other agency facility standards?	0	0	0	0	0	0	8	0	8
26	Are precocious males (mini-jacks and jacks) used for spawning as a set percentage or in proportion to their contribution to the adult run? (note whether mini-jacks are used in the comment box.)	0	7	0	0	0	0	0	0	7
19	Is the water source [for adult holding] specific-pathogen free?	3	0	3	0	0	0	0	0	6
28	Is the water source [for incubation] specific-pathogen free?	3	0	3	0	0	0	0	0	6
41	Is the water source [for rearing] specific-pathogen free?	3	0	3	0	0	0	0	0	6
76	Is the facility continuously staffed to ensure the security of fish populations on-site?	3	0	3	0	0	0	0	0	6
72	Does the facility operate within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit?	0	0	0	0	0	0	5	0	5
73	If the production from this facility falls below the minimum production requirement for an NPDES permit, does the facility operate in compliance with state or federal regulations for discharge?	0	0	0	0	0	0	5	0	5
25	Are back-up males used in the spawning protocol?	0	4	0	0	0	0	0	0	4

Segregated Harvest

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
33	Are eggs incubated under conditions that result in equal survival of all segments of the population to ponding? (Does any portion of the eggs derive a survival advantage or disadvantage from incubation procedures? If yes, then mark NO for response)	0	3	1	0	0	0	0	0	4
46	Are fish reared under conditions that result in equal survival of all segments of the population to release? (In other words, does any portion of the population derive a survival advantage or disadvantage from rearing procedures? If yes, then mark NO in box.)	0	3	1	0	0	0	0	0	4
20	Does the water used [for adult holding] result in natural water temperature profiles that provide optimum maturation and gamete development?	0	1	1	0	0	0	0	0	2
29	Does the water used [for incubation] provide natural water temperature profiles that result in hatching/emergence timing similar to that of the naturally produced population?	0	1	1	0	0	0	0	0	2
6	What is the percent natural origin fish in the hatchery broodstock?	0	0	0	0	0	0	0	0	0
13	Does the proportion of the spawners brought into the hatchery follow a "spread-the-risk" strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	0	0	0	0	0	0	0	0	0
27	Is the water source [for incubation] pathogen-free?	0	0	0	0	0	0	0	0	0
30	Can incubation water [for incubation] be heated or chilled to approximate natural water temperature profiles?	0	0	0	0	0	0	0	0	0
34	Are families incubated individually? (Includes both eying and hatching.)	0	0	0	0	0	0	0	0	0
52	Are fish reared in multiple facilities or with redundant systems to reduce the risk of catastrophic loss?	0	0	0	0	0	0	0	0	0

Segregated Harvest										
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
55	For captive broodstocks, are fish maintained on natural photoperiod to ensure normal maturation?	0	0	0	0	0	0	0	0	0
56	For captive broodstocks, are fish maintained reared at 12C to minimize disease?	0	0	0	0	0	0	0	0	0
57	For captive broodstocks, are diets and growth regimes selected that produce potent, fertile gametes and reduce excessive early maturation of fish?	0	0	0	0	0	0	0	0	0
58	For captive broodstocks, are families reared individually to maintain pedigrees?	0	0	0	0	0	0	0	0	0
60	Are the fish produced qualitatively similar to natural fish in morphology?	0	0	0	0	0	0	0	0	0
81	What is the percent hatchery origin fish (first generation) in the natural spawning escapement (for the same species/race)?	0	0	0	0	0	0	0	0	0
82	Do adults from this program make up less than 5% of the natural spawning escapement (for the species/race) in the subbasin?	0	0	0	0	0	0	0	0	0
83	Do adults from this program make up between 5 and 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0
84	Do adults from this program make up more than 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0

Appendix Table 1.6 Weights assigned to hatchery BMPs for Segregated Conservation Programs. BMPs listed in descending order of importance.

Segregated Conservation		Target Population			Other Populations					
#	**BMP Question**	**Harvest**	**Diversity & Spatial Struct.**	**Abundance & Productivity**	**Abundance & Productivity**	**Diversity & Spatial Struct.**	**Harvest Interactions**	**Environmental Factors**	**Monitoring and Effectiveness**	**Sum of Weights**
3	Does the broodstock chosen display morphological and life history traits similar to the natural population?	0	10	8	4	4	0	0	0	26
1	Does the broodstock chosen represent natural populations native or adapted to the watersheds in which hatchery fish will be released?	0	10	8	2	5	0	0	0	25
67	Are fish released in stream reaches within the historic range of that population?	0	10	8	5	0	0	0	0	23
70	Are 100% of the hatchery fish marked so that they can be distinguished from the natural populations?	0	0	10	1	1	0	0	10	22
12	Are representative samples of natural and hatchery population components collected with respect to size, age, sex ratio, run and spawn timing, and other traits important to long-term fitness? (For integrated populations, consider both natural and hatchery components; for segregated populations, you should only consider the hatchery component.)	0	10	5	3	3	0	0	0	21
48	Is the correct amount and type of food provided to achieve the desired growth rate?	0	8	8	5	0	0	0	0	21
49	Is the correct amount and type of food provided to achieve the desired condition factors for the species and life stage being reared?	0	8	8	5	0	0	0	0	21
50	Does the program use a diet and growth regime that mimics natural seasonal growth patterns? If not, describe the differences in the comment field?	0	8	8	5	0	0	0	0	21
62	Are the fish produced qualitatively similar to natural fish in growth rate?	0	8	8	5	0	0	0	0	21
63	Are the fish produced qualitatively similar to natural fish in physiological status?	0	8	8	5	0	0	0	0	21
25	Are back-up males used in the spawning protocol?	0	10	10	0	0	0	0	0	20
52	Are fish reared in multiple facilities or with redundant systems to reduce the risk of catastrophic loss?	0	10	10	0	0	0	0	0	20

Segregated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
64	Are fish released at sizes and life history stages similar to those of natural fish of the same species?	0	8	5	5	0	0	0	0	18
65	Are volitional releases during natural out-migration timing practiced?	0	8	5	5	0	0	0	0	18
66	Are fish released in a manner that simulates natural seasonal migratory patterns?	0	8	5	5	0	0	0	0	18
55	For captive broodstocks, are fish maintained on natural photoperiod to ensure normal maturation?	0	8	8	0	0	0	0	0	16
56	For captive broodstocks, are fish maintained reared at 12C to minimize disease?	0	8	8	0	0	0	0	0	16
57	For captive broodstocks, are diets and growth regimes selected that produce potent, fertile gametes and reduce excessive early maturation of fish?	0	8	8	0	0	0	0	0	16
23	Are males and females available for spawning on a given day randomly mated?	0	10	5	0	0	0	0	0	15
24	Are gametes pooled prior to fertilization?	0	10	5	0	0	0	0	0	15
33	Are eggs incubated under conditions that result in equal survival of all segments of the population to ponding? (Does any portion of the eggs derive a survival advantage or disadvantage from incubation procedures? If yes, then mark NO for response)	0	10	5	0	0	0	0	0	15
34	Are families incubated individually? (Includes both eying and hatching.)	0	10	5	0	0	0	0	0	15
42	Does the water used [for rearing] provide natural water temperature profiles that result in fish similar in size to naturally produced fish of the same species?	0	5	5	5	0	0	0	0	15
46	Are fish reared under conditions that result in equal survival of all segments of the population to release? (In other words, does any portion of the population derive a survival advantage or disadvantage from rearing procedures? If yes, then mark NO in box.)	0	10	5	0	0	0	0	0	15
59	Are the fish produced qualitatively similar to natural fish in size (fpp and length)?	0	5	3	5	0	0	0	0	13
61	Are the fish produced qualitatively similar to natural fish in behavior?	0	5	5	2	0	0	0	0	12

Segregated Conservation

#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
14	Are sufficient broodstock collected to maintain an effective population size of 1000 fish per generation? (More than 500 successful spawners of each sex.)	0	8	3	0	0	0	0	0	11
10	Is the percent natural origin fish used as broodstock for this program estimated?	0	0	0	0	0	0	0	10	10
16	Is the broodstock collected and held in a manner that results in less than 10% prespawning mortality?	0	0	10	0	0	0	0	0	10
17	Do you have guidelines for acceptable contribution of hatchery origin fish to natural spawning?	0	0	0	0	0	0	0	10	10
18	Are guidelines for hatchery contribution to natural spawning met for all affected naturally spawning populations?	0	0	0	0	0	0	0	10	10
19	Is the water source [for adult holding] specific-pathogen free?	0	0	10	0	0	0	0	0	10
21	Is the water supply [for adult holding] protected by alarms?	0	0	10	0	0	0	0	0	10
22	Is the water supply [for adult holding] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
26	Are precocious males (mini-jacks and jacks) used for spawning as a set percentage or in proportion to their contribution to the adult run? (note whether mini-jacks are used in the comment box.)	0	10	0	0	0	0	0	0	10
27	Is the water source [for incubation] pathogen-free?	0	0	10	0	0	0	0	0	10
28	Is the water source [for incubation] specific-pathogen free?	0	0	10	0	0	0	0	0	10
30	Can incubation water [for incubation] be heated or chilled to approximate natural water temperature profiles?	0	5	5	0	0	0	0	0	10
31	Is the water supply [for incubation] protected by flow alarms?	0	0	10	0	0	0	0	0	10
32	Is the water supply [for incubation] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
36	Are agency, tribal, or IHOT species-specific incubation recommendations followed for flows?	0	0	10	0	0	0	0	0	10
37	Are agency, tribal, or IHOT species-specific incubation recommendations followed for substrate?	0	0	10	0	0	0	0	0	10
38	Are agency, tribal, or IHOT species-specific incubation recommendations followed for density parameters?	0	0	10	0	0	0	0	0	10

Segregated Conservation										
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
39	Are disinfection procedures implemented during incubation that prevent pathogen transmission between populations of fish on site? (Do you have written protocols? If so, describe in the data comment box.)	0	0	10	0	0	0	0	0	10
41	Is the water source [for rearing] specific-pathogen free?	0	0	10	0	0	0	0	0	10
44	Is the water supply [for rearing] protected by alarms?	0	0	10	0	0	0	0	0	10
45	Is the water supply [for rearing] protected by back-up power generation?	0	0	10	0	0	0	0	0	10
53	Are agency, tribal, or IHOT juvenile rearing standards followed for loading?	0	0	10	0	0	0	0	0	10
54	Are agency, tribal, or IHOT juvenile rearing standards followed for density?	0	0	10	0	0	0	0	0	10
74	Is the facility sited so as to minimize the risk of catastrophic fish loss from flooding?	0	0	10	0	0	0	0	0	10
75	Is staff notified of emergency situations at the facility through the use of alarms, autodialer, and pagers?	0	0	10	0	0	0	0	0	10
76	Is the facility continuously staffed to ensure the security of fish populations on-site?	0	0	10	0	0	0	0	0	10
78	Do you have a goal for broodstock composition (hatchery vs. natural) in the hatchery?	0	0	0	0	0	0	0	10	10
79	Do you have a goal for spawning escapement composition (hatchery vs. natural) in the wild?	0	0	0	0	0	0	0	10	10
80	Do you have a goal for smolt-to-adult return survival?	0	0	0	0	0	0	0	10	10
85	Is the percent hatchery origin fish (first generation) spawning in the wild estimated?	0	0	0	0	0	0	0	10	10
86	Are standards specified for in-culture performance of hatchery fish?	0	0	0	0	0	0	0	10	10
87	Are in-culture performance standards met?	0	0	0	0	0	0	0	10	10

Segregated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
88	Are standards specified for post release performance of hatchery fish and their offspring?	0	0	0	0	0	0	0	10	10
89	Are post-release performance standards met?	0	0	0	0	0	0	0	10	10
90	Are hatchery programming and operational decisions based on an Adaptive Management Plan? (For example, is an annual report produced describing hatchery operations, results of studies, program changes etc? If a written plan does not exist then the answer is No.)	0	0	0	0	0	0	0	10	10
58	For captive broodstocks, are families reared individually to maintain pedigrees?	0	8	0	0	0	0	0	0	8
71	Does hatchery intake screening comply with Integrated Hatchery Operations Team (IHOT), National Marine Fisheries Service, or other agency facility standards?	0	0	0	0	0	0	8	0	8
51	Is the program attempting to better mimic the natural stream environment by providing natural or artificial cover?	0	2	5	0	0	0	0	0	7
20	Does the water used [for adult holding] result in natural water temperature profiles that provide optimum maturation and gamete development?	0	3	3	0	0	0	0	0	6
29	Does the water used [for incubation] provide natural water temperature profiles that result in hatching/emergence timing similar to that of the naturally produced population?	0	3	3	0	0	0	0	0	6
43	Does the hatchery operate to allow all migrating species of all ages to by-pass or pass through hatchery related structures?	0	0	0	0	0	0	5	0	5
68	Are fish released in the same subbasin as rearing facility? This question is trying to determine if fish (juveniles) are transported into the subbasin.	0	0	0	5	0	0	0	0	5
72	Does the facility operate within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit?	0	0	0	0	0	0	5	0	5
73	If the production from this facility falls below the minimum production requirement for an NPDES permit, does the facility operate in compliance with state or federal regulations for discharge?	0	0	0	0	0	0	5	0	5

Segregated Conservation											
#	BMP Question	Target Population			Other Populations			Environmental Factors	Monitoring and Effectiveness	Sum of Weights
		Harvest	Diversity & Spatial Struct.	Abundance & Productivity	Abundance & Productivity	Diversity & Spatial Struct.	Harvest Interactions			
15	Does the program avoid population transfers and subsequent releases of eggs or fish from outside the watershed?	0	1	1	1	1	0	0	0	4
69	Has the carrying capacity of the subbasin been taken into consideration in sizing this program in regards to determining the number of fish released?	0	0	0	2	2	0	0	0	4
40	If eggs are culled, is culling done randomly over all segments of the egg-take?	0	1	1	0	0	0	0	0	2
47	If juveniles are culled, is culling done randomly over all segments of the population? (respond yes if juveniles are not culled). Make sure to capture in the comments box the number culled, and the rational for culling.	0	1	1	0	0	0	0	0	2
4	Does the broodstock chosen have a pathogen history that indicates no threat to other populations in the watershed?	0	0	0	1	0	0	0	0	1
2	If population has been extirpated, is the broodstock chosen likely to adapt to the system based on life history and evolutionary history?	0	0	0	0	0	0	0	0	0
5	Does the broodstock chosen have the desired life history traits to meet harvest goals? (e.g. timing and migration patterns that result in full recruitment to target fisheries)?	0	0	0	0	0	0	0	0	0
6	What is the percent natural origin fish in the hatchery broodstock?	0	0	0	0	0	0	0	0	0
7	Do natural origin fish make up less than 5% of the broodstock for this program?	0	0	0	0	0	0	0	0	0
11	Are adult returns recycled to lower to provide additional harvest opportunities?	0	0	0	0	0	0	0	0	0
13	Does the proportion of the spawners brought into the hatchery follow a "spread-the-risk" strategy that attempts to improve the probability of survival for the entire population (hatchery and natural components)?	0	0	0	0	0	0	0	0	0
60	Are the fish produced qualitatively similar to natural fish in morphology?	0	0	0	0	0	0	0	0	0
77	Do you have a numerical goal for total catch in all fisheries?	0	0	0	0	0	0	0	0	0

Segregated Conservation

#	BMP Question	Target Population: Harvest	Target Population: Diversity & Spatial Struct.	Target Population: Abundance & Productivity	Other Populations: Abundance & Productivity	Other Populations: Diversity & Spatial Struct.	Other Populations: Harvest Interactions	Environmental Factors	Monitoring and Effectiveness	Sum of Weights
81	What is the percent hatchery origin fish (first generation) in the natural spawning escapement (for the same species/race)?	0	0	0	0	0	0	0	0	0
82	Do adults from this program make up less than 5% of the natural spawning escapement (for the species/race) in the subbasin?	0	0	0	0	0	0	0	0	0
83	Do adults from this program make up between 5 and 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0
84	Do adults from this program make up more than 30% of the natural spawning escapement (for the species/race) in the subbasin.	0	0	0	0	0	0	0	0	0

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Appendix G

Hood Canal Summer-run Chum Salmon

Effects Analysis by Population

For a list of acronyms used in this appendix, see Acronyms and Abbreviations in EIS

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1.0 Introduction

This appendix identifies hatchery program risks and benefits for the two Hood Canal summer-run chum salmon populations (Hood Canal and Strait of Juan de Fuca) identified in Sands et al. (2009) that comprise the Hood Canal Summer-run Chum Salmon evolutionary significant unit (ESU). The ESU is federally listed as threatened under the ESA. Potential mitigation measures are identified for hatchery programs that pose risks to summer-run chum salmon. The rivers and streams associated with the Hood Canal population are Union, Tahuya, Skokomish, Hamma Hamma, Duckabush, Dosewallips, Big Quilcene, and Little Quilcene Rivers and Big Beef Creek and Lilliwaup Creek. The rivers and streams associated with the Strait of Juan de Fuca population are Chimacum, Salmon, Snow, and Jimmycomelately Creeks, and the Dungeness River.

This appendix evaluates hatchery-related risks and benefits for the two Hood Canal summer-run chum salmon populations by alternative. Alternative 1 (No-action Alternative) also represents existing conditions. These existing conditions are summarized and reported in EIS Subsection 3.2.6, Hood Canal Summer-run Chum Salmon ESU.

2.0 Hood Canal Summer-run Chum Salmon Populations

Based on genetic analysis, historical and present geographic distribution, straying patterns, and life history variation Sands et al. (2009) identified two independent populations of natural-origin summer-run chum salmon. One population (Strait of Juan de Fuca population) occurs in the eastern Strait of Juan de Fuca watersheds (including Chimacum Creek), and the other (Hood Canal population) occurs in Hood Canal watersheds (Table G-1). There is minimal straying between the Hood Canal and the Strait of Juan de Fuca aggregations. In general, adults returning to Strait of Juan de Fuca streams may enter the Strait of Juan de Fuca earlier than Hood Canal aggregations. Entry of adults into fresh water, which occurs between late August and mid-October, however, is approximately a week later for the northern Strait of Juan de Fuca aggregation than for the southernmost Hood Canal aggregation (Union River) (WDFW and PNPTT 2000).

The geographical variation in time-to-emergence of juveniles reflects environmental differences (Bakkala 1970; Salo 1991) and genetic traits (Robison et al. 2001). The Strait of Juan de Fuca aggregations, which occupy colder streams than Hood Canal aggregations, generally produce fry that emerge later than fry from Hood Canal aggregations (Tynan 1997). Likewise, within the Hood Canal aggregation, summer-run chum salmon originating from the colder (mainly snow melt-fed) westside Hood Canal watersheds emerge later than summer-run chum salmon from warmer, rainfall-fed streams on the Kitsap Peninsula (WDFW and PNPTT 2000). Finally, the freshwater habitat of the Strait of Juan de Fuca and Hood Canal summer-run chum salmon populations are in different ecoregions, and the condition of the marine environment differs between the Strait of Juan de Fuca and Hood Canal.

Table G-1. Populations and watersheds comprising spawning aggregations that form the Hood Canal summer-run Chum Salmon ESU.

Population	Watershed
Hood Canal	Quilcene
	Dosewallips
	Duckabush
	Hamma Hamma
	Lilliwaup
	Union
	Tahuya[1]
	Big Beef Creek[1]
	Skokomish[2]
Strait of Juan de Fuca	Salmon/Snow
	Jimmycomelately
	Chimacum[1]
	Dungeness[3]

Source: Sands et al. (2009).
[1] Spawning aggregations in these watersheds are the result of recent conservation hatchery summer-run chum salmon programs that reintroduced spawning populations where the native stocks have been extirpated .
[2] Summer-run chum salmon in the Skokomish River are present at very low levels consistent with straying from other watersheds and the native population is considered functionally extinct (WDFW and PNPTT 2000).
[3] Summer-run chum salmon are thought to have occurred in the Dungeness River historically (WDFW and PNPTT 2000).

The hatchery programs that propagate listed summer-run chum salmon (Lilliwaup Hatchery and Tahuya River summer-run chum salmon programs) are not evaluated in this EIS because they previously received authorization under the ESA (NMFS 2002a) and environmental review under NEPA (NMFS 2002b, 2004); thus, they are not part of the co-manager hatchery RMPs and HGMPs subject to this EIS (EIS Subsection 4.2.5, Hood Canal Summer-run Chum Salmon ESU).

3.0 Methods

Appendix B, Hatchery Effects and Evaluation Methods for Fish, discusses the general effects of hatchery programs on natural-origin fish, as well as methods used to analyze effects on the Hood Canal Summer-run Chum Salmon ESU and its component populations at the ESU scale.

3.1 Population Analysis

The population-scale evaluation in this appendix emphasizes risks within freshwater rivers and streams where salmon and steelhead adults spawn and juveniles rear and eventually out-migrate to marine waters. Risks and benefits in marine waters are evaluated qualitatively at the marine area or ESU scale, and inferences are qualitatively applied.

Results are organized by summer-run chum salmon population, and risks are evaluated for the following:

- Fall-run chum salmon hatchery programs—evaluation consists of competition and predation risks
- Chinook salmon hatchery programs—evaluation consists of competition and predation risks
- Coho salmon hatchery programs—evaluation consists of competition and predation risks
- Steelhead hatchery programs—evaluation consists of competition and predation risks

Risks not evaluated for natural-origin summer-run chum salmon include the following programs:

- Fall-run chum salmon programs. Genetic risks of introgression and hatchery-induced selection are not evaluated because of run and spawn timing differences between natural-origin summer-run chum salmon and hatchery-origin fall-run chum salmon. Hatchery-induced selection risks from the two currently operating hatchery programs for summer-run chum salmon are not evaluated because they were previously found to be negligible (NMFS 2002a, 2002b, 2004).
- Fall-run and summer-run chum salmon, Chinook salmon, coho salmon, and steelhead hatchery programs. Hatchery facilities and operation risks (including fish disease risks) are not evaluated because risks to summer-run chum are negligible or low (NMFS 2002a, 2002b, 2004), and would not vary among the alternatives.

Analyses of benefits from hatchery programs to summer-run chum salmon do not include total return and viability. This is different from Chinook salmon and steelhead analyses, which do include these benefits. Total return and viability benefits for any species would only accrue from hatchery programs that propagate that species. Because hatchery programs that propagate listed summer-run chum salmon (Lilliwaup Hatchery and Tahuya River summer-run chum salmon programs) were previously evaluated, these benefits are not re-evaluated in this EIS. Marine-derived benefits are also not evaluated because these benefits directly attributed to the Hood Canal summer-run chum salmon hatchery programs were previously evaluated in NMFS (2002a, 2002b, 2004).

Details on hatchery programs and fish releases in Puget Sound that have the potential to affect natural-origin summer-run chum salmon are included in Appendix A, Puget Sound Hatchery Programs and Facilities.

3.2 ESU Analysis

Results from this appendix for the two summer-run chum salmon populations are summarized at the ESU scale in EIS Subsection 4.2.5, Hood Canal Summer-run Chum Salmon ESU. Risks to each summer-run chum salmon population are assigned a numeric score, and sums of scores for each population are divided by two (for the two populations) to determine the effect to the ESU. The resulting mean score then represents the risk level for the ESU as a whole (EIS Subsection 4.2.5.7, Competition; EIS Subsection 4.2.5.8, Predation [Summer-run Chum Salmon]).

3.3 Mitigation Measures and Adaptive Management

As described in EIS Subsection 4.1.1, Mitigation Measures and Adaptive Management, and EIS Subsection 4.2.5.11, Mitigation Measures and Adaptive Management (Summer-run Chum Salmon), potential mitigation measures are identified for the action alternatives to address risks associated with the hatchery programs. Mitigation measures in the EIS include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (included updated and new BMPs). For reference throughout this appendix, Table G-2 identifies a potential mitigation measure associated with risk ratings. As described in EIS Subsection 4.2.5.11, Mitigation Measures and Adaptive Management (Summer-run Chum Salmon), mitigation measures may help reduce risks, but may also reduce benefits. In addition, mitigation measures may affect other resources. For example, a reduction in a hatchery program may affect prey resources for other fish and wildlife, tribal fishing rights and water quality, among other resource values.

Table G-2. Example of a potential mitigation measure for hatchery programs applicable to listed summer-run chum salmon under adaptive management.

Mitigation Measure	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Increased Production)
Reduce numbers of hatchery-origin fish released: applicable to a specific hatchery program (Snow Creek coho salmon supplementation) **Value**[1] – Reduces predation risks **Constraints**[2] – May reduce numbers of hatchery-origin adults available for harvest		√		√

[1] Value describes how the measure may reduce risks.
[2] Constraints describe how the measure may reduce benefits.

4.0 Population Results

This subsection discusses risks and benefits for each Hood Canal summer-run chum salmon population, beginning with the Hood Canal population forming the southern part of the ESU, followed by the Strait of Juan de Fuca population forming the northwestern part of the ESU.

4.1 Hood Canal Population

4.1.1 Introduction

The rivers and streams associated with the Hood Canal summer-run chum salmon population are Big Quilcene, Little Quilcene, Dosewallips, Duckabush, Hamma Hamma, Lilliwaup, Union, and Tahuya Rivers, and Big Beef Creek. Three fall-run chum salmon hatchery programs, five Chinook salmon hatchery programs, three coho salmon hatchery programs, one steelhead hatchery program, and one pink salmon hatchery program from five hatcheries have the potential to impact the Hood Canal summer-run chum salmon population (Table G-3 and Table G-4), and are evaluated in this subsection.

Table G-3. Hatchery programs and categories of effects evaluated for the Hood Canal summer-run chum salmon population.

Species	Hatchery and Program	Risk	
		Competition	Predation
Chum salmon	Skokomish Hatchery (Enetai Hatchery) isolated fall-run chum salmon fry	√	√
	Hoodsport Hatchery isolated fall-run chum salmon fry	√	√
	McKernan Hatchery isolated fall-run chum salmon fry	√	√
Chinook salmon	George Adams Hatchery integrated fall-run Chinook salmon subyearling	√	√
	George Adams Hatchery (Rick's Pond) integrated fall-run Chinook salmon yearling	√	√
	Hoodsport Hatchery isolated fall-run Chinook salmon subyearling	√	√
	Hoodsport Hatchery isolated fall-run Chinook salmon yearling	√	√
	Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	√	√
Coho salmon	George Adams Hatchery isolated coho salmon yearling	√	√
	Quilcene Hatchery isolated coho salmon yearling	√	√
	Quilcene Hatchery net pen isolated coho salmon yearling	√	√
Pink salmon	Hoodsport Hatchery isolated pink salmon fry	√	√
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling (McKernan Hatchery and Lilliwaup Hatchery)	√	√

Table G-4. Hatchery salmon and steelhead production evaluated for the Hood Canal summer-run chum salmon population by alternative.

	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Chum salmon	Skokomish Hatchery (Enetai Hatchery) isolated fall-run chum salmon fry	2,500,000	2,500,000	0	2,500,000	0
	Hoodsport Hatchery isolated fall-run chum salmon fry	12,000,000	12,000,000	0	15,000,000	25
	McKernan Hatchery isolated fall-run chum salmon fry	10,000,000	10,000,000	0	15,000,000	50
	TOTAL fry	**24,500,000**	**24,500,000**	**0**	**32,500,000**	**33**
Chinook salmon	George Adams Hatchery integrated fall-run Chinook salmon subyearling	3,800,000	1,900,000	50	3,800,000	0
	George Adams Hatchery (Rick’s Pond) integrated fall-run Chinook salmon yearling	120,000	60,000	50	120,000	0
	Hoodsport Hatchery isolated fall-run Chinook salmon subyearling	2,800,000	2,800,000	0	2,800,000	0
	Hoodsport Hatchery isolated fall-run Chinook salmon yearling	120,000	120,000	0	120,000	0
	Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	110,000	110,000	0	110,000	0
	Total subyearlings	**6,710,000**	**4,810,000**	**28**	**6,710,000**	**0**
	Total yearlings	**240,000**	**180,000**	**25**	**240,000**	**0**
	TOTAL	**6,950,000**	**4,990,000**	**28**	**6,950,000**	**0**
Coho salmon	George Adams Hatchery isolated coho salmon yearling	300,000	150,000	50	300,000	0
	Quilcene Hatchery isolated coho salmon yearling	400,000	400,000	0	400,000	0
	Quilcene Hatchery net pen isolated coho salmon yearling	200,000	200,000	0	450,000	125
	TOTAL yearlings	**900,000**	**900,000**	**0**	**1,150,000**	**28**

Table G-4. Hatchery salmon and steelhead production evaluated for the Hood Canal summer-run chum salmon population by alternative, continued.

			Alternative 3		Alternative 4	
	Hatchery and Program	**Release Number for Alternative 1 and 2**	**Release Number**	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Pink salmon	Hoodsport Hatchery isolated pink salmon fry	500,000	500,000	0	1,000,000	100
Steelhead	Hood Canal Steelhead Supplementation Project integrated steelhead yearling (McKernan Hatchery and Lilliwaup Hatchery)	49,540	49,540	0	49,540	0
	Total yearlings	**49,540**	**49,540**	**0**	**49,540**	**0**
	Total adults	**883**	**883**	**0**	**883**	**0**
	TOTAL	**50,423**	**50,423**	**0**	**50,423**	**0**
All	**Total fry**	**25,000,000**	**25,000,000**	**0**	**33,500,000**	**34**
	Total subyearlings	**6,710,000**	**4,810,000**	**25**	**6,710,000**	**0**
	Total yearlings	**1,189,540**	**1,129,540**	**5**	**1,439,540**	**21**
	Total adults	**883**	**883**	**0**	**883**	**0**
	TOTAL	**32,900,423**	**30,940,423**	**6**	**41,650,423**	**27**

4.1.2 Results

Table G-5 summarizes the results for the Hood Canal summer-run chum salmon population. The action alternatives would include use of an adaptive management approach, but the results in Table G-5 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for the population are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail.

Table G-5. Summary of hatchery-related risks and benefits for the Hood Canal summer-run chum salmon population by alternative.

	Alternative 1 and 2	**Alternative 3**	**Alternative 4**
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	Low	Same as Alternative 1	Same as Alternative 1

4.1.2.1 Risks

The hatchery programs result in juvenile and adult competition risks and adult predation risks as described below.

4.1.2.1.1 Competition

Overall, juvenile and adult competition risks to the Hood Canal summer-run chum salmon population from fall-run chum salmon, Chinook salmon, coho salmon, pink salmon, and steelhead hatchery programs would be low under the four alternatives (Table G-5) for the reasons described below.

Juveniles. As described in EIS Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon, summer-run chum salmon juveniles spend little, if any, time rearing in freshwater areas, emigrating to marine waters soon after emerging as fry. Summer-run chum salmon are thus less susceptible to food resource competition with the other salmon and steelhead species produced by hatcheries. Summer-run chum salmon emerge and emigrate seaward predominately during March whereas most hatcheries release fish after April 1 (Figure 3.2-4 in EIS Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon). Thus, juvenile competition risks would be low under all alternatives (Table G-6). If space considerations result in releases of Hoodsport Hatchery pink salmon prior to April, then the risk would increase to moderate under Alternative 1, Alternative 2, and Alternative 3, and high under Alternative 4, because of the increased number of fish released.

Table G-6. Summary of competition and predation risks to the Hood Canal summer-run chum salmon population posed by hatchery programs by alternative.

Risk and Hatchery Program	Alternative 1 and 2	Alternative 3	Alternative 4
Competition			
Risk to juvenile summer-run chum salmon			
Skokomish Hatchery (Enetai Hatchery) isolated fall-run chum salmon fry	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run chum salmon fry	Low	Same as Alternative 1	Same as Alternative 1
McKernan Hatchery isolated fall-run chum salmon fry	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1

Table G-6. Summary of competition and predation risks to the Hood Canal summer-run chum salmon population posed by hatchery programs by alternative, continued.

Risk and Hatchery Program	**Alternative 1 and 2**	**Alternative 3**	**Alternative 4**
George Adams Hatchery (Rick's Pond) integrated fall-run Chinook salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery net pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated pink salmon fry	Low	Same as Alternative 1	Same as Alternative 1
Hood Canal Steelhead Supplementation Project integrated steelhead yearling (McKernan Hatchery and Lilliwaup Hatchery)	Low	Same as Alternative 1	Same as Alternative 1
Risk to adult summer-run chum salmon			
Skokomish Hatchery (Enetai Hatchery) isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1 and 2
McKernan Hatchery isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery integrated fall-run Chinook salmon subyearling	Negligible	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery (Rick's Pond) integrated fall-run Chinook salmon yearling	Negligible	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon subyearling	Negligible	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon yearling	Negligible	Same as Alternative 1	Same as Alternative 1

Table G-6. Summary of competition and predation risks to the Hood Canal summer-run chum salmon population posed by hatchery programs by alternative, continued.

Risk and Hatchery Program	Alternative 1 and 2	Alternative 3	Alternative 4
Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery isolated coho salmon yearling	Negligible	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery net pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated pink salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
Hood Canal Steelhead Supplementation Project integrated steelhead yearling (McKernan Hatchery and Lilliwaup Hatchery)	Low	Same as Alternative 1	Same as Alternative 1
Predation			
Skokomish Hatchery (Enetai Hatchery) isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
McKernan Hatchery isolated fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery integrated fall-run Chinook salmon subyearling	Negligible	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery (Rick's Pond) integrated fall-run Chinook salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
Hoodsport Hatchery isolated fall-run Chinook salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Hamma Hamma Hatchery integrated fall-run Chinook salmon subyearling	Low	Same as Alternative 1	Same as Alternative 1
George Adams Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Quilcene Hatchery net pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1

Table G-6. Summary of competition and predation risks to the Hood Canal summer-run chum salmon population posed by hatchery programs by alternative, continued.

Risk and Hatchery Program	Alternative 1 and 2	Alternative 3	Alternative 4
Hoodsport Hatchery isolated pink salmon fry	Low	Same as Alternative 1	Same as Alternative 1
Hood Canal Steelhead Supplementation Project integrated steelhead yearling (McKernan Hatchery and Lilliwaup Hatchery)	Low	Same as Alternative 1	Same as Alternative 1

Adults. Competition risks to adult summer-run chum salmon occur when hatchery-origin fish spawn at the same times and locations as the natural-origin fish. This can lead to disturbance of eggs deposited in previously constructed summer-run chum salmon redds. As described in EIS Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon, summer-run chum salmon spawning occurs from late August through late October, generally within the lowest 1 to 2 miles of streams entering Hood Canal. Fall-run chum salmon and steelhead species spawn at other times or locations. For hatchery-origin Chinook salmon and coho salmon hatchery programs, spawners may overlap with the later portion of the summer-run chum salmon spawning time for some programs. However, adult competition risks for these programs would be negligible or low under all alternatives (Table G-6) because hatchery-origin Chinook salmon return to hatchery facilities rather than natural summer-run chum salmon spawning areas (e.g., Hoodsport Hatchery Chinook salmon, George Adams Hatchery Chinook salmon and coho salmon, Quilcene Hatchery coho salmon). In addition, returning hatchery-origin fish would disperse over a broad area of streams (Hamma Hamma fall-run Chinook salmon program), and natural partitioning of spawning areas by the two species that co-evolved in the same river would limit the risk of redd superimposition.

4.1.2.1.2 Risks – Predation

Overall predation risks to the Hood Canal summer-run chum salmon population from fall-run chum salmon, Chinook salmon, coho salmon, pink salmon, and steelhead hatchery programs would be low under the four alternatives (Table G-5) for the reasons described below.

Direct predation would occur when fish released from hatcheries out-migrate at the same time (prior to April 1) and in the same locations as juvenile natural-origin summer-run chum salmon, and the hatchery-origin fish are of a large enough size (approximately 3 inches or greater [fork length]) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) to consume natural-origin summer-run chum salmon fry. Based on these considerations, the risks of direct predation from the hatchery programs would be negligible (Table G-6).

Indirect predation risks to natural-origin summer-run chum salmon occur when hatchery-origin fish are released prior to April 1 that could attract predators to release locations where natural-origin summer-run chum salmon are also present. These predation risks would be negligible or low under all alternatives (Table G-5). If space considerations result in releases of Hoodsport Hatchery pink salmon prior to April, then the risk would increase to moderate under all alternatives.

4.1.2.2 Summary – Hood Canal Population

Table G-5 summarizes the risks for all alternatives pertinent to the Hood Canal summer-run chum salmon population. For the 13 hatchery programs associated with this population, the overall risk of competition and predation effects would be low under all alternatives. Risks for all but one program would be negligible or low.

4.1.2.3 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (included updated and new BMPs). Because risks are not substantial, no potential mitigation measures are provided for the Hood Canal summer-run chum salmon population.

4.2 Strait of Juan de Fuca Population

4.2.1 Introduction

The rivers and streams associated with the Strait of Juan de Fuca summer-run chum salmon population are the Chimacum, Salmon, Snow, and Jimmycomelately Creeks, and the Dungeness River. One fall-run chum salmon hatchery program, one Chinook salmon hatchery program, three coho salmon hatchery programs, and one steelhead hatchery program from four hatcheries have the potential to impact the Strait of Juan de Fuca summer-run chum salmon population (Table G-7 and Table G-8), and are evaluated in this subsection.

Table G-7. Hatchery programs and categories of effects evaluated for the Strait of Juan de Fuca summer-run chum salmon population.

Species	Hatchery and Program	Risk	
		Competition	Predation
Chum salmon	Port Gamble Hatchery (Little Boston Hatchery) fall-run chum salmon fry	√	√
Chinook salmon	Dungeness Hatchery integrated spring-run Chinook salmon subyearling and yearling	√	√
Coho salmon	Port Gamble Net Pen isolated coho salmon yearling	√	√
	Snow Creek Hatchery integrated coho salmon fry, subyearling and yearling	√	√
	Dungeness Hatchery isolated coho salmon yearling	√	√
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling	√	√

Table G-8. Hatchery salmon and steelhead production evaluated for the Strait of Juan de Fuca summer-run chum salmon population by alternative.

	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Chum salmon	Port Gamble Hatchery (Little Boston Hatchery) fall-run chum salmon fry	500,000	500,000	0	500,000	0
Chinook salmon	Dungeness Hatchery integrated spring-run Chinook salmon subyearling	100,000	100,000	0	100,000	0
	Dungeness Hatchery integrated spring-run Chinook salmon yearling	100,000	100,000	0	100,000	0
	TOTAL	**200,000**	**200,000**	**0**	**200,000**	**0**
Coho salmon	Port Gamble net pen isolated coho salmon yearling	400,000	400,000	0	600,000	50
	Snow Creek supplementation integrated coho salmon fry	36,000	36,000	0	36,000	0
	Snow Creek supplementation integrated coho salmon subyearling	9,000	9,000	0	9,000	0

Table G-8. Hatchery salmon and steelhead production evaluated for the Strait of Juan de Fuca summer-run chum salmon population by alternative (continued).

			Alternative 3		Alternative 4	
	Hatchery and Program	**Release Number for Alternative 1 and 2**	**Release Number**	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
	Snow Creek supplementation integrated coho salmon yearling	9,000	9,000	0	9,000	0
	Dungeness Hatchery isolated coho salmon yearling	500,000	250,000	50	500,000	0
	TOTAL fry	**36,000**	**36,000**	**0**	**36,000**	**0**
	TOTAL subyearlings	**9,000**	**9,000**	**0**	**9,000**	**0**
	TOTAL yearlings	**909,000**	**659,000**	**28**	**1,109,000**	**22**
	TOTAL	**954,000**	**704,000**	**26**	**1,154,000**	**21**
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling	10,000	5,000	50	10,000	0
All	**Total fry**	**536,000**	**536,000**	**0**	**536,000**	**0**
	Total subyearlings	**109,000**	**109,000**	**0**	**109,000**	**0**
	Total yearlings	**1,019,000**	**764,000**	**25**	**1,219,000**	**20**
	TOTAL	**1,664,000**	**1,409,000**	**15**	**1,864,000**	**12**

4.2.2 Results

Table G-9 summarizes the results for the Strait of Juan de Fuca summer-run chum salmon population. The action alternatives would include use an adaptive management approach, but the results in Table G-9 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for the population are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for any moderate and high risks in Table G-9 is explained in the subsequent subsections for this population.

Table G-9. Summary of hatchery-related risks and benefits for the Strait of Juan de Fuca summer-run chum salmon population by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition	Low	Same as Alternative 1	Same as Alternative 1
Predation	Low	Same as Alternative 1	Same as Alternative 1

4.2.2.1 Risks

The hatchery programs would result in juvenile and adult competition risks and adult predation risks as described below.

4.2.2.1.1 Competition

Overall juvenile and adult competition risks to the Strait of Juan de Fuca summer-run chum salmon population from fall-run chum salmon, Chinook salmon, coho salmon, and steelhead hatchery programs would be low under the four alternatives (Table G-9) for the reasons described below.

Juveniles. The competition risks to juvenile summer-run chum salmon for all hatchery programs would be low under all alternatives (Table G-10), because there would be minimal spatial and temporal overlap between summer-run chum salmon juveniles and hatchery-origin fish. With the exception of the Snow Creek coho salmon supplementation program, releases of hatchery-origin fish into fresh water would occur after April 1 each year (Figure 3.2-4 in EIS Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon). However, for the Snow Creek coho salmon supplementation program, a majority of the juvenile coho salmon produced would be released as fry or fingerlings that rear in fresh water for a year before emigrating seaward. Summer-run chum salmon do not rear to a substantial degree in fresh water; as a result, coho salmon juveniles released from the Snow Creek coho salmon supplementation program would pose only low competition risks to summer-run chum salmon in the Snow Creek watershed under all alternatives (Table G-10) because production levels would not change (Table G-8).

Table G-10. Summary of competition and predation risks to the Strait of Juan de Fuca summer-run chum salmon population posed by hatchery programs by alternative.

Risk and Hatchery Program	Alternative 1 and 2	Alternative 3	Alternative 4
Competition			
Risk to juvenile summer-run chum salmon			
Port Gamble Hatchery (Little Boston Hatchery) fall-run chum salmon fry	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery integrated spring-run Chinook salmon subyearling and yearling	Low	Same as Alternative 1	Same as Alternative 1
Port Gamble Net Pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Snow Creek supplementation integrated coho salmon fry, subyearling, yearling	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated winter-run steelhead yearling	Low	Same as Alternative 1	Same as Alternative 1
Risk to adult summer-run chum salmon			
Port Gamble Hatchery (Little Boston Hatchery) fall-run chum salmon fry	Negligible	Same as Alternative 1 and 2	Same as Alternative 1 and 2
Dungeness Hatchery integrated spring-run Chinook salmon subyearling and yearling	Low	Same as Alternative 1	Same as Alternative 1
Port Gamble net pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Snow Creek supplementation integrated coho salmon fry, subyearling, yearling	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated winter-run steelhead yearling	Negligible	Same as Alternative 1	Same as Alternative 1
Predation			
Port Gamble Hatchery (Little Boston Hatchery) fall-run chum salmon fry	Negligible	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery integrated spring-run Chinook salmon subyearling and yearling	Negligible	Same as Alternative 1	Same as Alternative 1
Port Gamble net pen isolated coho salmon yearling	Low	Same as Alternative 1	Same as Alternative 1
Snow Creek supplementation integrated coho salmon fry, subyearling and yearling	Moderate	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated coho salmon yearling	Negligible	Same as Alternative 1	Same as Alternative 1
Dungeness Hatchery isolated winter-run steelhead yearling	Low	Same as Alternative 1	Same as Alternative 1

Adults. Competition risks to adult summer-run chum salmon would occur when hatchery-origin fish spawn at the same times and locations as the natural-origin fish. This can lead to disturbance of eggs deposited in previously constructed summer-run chum salmon redds. As described in EIS Subsection 3.2.6.1, Life History of Natural-origin Summer-run Chum Salmon, summer-run chum salmon spawning occurs from late August through late October, generally within the lowest 1 to 2 miles of streams. Fall-run chum salmon and steelhead species spawn at other times or locations. For hatchery-origin Chinook salmon and coho salmon hatchery programs, spawners may overlap with the later portion of the summer-run chum salmon spawning time for some programs. However, adult competition risks for these programs would be low when hatchery-origin salmon escaping harvest return to hatchery facilities or upstream spawning areas, minimizing use of areas used by summer-run chum salmon for spawning (e.g., Port Gamble net pen coho salmon, Dungeness Hatchery coho salmon, Snow Creek coho salmon supplementation). Risks would also be low when returning hatchery-origin fish disperse over a broad area of streams (Dungeness Hatchery Chinook salmon program), and natural partitioning of spawning areas by the two species that co-evolved in the same river limits the risk of redd superimposition. Adult competition risks to the Strait of Juan de Fuca summer-run chum salmon population would be negligible or low under all alternatives (Table G-10).

4.2.2.1.2 Risks – Predation

Overall predation risks to the Strait of Juan de Fuca summer-run chum salmon population from fall-run chum salmon, Chinook salmon, coho salmon, and steelhead hatchery programs under the four alternatives would be low (Table G-9) for the reasons described below.

Direct predation would occur when fish released from hatcheries emigrate at the same time (prior to April 1) and in the same locations as natural-origin summer-run chum salmon, and the hatchery-origin fish are of a large enough size (approximately 3 inches or greater [fork length]) to prey on natural-origin summer-run chum salmon fry. Only yearling coho salmon produced by the Snow Creek coho salmon supplementation program (released in February) meet those criteria (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and present a direct predation risk to summer-run chum salmon. In addition, the program would release modest numbers of coho salmon fry and subyearlings. To the extent that the hatchery-origin coho salmon fry and subyearlings would successfully rear to a larger size and become smolts emigrating the following year, they may consume smaller co-existing summer-run chum salmon fry.

Indirect predation would occur when concentrations of hatchery releases commingled with summer-run chum salmon juveniles in freshwater and marine areas attract predators. Indirect predation risks to summer-run chum salmon occur when hatchery-origin fish are released prior to April 1 and in locations where natural-origin summer-run chum may also be present. However, differences in habitat preferences between the species make indirect predation risks to summer-run chum salmon juveniles unlikely for the Snow Creek coho salmon supplementation program. The overall predation risk to summer-run chum salmon from the Snow Creek coho salmon supplementation program would be moderate under all alternatives (Table G-10). Predation risks from the other hatchery programs would be negligible or low (Table G-10).

4.2.2.2 Summary – Strait of Juan de Fuca Population

Table G-9 summarizes the risks for all alternatives pertinent to the Strait of Juan de Fuca summer-run chum salmon population. From the six hatchery programs associated with this population, the overall risk of competition and predation effects would be low under all alternatives (Table G-9). Risks for all but one program would be negligible or low (Table G-10). The Snow Creek supplementation coho salmon program would present a moderate predation (direct) risk under all alternatives.

4.2.2.3 Mitigation Measures and Adaptive Management

As described in Subsection 3.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (included updated and new BMPs). Mitigation measures are intended to reduce risks to natural-origin summer-run chum salmon from hatchery programs; no measures are identified to increase benefits. Measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish.

Table G-11 provides a potential mitigation measure for the Snow Creek supplementation coho salmon yearling hatchery program under the action alternatives. This mitigation measure would help reduce the direct predation risk to natural-origin summer-run chum salmon from this hatchery, which is rated as a moderate risk under all alternatives. The proposed mitigation measure would apply to Alternative 2 and Alternative 4. The mitigation measure would not apply to Alternative 3 because this alternative already includes specified decreases in hatchery production at other hatcheries to help decrease risks to the natural-origin summer-run chum salmon population.

Table G-11. Potential mitigation measure for the Snow Creek supplementation coho salmon program.

Risk Category	Mitigation Measure
Predation	Decrease the number of coho salmon yearlings released under the Snow Creek supplementation program to reduce the risk that hatchery-origin coho salmon yearlings would prey on emigrating summer-run chum salmon fry.

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Appendix H

Steelhead Effects Analysis by Basin

For a list of acronyms used in this appendix, see Acronyms and Abbreviations in EIS

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1.0 Introduction

This appendix identifies hatchery program risks and benefits for the Puget Sound Steelhead Distinct Population Segment (DPS) at the river basin scale. There are 10 river basins that encompass the 21 steelhead stocks and 32 populations comprising the DPS, as described in EIS Subsection 3.2.7.2, Distribution and Abundance of Natural-origin Steelhead, and shown in Table H-1.

This appendix evaluates hatchery-related risks and benefits for steelhead in the 10 river basins by alternative. Alternative 1 (the No-action Alternative) also represents existing conditions. The existing conditions described in this appendix are summarized and reported in EIS Subsection 3.2.7, Puget Sound Steelhead DPS. This appendix identifies potential mitigation measures for hatchery programs that have the potential to pose risks to natural-origin steelhead.

2.0 Methods

Information about the general effects of hatchery programs on natural-origin fish, and methods used to analyze effects on the Puget Sound Steelhead DPS and its component river basins, are provided in Appendix B, Hatchery Effects and Evaluation Methods for Fish, and EIS Subsection 4.2.6.1, Methods for Analysis (Steelhead).

2.1 River Basin Analysis

As described in Appendix B, Hatchery Effects and Evaluation Methods for Fish, the HPV Coarse Filter Tool is the primary tool used to evaluate competition, genetics, and hatchery facilities and operation risks for steelhead, and is complemented by other qualitative assessments (e.g., program size comparisons). Methods for total return benefits are based on the extent to which total adult returns compare to reference points based on return rate goals. Methods for viability benefits are analyzed for hatchery programs that are part of the listed DPS (or are proposed by NMFS to be part of the listed DPS), and program size. There are no viability benefits to steelhead in river basins having only isolated steelhead hatchery programs (i.e., fish from programs not listed under the ESA).

Table H-1. River basins, watersheds, steelhead stocks, and populations evaluated for the Puget Sound Steelhead DPS.

River Basin	Watershed	WDFW Stock[1]		Puget Sound Steelhead TRT Population[2]		
		Winter-run	**Summer-run**	**Major Population Group**	**Winter-run**	**Summer-run**
Nooksack	Nooksack Samish	Dakota Creek Mainstem/North Fork Nooksack Middle Fork Nooksack South Fork Nooksack Samish	South Fork Nooksack	Northern Cascades	Drayton Harbor Tributaries Nooksack Samish and Bellingham Bay	South Fork Nooksack
Skagit	Skagit Cascade	Skagit/Tributaries Sauk Cascade	Finney Creek Sauk Cascade		Baker (includes summer-run) Skagit (includes summer-run) Sauk (includes summer-run) Nookachamps Creek	
Stillaguamish	Stillaguamish	Stillaguamish	Deer Creek Canyon Creek		Stillaguamish	Deer Creek Canyon Creek
Snohomish	Snohomish Skykomish	Snohomish/Skykomish Pilchuck Snoqualmie	North Fork Skykomish Tolt		Snohomish/Skykomish Pilchuck Snoqualmie	North Fork Skykomish Tolt
Lake Washington	Lake Washington Sammamish River	Lake Washington		Central and South Sound	North Lake Washington and Lake Sammamish Cedar	
Green	Green Duwamish	Green			Green (includes summer-run[3])	

Table H-1. River basins, watersheds, steelhead stocks, and populations evaluated for the Puget Sound Steelhead DPS, continued.

River Basin	Watershed	WDFW Stock[1]		Puget Sound Steelhead TRT Population[2]		
		Winter-run	Summer-run	Major Population Group	Winter-run	Summer-run
Puyallup	Puyallup Carbon White Mowich	Mainstem Puyallup White Carbon			Puyallup/Carbon White	
South Sound	Nisqually	Nisqually Eld Inlet Totten Inlet Hammersley Inlet Case/Carr Inlet East Kitsap			Nisqually South Sound Tributaries East Kitsap	
Hood Canal	Skokomish Big Quilcene Duckabush Dewatto	Dewatto Tahuya Union Skokomish Hamma Hamma Quilcene/Dabob Bays	Skokomish Dosewallips	Hood Canal and Strait of Juan de Fuca	East Hood Canal South Hood Canal Skokomish (includes summer-run) West Hood Canal	
Strait of Juan de Fuca	Elwha Dungeness Snow Creek	Discovery Bay Sequim Bay Dungeness Morse Creek/MacDonald Elwha	Dungeness Elwha		Sequim/Discovery Bay Tributaries Dungeness (includes summer-run) Strait of Juan de Fuca Tributaries Elwha (includes summer-run[4])	

[1] Source: WDF et al. (1993).
[2] Source: Hard et al. (2014).
[3] Existing Green summer-run population is considered non-native (historical population possibly extirpated) (Hard et al. (2014).
[4] Native Elwha summer-run steelhead may no longer be present (Hard et al. 2014).

Results for each river basin are organized by hatchery program for species in the following order:

- Steelhead hatchery programs evaluation consists of competition, genetics, and hatchery facilities and operation risks.
- Chinook salmon hatchery programs evaluation consists of competition risks.
- Coho salmon hatchery programs evaluation consists of competition risks.

Risks not evaluated for natural-origin steelhead include:

- Predation
- Competition effects from releases of hatchery-origin fish younger than yearlings
- Competition effects from releases of hatchery-origin yearlings into marine water

For an explanation as to why these risks were not evaluated, see EIS Subsection 3.2.7.4, Hatchery Program Risks and Benefits (Steelhead).

Benefits from steelhead hatchery programs are evaluated for total return and viability, as described in EIS Subsection 3.2.7.4.5, Benefits – Total Return (Steelhead), and EIS Subsection 3.2.7.4.6, Viability.

Benefits from hatchery programs contributing marine-derived nutrients are not evaluated at the population scale, because of insufficient information at that scale. Instead, benefits are evaluated at the DPS scale as described in EIS Subsection 3.2.7.4.7, Benefits – Marine-derived Nutrients (Steelhead). Thus, refer to EIS Subsection 4.2.6.13, Benefits – Marine-derived Nutrients (Steelhead) for evaluation of this benefit for Chinook salmon.

Multiple steelhead stocks or populations are present in some river basins (e.g., Baker, Skagit, Sauk and Nookachamps Creek in the Skagit River basin). Because of analytical constraints and the scarcity of available information, where more than one stock or population exists in a river basin, or where more than one hatchery program affects a stock or population in a river basin, the aggregate effect is rated the same as the highest rating of the programs in the basin, for both risks and benefits. In other words, where more than one hatchery program affects a steelhead stock or population, or where multiple stocks or populations exist in a basin, the highest risk identified across programs is applied to the river basin being evaluated. This approach is reasonable because it compensates for existing analytical constraints and uses information that is available. Rating the composite risks to highest risk ratings in an area where there may also be lower risk ratings is a precautionary approach for natural-origin fish because it emphasizes risks that might otherwise be masked by lower risk ratings.

Details on hatchery programs and releases in Puget Sound are included in Appendix A, Puget Sound Hatchery Programs and Facilities.

The benefit from marine-derived nutrients is not evaluated at the hatchery program or river basin scale; instead, this benefit is evaluated only at the DPS scale. Thus, refer to EIS Subsection 4.2.6.13, Benefits—Marine-derived Nutrients (Steelhead), for evaluation of this benefit for steelhead.

2.2 DPS Analysis

Results from this appendix for the 10 steelhead river basins are summarized at the DPS scale in EIS Subsection 3.2.7, Puget Sound Steelhead DPS, and EIS Subsection 4.2.6, Puget Sound Steelhead DPS. Risks and benefits to steelhead in each river basin are assigned a numeric score, and sums of scores for each river basin are divided by the respective number of hatchery programs. The resulting mean then represents the risk or benefit level for the DPS as a whole (EIS Subsection 4.2.6.2, Determining Overall Risks and Benefits).

2.3 Mitigation Measures and Adaptive Management

As described in EIS Subsection 4.1.1, Mitigation Measures and Adaptive Management, and EIS Subsection 4.2.6.15, Mitigation Measures and Adaptive Management (Steelhead), potential mitigation measures are identified for the action alternatives to address risks associated with hatchery programs. Mitigation measures in the EIS include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (included updated and new BMPs). For reference throughout this steelhead appendix, Table H-2 identifies potential mitigation measures associated with risk ratings. Some mitigation measures may apply to more than one impact on natural-origin steelhead. As described in EIS Subsection 4.2.6.15, Mitigation Measures and Adaptive Management (Steelhead), mitigation measures may help reduce risks, but may also reduce benefits. In addition, mitigation measures may affect other resources. For example, a reduction in a hatchery program may affect prey resources for other fish and wildlife, tribal fishing rights, and water quality, among other resource values.

Table H-2. Potential mitigation measures associated with impacts to natural-origin steelhead by risk category.

Risk Category	Impact	Potential Mitigation Measure	
		Number	**Description**
Competition	Program does not avoid transfers into the basin	C1	Use only in-basin returns for broodstock
	All hatchery-origin adult returns are not removed from the watershed	C2	Increase harvest to remove returning hatchery-origin adults, apply more effective trapping, increase harvest to remove returning hatchery-origin adults, and/or develop more efficient fishery
	Smolt releases may interact with natural population	C3	Alter release strategy (such as trucking smolts for release near the river mouth or delaying releases until after natural-origin steelhead smolt out-migration), develop monitoring plan for juvenile interaction
	pHOS is not estimated	C4	Develop plan for monitoring of pHOS
	Fish are trucked and planted	C5	Develop acclimation ponds
	Chinook salmon or coho salmon hatchery-origin fish are released high in the watershed (above RM 20)	C6	Monitor post-release out-migration behavior and diet of hatchery-origin fish to determine the extent of the risks from the hatchery program. If competition is determined to be a substantial risk factor, truck hatchery-origin smolts to a downstream acclimation site for release near the mouth of the river
	Chinook salmon or coho salmon hatchery-origin fish are released during May—the primary natural-origin steelhead smolt out-migration period	C7	Delay release of hatchery-origin salmon until after the majority of natural-origin steelhead smolts have out-migrated
	Total release numbers for Chinook salmon or coho salmon hatchery-origin are greater than 50,000 fish	C8	Reduce program size
	No adequate adult trapping facilities	C9	Develop effective trapping/harvest of returning hatchery-origin adults

Table H-2. Potential mitigation measures associated with impacts to natural-origin steelhead by risk category, continued.

Risk Category	Impact	Potential Mitigation Measure	
		Number	**Description**
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations	G1	Develop integrated native-based program
	Program does not avoid transfers into the basin	G2	Use only in-basin returns for broodstock
	All hatchery-origin adult returns are not removed from the watershed	G3	Monitor hatchery-origin steelhead spawn timing and contribution to natural spawning. Based on results, develop more effective trapping/harvest of returning hatchery-origin adults, increase harvest to remove returning hatchery-origin adults, develop more efficient fishery, maintain a hatchery rack across the entire hatchery-origin steelhead return period, develop an earlier return timing of hatchery-origin fish to avoid mating with natural-origin steelhead, and/or cease the practice of adult hatchery-origin fish recycling from hatchery traps to downstream fishery harvest areas
	pHOS is not estimated	G4	Develop plan for monitoring of pHOS
	Fish are trucked and planted	G5	Develop acclimation ponds
	No adequate adult trapping facilities	G6	Use effective trapping/harvest of returning hatchery-origin adults
Hatchery Facilities and Operation	Program does not avoid transfers into the basin	H1	Use only in-basin returns for broodstock
	Facility water intake does not meet current standards	H2	Upgrade intakes, when feasible, to current standards
	Hatchery structures impede passage of natural-origin juveniles and adults	H3	Consider modifications to hatchery infrastructure (e.g., weir) (HSRG recommendation)
	No performance measures or monitoring plan developed	H4	Develop performance measures and monitoring plan
	Program not based on adaptive management plan	H5	Develop adaptive management plan for program
	Facility is not sited to minimize risk of catastrophic fish loss from flooding	H6	Develop flood risk management protocols and minimize exposure by restricting use during flood season or discontinue program

3.0 River Basin Results

Provided in this subsection are risks and benefits to natural-origin steelhead by river basin, beginning with those in the north-eastern part of the DPS (Nooksack River river basin), then progressing southerly and then northwesterly to the Strait of Juan de Fuca basin.

3.1 Nooksack River

3.1.1 Introduction

As shown in Table H-1, the Nooksack River basin includes the Nooksack River and Samish River watersheds where five natural-origin winter-run steelhead stocks and one summer-run steelhead stock occur, represented in three winter-run populations and one summer-run population. All of these stocks and populations are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS), and the steelhead in the Nooksack River basin represent the northernmost extent of the DPS.

The following rivers and streams are found within the Nooksack River basin and support hatchery-origin fish that could affect natural-origin steelhead: Nooksack River (mainstem, North Fork, Middle Fork, and South Fork), Kendall Creek (tributary of the Nooksack River), Skookum Creek tributary of the South Fork Nooksack River), Whatcom Creek (independent stream that flows from Lake Whatcom to Bellingham Bay), Samish River, and Friday Creek (Samish River tributary).

Two steelhead hatchery programs, one Chinook hatchery program, and two coho salmon hatchery programs at four hatchery facilities (Kendall Creek Hatchery, Whatcom Creek Hatchery, Samish Hatchery, and Skookum Creek Hatchery) have the potential to impact Nooksack River basin steelhead (Table H-3 and Table H-4), and are reviewed in this subsection.

Table H-3. Hatchery programs and categories of effects evaluated for Nooksack River basin steelhead.

		Risk			Benefit
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**
Steelhead	Kendall Creek Hatchery isolated winter-run steelhead program yearling	√	√	√	√
	Whatcom Creek Hatchery isolated winter-run steelhead program yearling	√	√	√	√

Table H-3. Hatchery programs and categories of effects evaluated for Nooksack River basin steelhead, continued.

		Risk			Benefit
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**
Chinook Salmon	Samish Hatchery isolated summer/fall-run Chinook salmon program yearling	√			
Coho Salmon	Kendall Creek Hatchery integrated coho salmon program yearling	√			
	Skookum Creek Hatchery integrated/segregated coho salmon program yearling	√			

Table H-4. Hatchery salmon and steelhead production in the Nooksack River basin by program and alternative.

			Alternative 3		Alternative 4	
Species	**Hatchery and Program**	**Release Number for Alternative 1 and 2**	**Release Number**	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Steelhead	Kendall Creek Hatchery isolated winter-run steelhead program yearling	150,000	75,000	50	150,000	0
	Whatcom Creek Hatchery isolated winter-run steelhead program yearling	40,000	40,000	0	45,000	12
	TOTAL	**190,000**	**115,000**	**37**	**195,000**	**3**
Chinook Salmon	Samish Hatchery isolated summer/fall-run Chinook salmon program yearling	100,000	100,000	0	100,000	0
	TOTAL	**100,000**	**100,000**	**0**	**100,000**	**0**
Coho Salmon	Kendall Creek Hatchery integrated coho salmon program yearling	300,000	150,000	50	300,000	0
	Skookum Creek Hatchery integrated/segregated coho salmon program yearling	1,000,000	500,000	50	2,000,000	100
	TOTAL	**1,300,000**	**650,000**	**50**	**2,300,000**	**77**
All	**TOTAL**	**1,590,000**	**865,000**		**2,595,000**	

3.1.2 Results

Results for Nooksack River basin steelhead are summarized in Table H-5. The action alternatives would include use of an adaptive management approach, but the results in Table H-5 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this river basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-5 is explained in the subsequent subsections for this river basin. Note that, for the Nooksack River basin, there are no integrated steelhead conservation hatchery programs and, thus, viability is not evaluated for natural-origin Nooksack River basin steelhead.

Table H-5. Summary of risks and benefits for Nooksack River basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead Hatcheries	Moderate	Low	Same as Alternative 1
Chinook Salmon Hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Coho Salmon Hatcheries	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1

3.1.2.1 Risks

3.1.2.1.1 Steelhead Hatchery Programs

The two isolated steelhead hatchery programs result in competition, genetic, and hatchery facilities and operation risks.

Kendall Creek Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the isolated steelhead hatchery program at the Kendall Creek Hatchery would result in competition, genetics, and hatchery facilities and operation types of impacts. These impacts would result in moderate risks because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-6). The hatchery production level would be the same under Alternative 4 as under Alternative 1 and Alternative 2 (Table H-4); thus, all three alternatives would have the same risk levels. Under Alternative 3, hatchery production would decrease by 50 percent (to 75,000 smolts, as indicated in Table H-4), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-5).

Table H-6. Impacts to natural-origin steelhead associated with the Kendall Creek Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. Smolt releases may interact with natural population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. Facility water intake does not meet current standards. Hatchery structures impede passage of natural-origin juveniles and adults. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Whatcom Creek Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, a total of 40,000 smolts would be released from the isolated steelhead hatchery program at the Whatcom Creek Hatchery (Table H-4). A portion of them would be released on-station into Whatcom Creek (5,000 smolts), and the majority would be trucked for release into the Samish River (35,000 smolts). The effects from the program include competition, genetics, and hatchery facilities and operation impacts, and are rated as moderate risks because at least one BMP is not in compliance (Table H-7). The hatchery releases would be the same under Alternative 3 as under Alternative 1 and Alternative 2 (Table H-4); thus, the three alternatives have the same risk levels. Under Alternative 4, the total number of smolts released from the program would increase by 12 percent (to 45,000 smolts, as indicated in Table H-4) because 5,000 more smolts would be trucked to the Samish River for release. This increase would not be large enough to raise risk ratings. Thus, all alternatives are considered a moderate risk for competition, genetics, and hatchery facilities and operation (Table H-5).

Table H-7. Impacts to natural-origin steelhead associated with the Whatcom Creek Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. Smolt releases may interact with natural-origin population. Most fish are trucked and planted. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. Fish are trucked and planted. pHOS is not estimated.
Hatchery Facilities and Operation	Facility water intake does not meet current standards. Facility impedes passage of natural-origin juveniles and adults. No performance measures or monitoring plan developed. Program not based on adaptive management plan. Program does not avoid transfers into the basin.

Summary – Steelhead Hatchery Programs. In summary, competition, genetic, and hatchery facility and operation risks to natural-origin steelhead from steelhead hatchery yearling programs in the Nooksack River basin would be moderate for Alternative 1, Alternative 2, and Alternative 4, and low for Alternative 3 (Table H-5) corresponding to differing production levels. The Kendall Creek Hatchery releases the largest number of hatchery-origin steelhead into the basin (150,000 yearlings versus 40,000 yearlings for Whatcom Creek, as indicated in Table H-4) and, thus, would have the most influence on these risk ratings.

3.1.2.1.2 Chinook Salmon Hatchery Program

There is one Chinook salmon hatchery yearling program in the Nooksack River basin that poses a competition risk to natural-origin steelhead. Under all alternatives, the Samish Hatchery would release 100,000 hatchery-origin fall-run Chinook salmon yearlings each year (Table H-4). These fish present a competition risk because they are released into the Samish River when natural-origin winter-run steelhead may be rearing in downstream locations prior to seaward out-migration. The hatchery-origin Chinook salmon yearlings are generally approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with the similar size natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The two species could both be present in the watershed during the March hatchery release timeframe where the hatchery-origin Chinook salmon are released relatively low in the Samish River watershed (RM 10.5). However, competitive interactions between the species is likely only for a short period because the hatchery-origin

Chinook salmon are volitionally released as smolts low in the watershed prior to the main out-migration period for natural-origin steelhead smolts; moreover, Chinook salmon would likely out-migrate from the Samish River promptly (within a few days after release).

In summary, although differences in use of food and space between Samish Hatchery Chinook salmon yearling releases and natural-origin steelhead may occur and the release number is 100,000 yearlings, the risk of competition under Alternative 1 and Alternative 2 would be low (Table H-5) due to release location and timing. Because these factors do not change under the alternatives, risk levels would be the same among all alternatives (Table H-5).

3.1.2.1.3 Coho Salmon Hatchery Programs

Releases of hatchery-origin coho salmon pose a competition risk to natural-origin steelhead. Two hatchery yearling programs (Kendall Creek Hatchery and Skookum Creek Hatchery) produce coho salmon yearlings for release into the Nooksack River basin. These programs are analyzed together because the two hatcheries have the same risk levels. Under Alternative 1 and Alternative 2, 300,000 coho salmon yearlings would be released in the Nooksack River from the Kendall Creek Hatchery (Table H-4) (RM 9.5 of the North Fork Nooksack River, tributary of the mainstem Nooksack River at RM 46) in mid to late May each year at an average size of 5.2 inches fork length according to the program's HGMP. An additional 1 million hatchery-origin coho salmon yearlings would be released into the South Fork Nooksack River (RM 14.3) each year from the Skookum Creek Hatchery yearling program (Table H-4). These coho salmon would be released in mid to late May at an average size of 5.5 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) at RM 14.3 on the South Fork Nooksack River, which is a tributary of the mainstem Nooksack River at RM 36.5. Coho salmon yearlings released from both hatchery yearling programs have the potential to compete with similarly sized natural-origin steelhead smolts (average size of 6.5 inches) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) during and after the release period because the two species out-migrate from the mainstem and two tributaries of the Nooksack River.

In summary, despite considerable differences in coho salmon release levels across alternatives, the risk of hatchery-origin coho salmon yearling competition to natural-origin steelhead would be high for all alternatives (Table H-7). Although coho salmon releases under Alternative 3 would be 50 percent less than Alternative 1 and Alternative 2, and releases under Alternative 4 would be 77 percent greater than Alternative 1 and Alternative 2 (Table H-4), risk levels would remain high for all alternatives due to the up-river release locations, the large number of coho salmon smolt releases in the Nooksack River watershed, and the release timing in May.

3.1.2.2 Benefits

3.1.2.2.1 Total Return

The isolated winter-run steelhead hatchery yearling programs in the Nooksack River basin would contribute hatchery-origin adult steelhead to the Nooksack River, Samish River, and Whatcom Creek for harvest and hatchery broodstock use at the total return levels shown in Table H-8.

Table H-8. Contributions of hatchery-origin steelhead to total returns in the Nooksack River basin by alternative.

	Alternative 1 and 2	**Alternative 3**	**Alternative 4**
Annual smolt release number	190,000	115,000	195,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	1,900	1,150	1,950
Recent year average			
Adult return rate[2]	0.41 percent	0.41 percent	0.41 percent
Adult return	779	471	799
Projected total return as a percent of adult return goal	**41 percent**	**41 percent**	**41 percent**

[1] Smolt-to-adult survival rate goal for adult returns for Puget Sound hatchery-origin steelhead yearling releases is from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2005]).

[2] The 10-year (1997 to 2006) average estimated adult return to sport and tribal harvest plus recorded rack returns for hatchery-origin steelhead released through the WDFW Kendall Creek Hatchery yearling program into the North Fork Nooksack River was 0.41 percent. The average annual return rate over the same period for steelhead released into the Samish River through the Bellingham Technical College cooperative was 0.01 percent. Because of a much larger program size, the Kendall Creek Hatchery rate (0.41 percent) was used above to estimate actual returns. Hatchery contribution data are from WDFW (2008).

The benefits of Nooksack River basin steelhead hatchery yearling programs to the total return of non-listed steelhead in the basin under all alternatives would be low (Table H-5). This is because the 10-year (1997 to 2006) mean adult return for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goals for the basin (41 percent) is less than 50 percent for all alternatives (Table H-8).

3.1.2.3 Summary – Nooksack River Basin

Table H-5 summarizes the risks and benefits for all alternatives pertinent to Nooksack River basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the five hatchery yearling programs evaluated in the Nooksack River basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 would range from low to high with the Chinook salmon hatchery as a low risk and the coho salmon hatcheries as a high risk. Reduced hatchery-origin steelhead production under Alternative 3 would decrease competition, genetic, and hatchery facilities and operation risks from the isolated winter-run steelhead hatchery yearling programs (Kendall Creek Hatchery and Whatcom Creek Hatchery) to a low level. Risks under Alternative 4 would be the same as for Alternative 1 and Alternative 2. Total return benefits from the hatchery yearling programs in the Nooksack River basin would be low for all alternatives because estimated adult returns would be less than half of the Puget Sound-wide goal for steelhead.

Overall, the decreased production for steelhead hatcheries under Alternative 3 (37 percent decrease, Table H-4) would help to decrease the risk levels for competition, genetics, and hatchery facilities and operation (Table H-5). However, the increased production of steelhead under Alternative 4 (3 percent, Table H-4) would not increase risk levels compared to Alternative 1 and Alternative 2 because the risk level is already high, which is the maximum risk rating.

3.1.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures may be repeated in Table H-2 if the measures would result in decreasing more than one risk category.

3.1.2.4.1 Steelhead Hatchery Programs

Kendall Creek Hatchery Isolated Winter-run Steelhead Program. Key mitigation measures that may be applied to address competition risks for the Kendall Creek Hatchery isolated winter-run steelhead yearling program include implementing hatchery management actions that create a refuge for natural-origin Nooksack River basin steelhead smolts from competition with hatchery-origin steelhead, and/or reducing or terminating the hatchery steelhead yearling program. Altering release strategies include delaying release of hatchery-origin steelhead until after the major natural-origin steelhead out-migration period, and trucking the hatchery-origin steelhead smolts downstream for release near the Nooksack River mouth. Trucking smolts for release near the mouth of the river may also help to increase the portion of juvenile hatchery-origin fish surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate through confined up-river areas seaward.

Key genetic risk mitigation measures for a continued isolated program intent for the Kendall Creek Hatchery steelhead yearling program include reducing or terminating the hatchery steelhead program; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized broodstock; maintaining the hatchery rack across the entire hatchery-origin steelhead return period (which would help implement more effective trapping); and implementing increased harvest rates to remove all arriving adults surplus to broodstock needs.

Although transition of the Kendall Creek Hatchery from an isolated program to an integrated program may be considered as a potential genetic risk mitigation measure, it is uncertain whether an integrated hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Nooksack River basin steelhead.

A hatchery facilities and operation risk under all alternatives is the permanent Kendall Creek Hatchery rack on Kendall Creek that presents a barrier to adult steelhead and salmon upstream migration. This risk factor to North Fork Nooksack steelhead could be mitigated by upgrading the hatchery rack to meet current fish passage standards, which would provide for upstream passage of migrating adult steelhead under all operational and flow conditions.

Table H-9 summarizes potential mitigation measures for the Kendall Creek Hatchery action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate risks under Alternative 2 and Alternative 4 (Table H-5).

Table H-9. Potential mitigation measures for the Kendall Creek Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H3, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

Whatcom Creek Hatchery Isolated Winter-run Steelhead Program. Key mitigation measures that may be applied to address competition risks for the Whatcom Creek Hatchery isolated winter-run steelhead yearling program include hatchery management actions that create a refuge for natural-origin Samish River and Whatcom Creek winter-run steelhead smolts from hatchery-origin steelhead competition. These measures include reducing or terminating the hatchery-origin steelhead program, modifying strategies for acclimation and release of hatchery-origin smolts toward the lowest portion of the Samish River (RM 1.0, at existing trapping location), and delaying release of hatchery-origin steelhead until after the major natural-origin steelhead smolt out-migration period (Table H-10).

Key genetic risk mitigation measures for a continued isolated yearling program for the Whatcom Creek Hatchery steelhead program include reducing or terminating the hatchery steelhead program, maintaining the hatchery rack(s) across the entire hatchery-origin steelhead return period, and increasing harvest rates to maximize removal of all arriving adults (Table H-10).

Although transition of the Whatcom Creek Hatchery isolated winter-run steelhead yearling program to an integrated program may be considered as a potential genetic risk mitigation measure, it is uncertain whether an integrated hatchery program would exacerbate rather than mitigate genetic risks, and be beneficial to the viability of natural-origin Nooksack River basin steelhead.

A key mitigation measure for reducing hatchery facilities and operation risk in the Nooksack River basin is modification of the fish passage structure at the Whatcom Creek Hatchery in Friday Creek and the Samish River to provide for upstream and downstream movements of natural-origin juvenile and adult steelhead under all operational and flow conditions (Table H-10).

Table H-10 summarizes potential mitigation measures for the Whatcom Creek Hatchery for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under all action alternatives (Table H-5). These measures would apply to all action alternatives.

Table H-10. Potential mitigation measures for the Whatcom Creek Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H3, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.1.2.4.2 Coho Salmon Hatchery Programs

Two hatchery yearling programs release coho salmon into freshwater areas of the Nooksack River basin (Kendall Creek Hatchery and Skookum Creek Hatchery), and the competition risk level would be high for all alternatives (Table H-5). Key mitigation measures to address these risks are provided in Table H-11. These measures would apply to all action alternatives; however, mitigation measures that reduce program size would not apply to Alternative 3 because this alternative already includes decreases in hatchery production. The mitigation measure of trucking the hatchery-origin coho salmon smolts downstream near the river mouth (Measure C6) would have the additional benefit of increasing the portion of juvenile hatchery-origin fish surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish out-migrate from confined up-river areas seaward.

Table H-11. Potential mitigation measures for the Kendall Creek Hatchery and Skookum Creek Hatchery coho yearling programs.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.2 Skagit River

3.2.1 Introduction

As shown in Table H-1, the Skagit River basin includes the Skagit River and Cascade River watersheds where three natural-origin winter-run steelhead stocks and three natural-origin summer-run steelhead stocks occur, represented in four winter-run and summer-run populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are within the Skagit River basin and receive hatchery-origin fish that could affect natural-origin steelhead: Skagit River, Cascade River (tributary of the Skagit River at RM 78.5), Baker River (tributary of Skagit River at RM 56.5), and Clark Creek (tributary of Cascade Creek).

Two steelhead hatchery yearling programs, one Chinook salmon hatchery program, and one coho salmon hatchery program from two hatchery facilities (Marblemount Hatchery and Barnaby Slough Hatchery) have the potential to impact Skagit River basin steelhead (Table H-12 and Table H-13); these are reviewed in this subsection.

Table H-12. Hatchery programs and categories of effects evaluated for Skagit River basin steelhead.

Species	Hatchery and Program	Risk			Benefit
		Competition	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**
Steelhead	Marblemount Hatchery isolated winter-run steelhead yearling	√	√	√	√
	Barnaby Slough Hatchery isolated winter-run steelhead yearling	√	√	√	√
Chinook Salmon	Marblemount Hatchery integrated spring-run Chinook salmon yearling	√			
Coho Salmon	Marblemount Hatchery isolated coho salmon yearling	√			
	Baker Lake isolated coho salmon yearling	√			

Table H-13. Hatchery salmon and steelhead production in the Skagit River basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Steelhead	Marblemount Hatchery isolated winter-run steelhead yearling	334,000	167,000	50	364,000	9
	Barnaby Slough Hatchery isolated winter-run steelhead yearling	200,000	100,000	50	200,000	0
	TOTAL	**534,000**	**267,000**	**50**	**564,000**	**6**
Chinook Salmon	Marblemount Hatchery integrated spring-run Chinook salmon yearling	150,000	150,000	0	150,000	0
Coho Salmon	Marblemount Hatchery isolated coho salmon yearling	250,000	125,000	50	250,000	0
	Baker Lake isolated coho salmon yearling	60,000	30,000	50	60,000	0
	TOTAL	**310,000**	**175,000**	**50**	**310,000**	**0**
All	**TOTAL**	**994,000**	**592,000**	**43**	**1,024,000**	**3**

3.2.2 Results

Results for the Skagit River basin are summarized in Table H-14. The action alternatives would include use of an adaptive management approach, but the results in Table H-14 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-14 is explained in the subsequent subsections for this basin. Note that, for the Skagit River basin, there are no integrated steelhead conservation hatchery programs and, thus, viability is not evaluated for natural-origin Skagit River basin steelhead.

Table H-14. Summary of risks and benefits assigned for Skagit River basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead Hatcheries	Moderate	Low	Same as Alternative 1
Chinook Salmon Hatcheries	High	Same as Alternative 1	Same as Alternative 1
Coho Salmon Hatcheries	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1

3.2.2.1 Risks

3.2.2.1.1 Steelhead Hatchery Programs

Under Alternative 1 and Alternative 2, the isolated steelhead hatchery yearling programs at the Marblemount Hatchery and Barnaby Slough Hatchery would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-15). The two hatcheries are evaluated together because they have similar impacts and production levels among alternatives. The impacts would result in moderate risks under Alternative 1 and Alternative 2 (Table H-14) because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-14). In comparison to Alternative 1 and Alternative 2, the hatchery production level would be reduced by 50 percent under Alternative 3 and increased by 6 percent under Alternative 4 (both hatcheries combined) (Table H-13). As a result, the risk levels would be reduced to low risks under Alternative 3 and would not change under Alternative 4 compared to Alternative 1 and Alternative 2 (Table H-14).

Table H-15. Impacts to natural-origin steelhead associated with the Marblemount Hatchery and Barnaby Slough Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. Smolt releases may interact with natural population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. Facility water intake does not meet current standards. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

3.2.2.1.2 Chinook Salmon Hatchery Program

Under Alternative 1 and Alternative 2, up to 150,000 hatchery-origin spring-run Chinook salmon yearlings would be released by the Marblemount Hatchery into Clark Creek (a tributary of the Cascade River) each year between mid-April and mid-May during the natural-origin steelhead smolt out-migration period. This production level would not vary among alternatives. The hatchery-origin Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with similar size natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) migrating at this time of year; the Chinook yearlings are released high in the watershed (RM 78.5). The spring-run release timing, hatchery production level, and the release location in the upper watershed are all risk factors that elevate the potential for resource competition with similarly sized natural-origin steelhead smolts emigrating downstream of the release site. These risk factors combined would result in a high risk level for competition under all alternatives because production levels would not change (Table H-14).

3.2.2.1.3 Coho Salmon Hatchery Programs

Marblemount Hatchery Isolated Coho Salmon Program. As shown in Table H-14, approximately 250,000 coho salmon yearlings are released each year at one Skagit River watershed location (Cascade River at RM 1.0, which is a tributary of the Skagit River at RM 78.5) through the Marblemount Hatchery yearling program. The hatchery-origin coho yearlings are generally released from the hatchery in May at an average individual size of approximately 5.5 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Resource competition may occur with the similar size natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Natural-origin steelhead smolts emigrating in the Skagit River downstream from the Cascade River (the uppermost hatchery release site in the Skagit River basin) during the hatchery coho salmon release period have the potential to be impacted through resource competition by the hatchery-origin coho salmon yearlings. The location of the hatchery-origin coho salmon release site relatively high in the watershed, the release timing, and the relatively large coho salmon release number (250,000 fish, as indicated in Table H-13) may increase the intensity and duration of interaction with natural-origin steelhead, while the release of coho salmon smolts that out-migrate relatively rapidly seaward may attenuate competition risks. The risk rating would be high for all alternatives. Although production would decrease by 50 percent under Alternative 3 (Table H-13), the decrease would not reduce the high risk rating.

Baker Lake Isolated Coho Salmon Program. Under Alternative 1, a total of 60,000 coho salmon yearlings are released in Baker Lake, Lake Shannon, and the mouth of Baker River (RM 1.0), which is a tributary of the Skagit River (RM 56.5), during May and June (Table H-13). The risk of effects from competition would be moderate under Alternative 1, Alternative 2, and Alternative 4 based on production levels, release timing, and release location, which are the same among the three alternatives. However, the impact would be considered low under Alternative 3 based on a decrease of 50 percent of hatchery production (Table H-13).

Summary - Coho Salmon Hatchery Programs. Overall, considering the up-river hatchery-origin coho salmon release locations and the magnitude of the total coho salmon smolt release size, the risk of hatchery-origin coho salmon yearling competition effects on natural Skagit River steelhead would be high under all alternatives. Although Alternative 3 would result in a decrease of coho salmon yearling releases of 50 percent under Alternative 3 (175,000 fish, as indicated in Table H-13) relative to the other alternatives (310,000 fish, Table H-13), competition risks posed under Alternative 3 would remain high (Table H-14).

3.2.2.2 Benefits

3.2.2.2.1 Total Return

Under the alternatives, the two isolated winter-run steelhead hatchery yearling programs (Marblemount Hatchery and Barnaby Slough Hatchery) in the Skagit River basin would contribute adult returns of steelhead for fisheries harvest and hatchery broodstock use at the annual total return levels provided in Table H-16.

Table H-16. Contributions of hatchery-origin steelhead to total returns in the Skagit River basin by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Annual smolt release number	534,000	267,000	564,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	5,340	2,670	5,640
Recent year average			
Adult return rate[2]	0.30 percent	0.30 percent	0.30 percent
Adult return	1,602	801	1,692
Projected total return as a percent of adult return goal	**30 percent**	**30 percent**	**30 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases, from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2005]).
[2] The 10-year (1997 to 2006) return year average estimated adult contribution to sport and tribal harvest plus recorded rack returns for hatchery-origin steelhead released through WDFW's on-station winter-run steelhead releases at Marblemount Hatchery was 0.30 percent. Hatchery contribution data are from WDFW (2008).

The benefits of Skagit River basin steelhead hatchery yearling programs to the total return of non-listed steelhead in the basin under all alternatives would be low (Table H-14). This is because the 10-year (1997 to 2006) mean adult returns for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goals for the basin (30 percent) is less than 50 percent for all alternatives (Table H-16).

3.2.2.3 Summary – Skagit River Basin

Table H-14 summarizes the risks and benefits for all alternatives pertinent to Skagit River basin steelhead, absent any modifications to the action alternatives from the application of adaptive management over the long term. From the five hatchery yearling programs evaluated in the Skagit River basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 would range from moderate to high with the Chinook salmon and coho salmon hatcheries as high risks and steelhead hatcheries as a moderate risk. Reduced hatchery-origin production under Alternative 3 would decrease competition, genetic, and hatchery facilities and operation risks to a low level for the isolated winter-run steelhead hatchery yearling programs (Marblemount Hatchery and Barnaby South Creek Hatchery). Risks under Alternative 4 would be the same as for Alternative 1 and Alternative 2. Abundance benefits from the hatchery programs in the Skagit River basin would be low for all alternatives because estimated adult returns would be less than half of the Puget Sound-wide goal for steelhead.

Overall, decreased production from steelhead hatcheries under Alternative 3 (50 percent decrease, Table H-13) would decrease the risk levels for competition, genetics, and hatchery facilities and operations (Table H-14).

3.2.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.2.2.4.1 Steelhead Hatchery Programs

Key risk mitigation measures for steelhead hatchery programs that could be applied under the alternatives include implementation of hatchery management actions that create a refuge for natural-origin Skagit winter-run steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing or terminating one or both hatchery-origin steelhead release programs and/or trucking some or all hatchery-origin steelhead smolts from the hatcheries downstream for release near the Skagit River mouth (which would alter the release strategy). Altering the release strategy could include delaying release of hatchery-origin steelhead until after the major natural-origin steelhead smolt out-migration period (which would also alter the release strategy). Trucking and planting hatchery-origin steelhead smolts near the mouth of the Skagit River may increase the proportion of steelhead smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from up-river release sites seaward.

Assuming a continued isolated harvest operational intent for the steelhead hatchery programs, key genetic risk mitigation measures applied to reduce effects on natural-origin steelhead may include reducing or terminating the hatchery steelhead release programs; ceasing out-of-watershed transfers to sustain the hatchery programs and creating a localized broodstock; selecting (through broodstock collection and mating practices) for an earlier return timing for adult hatchery-origin steelhead of exogenous stock localized in the river; maintaining the hatchery rack(s) across the entire hatchery-origin steelhead return period (which would help implement more effective trapping); and/or implementing increased harvest rates to maximize removal of all arriving mass-marked hatchery-origin adults.

Although transition of the Marblemount Hatchery and Barnaby Slough Hatchery isolated winter-run yearling programs to integrated conservation programs may be considered as a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Skagit River basin steelhead.

Table H-17 summarizes potential mitigation measures for the Skagit River steelhead hatcheries. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4.

Table H-17. Potential mitigation measures for Marblemount Hatchery and Barnaby Slough Hatchery isolated winter-run yearling programs.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.2.2.4.2 Chinook Salmon Hatchery Program

The Marblemount Hatchery releases 150,000 spring-run Chinook salmon yearlings into the Skagit River basin (Table H-13); as a result, the competition risk level would be high for all alternatives (Table H-14). Mitigation measures to address these risks are summarized in Table H-18, and address the timing of release of hatchery-origin fish, release location, and number of hatchery-origin fish released. These measures would apply to all action alternatives.

Table H-18. Potential mitigation measures for the Marblemount Hatchery integrated spring-run Chinook salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.2.2.4.3 Coho Salmon Hatchery Programs

Marblemount Hatchery Isolated Coho Salmon Program. The Marblemount Hatchery would release 125,000 to 350,000 coho salmon yearlings into the Skagit River basin under all alternatives (Table H-13), resulting in a high competition risk level for all alternatives (Table H-14). Mitigation measures to address these risks are summarized in Table H-19. These measures would apply to all action alternatives. For

Alternative 2 and Alternative 4, reducing the program would also help to reduce and/or eliminate the competition risk. Alternative 3 already includes decreases in hatchery production.

Table H-19. Potential mitigation measures for the Marblemount Hatchery isolated coho salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

Baker Lake Hatchery Isolated Coho Salmon Program. The Baker Lake Hatchery would release 60,000 coho yearlings into the Skagit River basin under Alternative 2 and Alternative 4 (Table H-13), resulting in a moderate competition risk level. Key mitigation measures to address these risks are provided in Table H-20. These measures would apply to these action alternatives.

Table H-20. Potential mitigation measures for the Baker Lake Hatchery isolated coho salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.3 Stillaguamish River

3.3.1 Introduction

As shown in Table H-1, the Stillaguamish River basin includes one watershed where one natural-origin winter-run steelhead stock and two natural-origin summer-run steelhead stocks occur, represented in one winter-run population and two summer-run populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Stillaguamish River basin and support hatchery-origin fish that could affect natural-origin steelhead: Stillaguamish River, which is comprised of the mainstem, North Fork Stillaguamish River, and South Fork Stillaguamish River. Two areas of hatchery-origin fish release include Pilchuck Creek (tributary of the mainstem Stillaguamish River at RM 9.4), Canyon Creek (tributary of the South Fork Stillaguamish River at RM 33.7), and Harvey/Armstrong Creek (tributary of the Stillaguamish River at RM 15.3).

Two steelhead hatchery programs, and one coho salmon hatchery program from three hatchery facilities (Whitehorse Pond Hatchery, Harvey Creek Hatchery, and North Fork/Johnson Creek Hatchery) have the potential to impact Stillaguamish River basin steelhead (Table H-21 and Table H-22), and are reviewed in this subsection. The Stillaguamish coho salmon yearling program includes both the Harvey Creek Hatchery and North Fork/Johnson Creek Hatchery.

Table H-21. Hatchery programs and categories of effects evaluated for Stillaguamish River basin steelhead.

Species	Hatchery and Program	Risk			Benefit
		Competition	Genetics	Hatchery Facilities and Operation	Total Return
Steelhead	Whitehorse Pond Hatchery isolated summer-run steelhead yearling	√	√	√	√
	Whitehorse Pond Hatchery isolated winter-run steelhead yearling	√	√	√	√
Coho Salmon	Harvey Creek Hatchery and North Fork/Johnson Creek Hatchery integrated coho salmon yearling (associated with Stillaguamish program)	√			

Table H-22. Hatchery salmon and steelhead production in the Stillaguamish River basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Steelhead	Whitehorse Pond Hatchery isolated summer-run steelhead yearling	70,000	35,000	50	70,000	0
	Whitehorse Pond Hatchery isolated winter-run steelhead yearling	150,000	75,000	50	150,000	0
	TOTAL	**220,000**	**110,000**	**50**	**220,000**	**0**
Coho Salmon	Harvey Creek Hatchery/North Fork/Johnson Creek Hatchery integrated coho salmon yearling (associated with Stillaguamish coho salmon program)	54,000	27,000	50	54,000	0
All	**TOTAL**	**274,000**	**137,000**	**50**	**274,000**	**0**

3.3.2 Results

Results for the Stillaguamish River basin are summarized in Table H-23. The action alternatives would include use of an adaptive management approach, but the results in Table H-23 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-23 is explained in the subsequent subsections for this river basin. Note that, for the Stillaguamish River basin, there are no integrated steelhead conservation hatchery programs and, thus, viability is not evaluated.

Table H-23. Summary of risks and benefits for Stillaguamish River basin steelhead by alternative.

Risks	Alternative 1 and 2	Alternative 3	Alternative 4
Competition			
Steelhead hatcheries	Moderate	Low	Same as Alternative 1
Coho salmon hatcheries	Moderate	Low	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Abundance	Moderate	Same as Alternative 1	Same as Alternative 1

3.3.2.1 Risks

3.3.2.1.1 Steelhead Hatchery Programs

The Whitehorse Pond Hatchery isolated steelhead hatchery yearling programs would result in competition, genetic, and hatchery facilities and operation risks (Table H-24). Under Alternative 1 and Alternative 2, the isolated steelhead hatchery yearling programs would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-23). These impacts would result in a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation is not met. The hatchery production level would be the same under Alternative 4 as under Alternative 1 and Alternative 2 (Table H-22); thus, all three alternatives would have the same risk levels. Under Alternative 3, hatchery production would decrease by 50 percent for both programs, which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-23).

Table H-24. Impacts to natural-origin steelhead associated with the Whitehorse Ponds Hatchery isolated summer-run and winter-run yearling programs.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from watershed. Smolt releases may interact with natural-origin populations. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and have been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from watershed. pHOS is not estimated.
Hatchery Facilities and Operation	No performance measures or monitoring plan developed. Programs not based on adaptive management plan.

3.3.2.1.2 Coho Salmon Hatchery Program

Under Alternative 1, Alternative 2, and Alternative 4, approximately 54,000 coho salmon yearlings would be released in early to mid-May each year by the Harvey Creek Hatchery and North Fork/Johnson Creek Hatchery into two Stillaguamish River watershed tributaries (Table H-22). Coho salmon yearlings released through the program have the potential to compete with natural-origin steelhead smolts during and after the release period as the two species emigrate seaward in the tributaries and mainstem. The locations of the hatchery coho salmon release sites are relatively high in the Stillaguamish River watershed (Harvey Creek Hatchery is 2 miles upstream of the mouth of Harvey Creek, 15.3 miles upstream of the mouth of the Stillaguamish River mainstem; North Fork/Johnson Creek Hatchery is located 2 miles upstream of the mouth of Johnson Creek, which enters the North Fork Stillaguamish River at RM 15, which is 37 miles upstream from the mouth of the Stillaguamish River). The release location may increase the duration of coho salmon smolt interaction with steelhead, while the relatively modest fish production level, and the release of the coho salmon as yearling smolts that out-migrate relatively rapidly seaward may reduce resource competition risks.

Considering the up-river hatchery-origin fish release locations, the May timing of the release, and the total annual coho salmon smolt release number, the risk of hatchery-origin coho salmon yearling competition effects on natural-origin Stillaguamish River steelhead would be moderate under Alternative 1, Alternative 2, and Alternative 4 (Table H-23). Because the number of coho salmon yearlings released each year would be reduced by half under Alternative 3 (27,000 fish, Table H-22) relative to the other alternatives (54,000 fish under Alternative 1, Alternative 2, and Alternative 4, as indicated in Table H-22), competition risks posed under Alternative 3 would be low (Table H-23).

3.3.2.2 Benefits

3.3.2.2.1 Total Return

Under the alternatives, the isolated winter-run and summer-run steelhead hatchery yearling programs in the Stillaguamish River basin would contribute adult returns of steelhead for fisheries harvest and hatchery broodstock use at the annual return levels provided in Table H-25.

Table H-25. Contributions of hatchery-origin steelhead to total returns in the Stillaguamish River basin by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Annual smolt release number	220,000	110,000	220,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	2,200	1,100	2,200
Recent year average			
Adult return rate[2]	0.51 percent	0.51 percent	0.51 percent
Adult return	1,122	561	1,122
Projected total return as a percent of adult return goal	**51 percent**	**51 percent**	**51 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases, from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2005]).

[2] The 10-year (1997–2006) return year average estimated adult contribution to sport and tribal harvest plus recorded rack returns for hatchery-origin steelhead released through WDFW Whitehorse Pond programs in the Stillaguamish River basin were 0.30 percent for summer-run steelhead and 0.71 percent for winter-run steelhead (contribution rates summed in basin totals). An average adult return rate of 0.51 percent was applied to estimate adult return levels. Hatchery contribution data are from WDFW (2008).

The Stillaguamish River basin steelhead hatchery yearling programs would have moderate benefits to the total return of non-listed steelhead in the basin under all alternatives (Table H-23). This is because the 10-year (1997 to 2006) mean adult returns for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goals for the basin (51 percent) would be greater than 50 percent for all alternatives (Table H-25).

3.3.2.3 Summary – Stillaguamish River Basin

Table H-23 summarizes the risks and benefits for all alternatives pertinent to Stillaguamish River basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the three hatchery programs evaluated in the Stillaguamish River basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 would be moderate. Reduced hatchery-origin steelhead production under Alternative 3 would decrease competition, genetic, and hatchery facilities and operation risks from the isolated winter-run and summer-run steelhead hatchery yearling programs at Whitehorse Pond Hatchery to a low level (Table H-23). Risks under Alternative 4 would be the same as for Alternative 1 and Alternative 2 because there would be no hatchery production changes. Total return benefits from the hatchery programs in the Stillaguamish River basin would be moderate for all alternatives (Table H-23) because estimated adult returns would be slightly greater than half of the Puget Sound-wide goal (Table H-25).

3.3.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.3.2.4.1 Steelhead Hatchery Programs

Key risk mitigation measures that may be applied to steelhead hatchery programs under the alternatives to reduce competition impacts include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include trucking some or all hatchery-origin steelhead smolts from the hatcheries downstream for release near the mouth of the mainstem Stillaguamish River (which would help implement more effective trapping methods); and delaying release of hatchery-origin steelhead until after the major natural-origin steelhead smolt out-migration period (which would help alter the release strategy). Trucking and planting hatchery-origin steelhead smolts near the mouth of the Stillaguamish River may increase the portion of smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from up-river release sites seaward.

Assuming an operational intent for a continued isolated harvest for the Whitehorse Pond winter-run steelhead hatchery program, key genetic risk mitigation measures applied to reduce effects on natural-origin steelhead may include ceasing out-of-watershed transfers to sustain the hatchery program; creating a localized broodstock; selecting through broodstock collection and mating practices for an earlier return timing for adult hatchery-origin steelhead localized in the river; maintaining the Whitehorse Pond rack across the entire hatchery-origin steelhead return period; and/or implementing increased harvest rates to maximize removal of all arriving hatchery-origin adults.

Although transition of the Whitehorse Pond Hatchery isolated summer-run and winter-run steelhead yearling programs to integrated conservation programs may be considered as a potential genetic risk mitigation measure, it is uncertain whether integrated conservation hatchery programs would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Stillaguamish River basin steelhead. The origin of the Skamania hatchery stock is out-of-DPS (not listed) and it is not segregated from natural-origin summer-run steelhead returns; thus, discontinuing the Skamania stock releases would be recommended to reduce genetic risks.

Table H-26 summarizes potential mitigation measures for the Whitehorse Pond Hatchery isolated summer-run and winter-run yearling programs for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4 (Table H-23).

Table H-26. Potential mitigation measures for the Whitehorse Pond Hatchery isolated summer-run and winter-run steelhead yearling programs.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H4 and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.3.2.4.2 Coho Salmon Hatchery Program

Table H-27 summarizes the potential mitigation measures for the Stillaguamish coho salmon integrated coho salmon hatchery yearling program (Harvey Creek Hatchery and North Fork/Johnson Creek Hatchery) for the two of the action alternatives. These mitigation measures would help reduce competition, which is rated as a moderate risk under Alternative 2 and Alternative 4.

Table H-27. Potential mitigation measures for the Harvey Creek Hatchery and North Fork/Johnson Creek Hatchery integrated coho salmon hatchery yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.4 Snohomish River

3.4.1 Introduction

As shown in Table H-1, the Snohomish River basin includes the Snohomish and Skykomish River watersheds where three natural-origin winter-run steelhead stocks and two summer-run steelhead stocks occur, represented in three winter-run populations and two summer-run populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Snohomish River basin and support hatchery-origin fish that could affect natural-origin steelhead: Snohomish River, Skykomish River, North Fork Skykomish River, Snoqualmie River, Sultan River, Raging River, Tolt River, Pilchuck River, Wallace River, Howard Creek, Barr Creek, Tokul Creek, and Tulalip Creek.

Four steelhead hatchery programs, one Chinook hatchery program, and one coho salmon hatchery programs from four hatchery facilities (Reiter Ponds Hatchery, Tokul Creek Hatchery, and Wallace River Hatchery) have the potential to impact Snohomish River basin steelhead (Table H-28 and Table H-29), and are reviewed in this subsection.

Table H-28. Hatchery programs and categories of effects evaluated for Snohomish River basin steelhead.

		Risk			Benefit
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**
Steelhead	Reiter Ponds Hatchery isolated summer-run steelhead yearling	√	√	√	√
	Reiter Ponds Hatchery isolated winter-run steelhead yearling	√	√	√	√
	Tokul Creek Hatchery isolated winter-run steelhead yearling	√	√	√	√
	Wallace River Hatchery isolated winter-run steelhead yearling	√	√	√	√
Chinook Salmon	Wallace River Hatchery integrated summer-run Chinook salmon yearling	√			
Coho Salmon	Wallace River Hatchery integrated coho salmon yearling	√			

Table H-29. Hatchery salmon and steelhead production in the Snohomish River basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Steelhead	Reiter Ponds isolated summer-run steelhead yearling	250,000	125,000	50	250,000	0
	Reiter Ponds Hatchery isolated winter-run steelhead yearling	250,000	125,000	50	250,000	0
	Tokul Creek Hatchery isolated winter-run steelhead yearling	185,000	92,500	50	185,000	0
	Wallace River Hatchery isolated winter-run steelhead yearling	20,000	10,000	50	20,000	0
	TOTAL	705,000	352,500	50	705,000	0
Chinook Salmon	Wallace River Hatchery integrated summer-run Chinook salmon yearling	250,000	125,000	50	500,000	100
Coho Salmon	Wallace River Hatchery integrated coho salmon yearling	150,000	75,000	50	300,000	100
All	**TOTAL**	**1,105,000**	**552,500**	**50**	**1,505,000**	**36**

3.4.2 Results

Results for the Snohomish River basin are summarized in Table H-30. The action alternatives would include use of an adaptive management approach, but the results in Table H-30 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-30 is explained in the subsequent subsections for this basin. Note that, for the Snohomish River basin, there are no integrated steelhead conservation hatchery programs and, thus, viability is not evaluated.

Table H-30. Summary of risks and benefits for Snohomish River basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead Hatcheries	Moderate	Low	Same as Alternative 1
Chinook Salmon Hatcheries	High	Same as Alternative 1	Same as Alternative 1
Coho Salmon Hatcheries	High	Moderate	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	High	Same as Alternative 1	Same as Alternative 1

3.4.2.1 Risks

The four isolated steelhead hatchery programs result in competition, genetic, and hatchery facilities and operation risks.

3.4.2.1.1 Steelhead Hatchery Programs

Under Alternative 1 and Alternative 2, the four isolated steelhead hatchery yearling programs (Reiter Ponds isolated summer-run and winter-run steelhead programs; Tokul Creek Hatchery isolated winter-run steelhead; and Wallace River Hatchery isolated winter-run steelhead) at the three hatcheries would result in moderate risks regarding competition, genetics, and hatchery facilities and operation types of impacts (Table H-30). The hatchery programs are evaluated together because they pose similar impacts (Table H-31). These impacts would pose a moderate risk (Table H-30) because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met. The hatchery production level would be the same under Alternative 4 as under Alternative 1 and Alternative 2 (Table H-29); thus, all three alternatives would have the same risk levels. Under Alternative 3, hatchery production would decrease by 50 percent for all hatchery programs, which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-30).

Table H-31. Impacts to natural-origin steelhead associated with steelhead hatchery yearling programs by risk category for Snohomish River basin.

Risk Category	Impact
Competition	Programs do not avoid transfers into the basin. All adult returns are not removed from the watershed. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Locally genetically appropriate broodstock is not used and has been in culture more than three generations. Programs do not avoid transfers into the basin. All adult returns are not removed from the watershed. pHOS is not estimated.
Hatchery Facilities and Operation	No performance measures or monitoring plan developed. Programs not based on adaptive management plan. Programs do not avoid transfers into the basin. Hatchery structures impede passage of natural-origin juveniles and adults.

3.4.2.1.2 Chinook Salmon Hatchery Programs

Under Alternative 1 and Alternative 2, up to 250,000 summer-run Chinook salmon yearlings would be released from Wallace River Hatchery in April each year (Table H-29). The hatchery-origin Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with the similarly sized natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The Chinook salmon yearlings would be released high in the watershed (Skykomish RM 60.2). The large size of the fish, and the release location in the upper watershed (the program releases the fish in the Wallace River at RM 4.0, which is a tributary of the Skykomish River at RM 36) are risk factors regarding potential competition with similarly sized natural-origin steelhead smolts emigrating downstream of the hatchery release site.

There may also be a niche separation between Chinook salmon and steelhead due to food preference and river out-migration area differences that further affect competition risks. However, considering the Chinook salmon yearling release magnitude and location, the competition risk posed by the Wallace River Hatchery Chinook salmon yearling program to natural-origin steelhead would be high under all alternatives (Table H-30). Competition effects of Wallace River Hatchery summer-run Chinook salmon yearling releases on natural-origin steelhead would be less under Alternative 3, because the release number would be reduced by half (to 125,000 fish) relative to Alternative 1 and Alternative 2 (Table H-31). However, the risk would remain high due to the number of fish released, and the location and time of release. Under Alternative 4, annual yearling releases would be increased to 500,000 yearlings, and, although this alternative would likely have the greatest risk of competition impacts for natural-origin steelhead parr/smolts, the risk level would remain high because the risk level is already high, which is the maximum risk rating.

3.4.2.1.3 Coho Salmon Hatchery Program

Under Alternative 1 and 2, 150,000 coho salmon yearlings would be released in early to mid-May each year from Wallace River Hatchery into the Skykomish River watershed (Table H-29). Coho salmon yearlings released through the program have the potential to compete with natural-origin steelhead smolts during and after their release from the hatchery as the two species out-migrate seaward. The location of the hatchery coho salmon release site relatively high in the Skykomish River watershed (in the Wallace River at RM 4.0, which is a tributary of the Skykomish River at RM 36) increases the duration and likely the intensity of interaction with any co-occurring natural-origin steelhead, while the release of the coho salmon as yearling smolts that out-migrate relatively rapidly seaward may attenuate competition effects.

Considering the up-river hatchery-origin fish release location, the May timing of the release, and the relatively large magnitude of the total annual coho salmon smolt release, the risk of hatchery-origin coho salmon yearling competition effects on natural-origin Skykomish River steelhead would be high under Alternative 1 and Alternative 2 (Table H-30). Because the number of coho salmon yearlings released each year would be reduced by half under Alternative 3 (to 75,000 fish) relative to Alternative 1 and Alternative 2, competition risks posed under Alternative 3 would be moderate (Table H-30). Alternative 4 coho salmon yearling releases would be doubled (300,000 fish, Table H-29) relative to Alternative 1 and Alternative 2 levels (150,000 fish, Table H-29). Competition effects under this increased production alternative are likely the greatest of the alternatives examined, although the risk level would remain as a high competition risk, which is the same risk level as Alternative 1 and Alternative 2 (Table H-30).

3.4.2.2 Benefits

3.4.2.2.1 Total Return

The winter-run and summer-run steelhead isolated hatchery yearling programs in the Snohomish River basin would contribute hatchery-origin adult steelhead to rivers and creeks in the basin for harvest and hatchery broodstock use at the return levels as shown in Table H-32.

Table H-32. Contributions of hatchery-origin steelhead to total returns in the Snohomish River basin by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Annual smolt release number	705,000	352,500	705,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	7,050	3,525	7,050
Recent year average			
Adult return rate[2]	1.45 percent	1.45 percent	1.45 percent
Adult return	10,222	5,111	10,222
Projected total return as a percent of adult return goal	**145 percent**	**145 percent**	**145 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases, from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2005]).
[2] The 10-year (1997–2006) return year average estimated adult contribution to sport and tribal harvest plus recorded rack returns for hatchery-origin steelhead released through WDFW hatchery programs in Snohomish River basin ranged from 1.33 percent (Skykomish basin releases) and 1.45 percent (Snohomish basin releases) to 1.51 percent (Snoqualmie basin releases). For the purposes of this comparison, the estimated actual return rate for the Snohomish basin is used. Hatchery contribution data are from WDFW (2008).

The benefits of the Snohomish River basin steelhead hatchery yearling programs would be rated as high for the total returns of non-listed steelhead in the basin under all alternatives (Table H-30). This is because the 10-year (1997 to 2006) mean adult return for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goals (145 percent) for the basin would be greater than 75 percent for all alternatives (Table H-32).

3.4.2.3 Summary – Snohomish River Basin

Table H-30 summarizes the risks and benefits for all alternatives pertinent to Snohomish River basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the six hatchery programs evaluated in the Snohomish River basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 would range from moderate to high with the steelhead hatcheries having a moderate risk and the Chinook salmon and coho salmon hatcheries having a low risk. Reduced hatchery-origin steelhead production under Alternative 3 would decrease competition, genetic, and hatchery facilities and operation risks from the isolated winter-run steelhead hatchery yearling programs (Reiter Ponds Hatchery, Tokul Creek Hatchery, and Wallace River Hatchery) to a low level. Risks under Alternative 4 would be the same as for Alternative 1 and Alternative 2 because changes in production would not be substantial enough to affect a risk level. Total return benefits from the hatchery programs in the Snohomish River basin would be high for all alternatives because estimated adult returns are greater than 75 percent of the Puget Sound-wide goal for steelhead.

Overall, the decreased production for steelhead hatcheries under Alternative 3 (50 percent decrease, Table H-29) would help to decrease the risk levels for competition, genetics, and hatchery facilities and operation (Table H-30). However, the increased production for Chinook and coho salmon under Alternative 4 (100 percent increase, Table H-29) would not increase risk levels compared to Alternative 1 and Alternative 2 because the risk level is already high, which is the maximum risk rating used.

3.4.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.4.2.4.1 Steelhead Hatchery Programs

Key risk mitigation measures that may be applied for steelhead hatchery programs under the alternatives to reduce competition impacts include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing or terminating selected hatchery-origin steelhead release programs. Altering the release strategy could include trucking some or all hatchery-origin steelhead smolts from the hatcheries downstream for release near the mouth of the mainstem Snohomish River (which would alter the release strategy), and delaying release of hatchery-origin steelhead until after the major natural-origin steelhead smolt out-migration period (which would also help to alter the release strategy). Trucking and planting hatchery-origin steelhead smolts near the mouth of the Snohomish River may increase the portion of hatchery-origin smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from up-river release sites seaward.

Key genetic risk mitigation measures applied to reduce effects on natural-origin steelhead may include reducing or terminating the hatchery winter-run steelhead release programs; ceasing out-of-watershed transfers to sustain the hatchery programs and creating a localized Snohomish hatchery winter-run steelhead broodstock; selecting through broodstock collection and mating practices for an earlier return timing for adult hatchery-origin steelhead localized to the river basin; maintaining hatchery racks across the entire hatchery-origin steelhead return period, and/or implementing increased harvest rates to maximize removal of all arriving mass-marked hatchery-origin adults.

Although transition of the Snohomish River basin isolated programs to integrated conservation programs may be considered as a potential genetic risk mitigation measure, it is uncertain whether integrated conservation hatchery programs would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Snohomish River basin steelhead. The Skamania stock is out-of-DPS origin, not segregated from natural-origin summer-run steelhead returns, and unlisted under the ESA; thus, discontinuing the Skamania stock releases would be recommended.

Of concern under all alternatives is the standing of the permanent Wallace River Hatchery weir and adult collection pond as barriers and negative factors for adult steelhead and salmon upstream migration in May Creek, a Wallace River tributary. This risk factor to Skykomish steelhead could be mitigated by upgrading the hatchery weir and pond to meet current fish passage standards, providing for upstream passage of migrating adult steelhead under all operational and flow conditions. The permanent barrier to upstream steelhead migration associated with location of the Reiter Ponds in Hogarty Creek (a Skykomish tributary) is also of concern under all alternatives. This risk factor to Skykomish steelhead could be mitigated by upgrading the hatchery ponds to meet current fish passage standards, providing for upstream passage of migrating adult steelhead under all operational and flow conditions.

Table H-33 summarizes potential mitigation measures for isolated steelhead hatchery yearling programs for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4 (Table H-30).

Table H-33. Potential mitigation measures for Snohomish River basin steelhead hatchery yearling programs.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H3, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.4.2.4.2 Chinook Salmon Hatchery Program

Table H-34 summarizes potential mitigation measures for the Wallace River Hatchery summer-run Chinook salmon yearling program. These mitigation measures would help reduce competition risks, which are rated as high risks under all action alternatives. The measures would apply to all action alternatives; however, mitigation measures that reduce or eliminate programs would not apply to Alternative 3 because this alternative already includes decreases in hatchery production. Reducing or terminating the program under Alternative 2 and Alternative 4 would also help to reduce and/or eliminate competition risk. Trucking and planting the hatchery-origin Chinook salmon yearlings near the mouth of the Snohomish River may increase the portion of hatchery-origin juveniles surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the Wallace River release site seaward.

Table H-34. Potential mitigation measures for the Wallace River Hatchery integrated summer-run Chinook salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.4.2.4.3 Coho Salmon Hatchery Program

Table H-35 summarizes potential mitigation measures for the Wallace River Hatchery integrated coho salmon yearling program. These mitigation measures would help reduce competition risks, which are rated as a high risk under Alternative 2 and Alternative 4 and a moderate risk under Alternative 3. These measures would apply to all action alternatives; however, mitigation measures that reduce or eliminate program size would not apply to Alternative 3 because this alternative already includes decreases in hatchery production.

Table H-35. Potential mitigation measures for the Wallace River Hatchery integrated coho salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.5 Lake Washington

3.5.1 Introduction

As shown in Table H-1, the Lake Washington basin consists of the Lake Washington and Sammamish River watersheds. The natural-origin Lake Washington winter-run steelhead stock occurs in this river basin, which is considered three independent populations by Myers et al. (2014). All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

Natural-origin steelhead within the Lake Washington basin are affected by hatchery salmon released in the Issaquah Creek, which drains into Sammamish River before discharging into Lake Washington, as well as salmon released in the ship canal and Lake Union (Lake Washington was modified to connect to Lake Union).

Two coho salmon hatchery programs from two hatchery facilities (Issaquah Hatchery and Portage Bay Hatchery) have the potential to affect Lake Washington basin steelhead (Table H-36 and Table H-37), and are reviewed in this subsection. There are no hatchery programs releasing steelhead in the Lake Washington basin. Thus, there are no benefits in the basin from steelhead hatchery production.

Table H-36. Hatchery programs and categories of effects evaluated for Lake Washington basin steelhead.

Species	Hatchery and Program	Risk		
		Competition	Genetics	Hatchery Facilities and Operation
Coho Salmon	Issaquah Hatchery integrated coho salmon yearling	√		
	Portage Bay Hatchery isolated coho salmon yearling	√		

Table H-37. Hatchery salmon production in the Lake Washington basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Coho Salmon	Issaquah Hatchery integrated coho salmon yearling	450,000	450,000	0	450,000	0
	Portage Bay Hatchery isolated coho salmon yearling	90,000	90,000	0	90,000	0
All	**TOTAL**	**540,000**	**540,000**	**0**	**540,000**	**0**

3.5.2 Results

Results for the Lake Washington basin are summarized in Table H-38. The action alternatives would include use of an adaptive management approach, but the results in Table H-38 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks in Table H-38 is explained in the subsequent subsections for this basin.

Table H-38. Summary of risks for Lake Washington basin steelhead by alternative.

Risk	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Coho salmon hatcheries	High	Same as Alternative 1	Same as Alternative 1

3.5.2.1 Risks

3.5.2.1.1 Coho Salmon Hatchery Programs

Issaquah Hatchery Integrated Coho Salmon Program. Under Alternative 1 and Alternative 2, 450,000 coho salmon yearlings would be released in early to mid-May each year from the Issaquah Hatchery (Table H-37). These hatchery-origin coho salmon yearlings may compete with natural-origin steelhead smolts originating from populations in the Lake Washington watershed during and after the coho salmon release period because the two species commingle in the lakes and out-migrate to Puget Sound through the Ballard Locks. The release of the hatchery-origin coho salmon into lake habitat may slow their seaward out-migration (relative to release of hatchery-origin coho salmon into a river system), potentially increasing the duration of interaction with steelhead rearing and emigrating seaward in the basin. However, the coho salmon released from both hatcheries as yearling smolts would tend to out-migrate relatively rapidly seaward rather than rear in the lakes where competition effects on steelhead may be most pronounced.

Considering the hatchery-origin fish release locations (into lacustrine waters), the relatively large magnitude of coho salmon smolt releases from the Issaquah Hatchery, and the May release timing for the smolts, the risk of hatchery-origin coho salmon yearling competition effects on natural-origin Lake Washington steelhead would be high under all alternatives. The number of coho salmon yearlings released each year through the two programs would remain the same across the alternatives, and there are no differences in competition effects among the alternatives.

Portage Bay Hatchery Isolated Coho Salmon Program. A total of 90,000 coho salmon yearlings would be released into Lake Union through the Portage Bay Hatchery under all alternatives (Table H-37), with likely similar competition effects as described above for the Issaquah Hatchery.

Considering the hatchery-origin fish release locations (into lacustrine waters), the lower annual coho salmon smolt release from the Portage Bay Hatchery, and the May release timing for the smolts, the risk of hatchery-origin coho salmon yearling competition effects on natural-origin Lake Washington steelhead would be high under all alternatives. The number of coho salmon yearlings released each year through the two programs would remain the same across the alternatives, and there are no differences in competition effects between the alternatives.

Summary for Coho Salmon Hatchery Programs. In summary, competition risks to natural-origin steelhead from coho salmon hatchery programs in the Lake Washington basin would be high for all alternatives due to the high production levels and release timing (Table H-38). The Issaquah Hatchery would release the most the hatchery-origin steelhead into the basin (450,000 yearlings versus 90,000 yearlings for Portage Bay, Table H-37) and, thus, would have the most influence on these risk factors.

3.5.2.2 Summary – Lake Washington Basin

Table H-38 summarizes the risks and benefits for all alternatives pertinent to Lake Washington basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the two coho salmon hatchery programs evaluated in the Lake Washington basin, the overall risk (coho salmon competition risk is the only risk considered) to natural-origin steelhead under all alternatives would be high (Table H-38). Hatchery production would not change under any of the alternatives (Table H-37).

3.5.2.3 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.5.2.3.1 Coho Salmon Hatchery Programs

Two hatchery yearling programs release coho salmon into freshwater areas of the Lake Washington basin (Issaquah Hatchery and Portage Bay Hatchery), and the competition risk level would be high for all alternatives (Table H-38). Key mitigation measures to address the competition risk are provided in Table H-39. These measures would apply to all action alternatives. Trucking and planting the hatchery-origin coho salmon near the Ballard Locks may increase the portion of juvenile coho salmon surviving to enter Puget Sound by circumventing mortality normally experienced as the fish migrate through the Lake Washington watershed seaward.

Table H-39. Potential mitigation measures for the Issaquah Hatchery and Portage Bay Hatchery coho salmon yearling programs.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6 Green River

3.6.1 Introduction

As shown in Table H-1, the Green River basin includes the Green River and Duwamish River watersheds where one natural-origin winter-run steelhead stock occurs, represented in one winter-run population. These steelhead are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Green River basin and support hatchery-origin fish that could affect natural-origin steelhead: Green River and creeks that flow into Green River (Icy Creek, Soos Creek, and Crisp Creek). The Green River flows into the Duwamish River before flowing into Puget Sound.

Three steelhead hatchery programs, one Chinook hatchery program, and two coho salmon hatchery programs from five hatchery facilities (Palmer Ponds Hatchery, Palmer Ponds - Flaming Geyser Hatchery, Soos Creek Hatchery, Icy Creek Hatchery, and Crisp Creek Ponds Hatchery) have the potential to impact Green River basin steelhead (Table H-40 and Table H-41), and are reviewed in this subsection. For the purposes of this EIS, the six components of the Palmer Ponds Hatchery program are evaluated separately.

Table H-40. Hatchery programs and categories of effects evaluated for Green River basin steelhead.

		Risk			Benefit	
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Steelhead	Palmer Ponds Hatchery isolated winter-run steelhead yearling	√	√	√	√	
	Palmer Ponds - Flaming Geyser Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds winter-run steelhead program)	√	√	√	√	
	Palmer Ponds Hatchery isolated summer-run steelhead yearling	√	√	√	√	
	Soos Creek Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	√	√	√	√	
	Soos Creek Hatchery Green River wild stock integrated winter-run steelhead yearling	√	√	√	√	√
	Soos Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	√	√	√	√	
	Icy Creek Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	√	√	√	√	
	Icy Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	√	√	√	√	

Table H-40. Hatchery programs and categories of effects evaluated for Green River basin steelhead, continued.

Species	Hatchery and Program	Risk			Benefit	
		Competition	Genetics	Hatchery Facilities and Operation	Total Return	Viability
Chinook Salmon	Icy Creek Hatchery integrated fall-run Chinook salmon yearling (part of Soos Creek/Icy Creek program)	√				
Coho Salmon	Soos Creek Hatchery integrated coho salmon yearling	√				
	Crisp Creek Ponds integrated coho salmon yearling	√				

Table H-41. Hatchery salmon and steelhead production in the Green River basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Steelhead	Palmer Ponds Hatchery isolated winter-run steelhead yearling	150,000	75,000	50	208,000	39
	Palmer Ponds - Flaming Geyser Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	15,000	7,500	50	15,000	0
	Palmer Ponds Hatchery isolated summer-run steelhead yearling	30,000	15,000	50	30,000	0
	Soos Creek Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	35,000	17,500	50	35,000	0

Table H-41. Hatchery salmon and steelhead production in the Green River basin by program and alternative (continued).

			Alternative 3		Alternative 4	
Species	**Hatchery and Program**	**Release Number for Alternative 1 and 2**	**Release Number**	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
	Soos Creek Hatchery Green River wild stock integrated winter-run steelhead yearling	50,000	50,000	0	50,000	0
	Soos Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	30,000	15,000	50	30,000	0
	Icy Creek Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	20,000	10,000	50	20,000	0
	Icy Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	20,000	10,000	50	20,000	0
	TOTAL	**350,000**	**200,000**	**43**	**408,000**	**17**
Chinook Salmon	Soos Creek/Icy Creek Hatchery integrated fall-run Chinook salmon yearling (part of Soos Creek/Icy Creek program)	300,000	150,000	50	300,000	0
Coho Salmon	Soos Creek Hatchery integrated coho salmon yearling	600,000	300,000	50	600,000	0
	Crisp Creek Ponds integrated coho salmon yearling	200,000	100,000	50	300,000	50
	TOTAL	**800,000**	**400,000**	**50**	**900,000**	**13**
All	**TOTAL**	**1,450,000**	**750,000**	**48**	**1,608,000**	**11**

3.6.2 Results

Results for the Green River basin are summarized in Table H-42. The action alternatives would include use of an adaptive management approach, but the results in Table H-42 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-42 is explained in the subsequent subsections for this basin.

Table H-42. Summary of hatchery-related risk and benefit effect levels assigned for Green River basin steelhead.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead hatcheries	Moderate	Low	Same as Alternative 1
Chinook salmon hatchery	High	Same as Alternative 1	Same as Alternative 1
Coho salmon hatcheries	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	Moderate	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

3.6.2.1 Risks

3.6.2.1.1 Steelhead Hatchery Programs

The seven isolated steelhead hatchery programs and one integrated conservation steelhead hatchery program result in competition, genetic, and hatchery facilities and operation risks. An overall summary of effects from steelhead facilities is provided in Table H-43.

Table H-43. Summary of risks to Green River basin steelhead from steelhead hatchery programs by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Risks (Competition, Genetics, Hatchery Facilities, and Operation)			
Palmer Ponds Hatchery isolated winter-run steelhead yearling	Moderate	Low	High
Palmer Ponds - Flaming Geyser Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	Moderate	Low	Same as Alternative 1
Palmer Ponds Hatchery isolated summer-run steelhead yearling	Moderate	Low	Same as Alternative 1
Soos Creek Hatchery isolated winter-run yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	Moderate	Low	Same as Alternative 1 and 2
Soos Creek Hatchery Green River wild stock integrated winter-run yearling	Moderate	Same as Alternative 1 and 2	Same as Alternative 1 and 2
Soos Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	Moderate	Low	Same as Alternative 1 and 2
Icy Creek Hatchery isolated winter-run steelhead yearling (part of Palmer Ponds Hatchery winter-run steelhead program)	Moderate	Low	Same as Alternative 1 and 2
Icy Creek Hatchery isolated summer-run steelhead yearling (part of Palmer Ponds Hatchery summer-run steelhead program)	Moderate	Low	Same as Alternative 1 and 2
Summary	**Moderate**	**Low**	**Same as Alternative 1**

Palmer Ponds Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the isolated winter-run steelhead hatchery yearling program at the Palmer Ponds Hatchery would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation is not met (Table H-44). Production under Alternative 1 and Alternative 2 would be 150,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (75,000 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would increase by 39 percent under Alternative 4 (208,000 yearlings, Table H-41) compared to Alternative 1 and Alternative 2, which would result in a high risk level (Table H-43).

Table H-44. Impacts to natural-origin steelhead associated with the Palmer Ponds Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. pHOS is not estimated. No adequate adult trapping facilities.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Palmer Ponds – Flaming Geyser Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the Palmer Ponds – Flaming Geyser isolated winter-run steelhead hatchery yearling program would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation is not met (Table H-45). Production under Alternative 1 and Alternative 2 would be 15,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (7,500 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would not change under Alternative 4 and the risk level would be the same as Alternative 1 and Alternative 2 (Table H-43).

Table H-45. Impacts to natural-origin steelhead associated with the Palmer Ponds - Flaming Geyser isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from watershed. No adequate adult trapping facilities. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from watershed. No adequate adult trapping facilities. Juvenile fish not acclimated to release sites. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Palmer Ponds Hatchery Isolated Summer-run Steelhead Program. Under Alternative 1 and Alternative 2, the Palmer Ponds Hatchery isolated summer-run steelhead yearling program would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-46). Production under Alternative 1 and Alternative 2 would be 30,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (15,000 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would not change under Alternative 4 and the risk level would be the same as Alternative 1 and Alternative 2 (Table H-43).

Table H-46. Impacts to natural-origin steelhead associated with the Palmer Ponds Hatchery isolated summer-run yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. Smolt releases may interact with natural population. pHOS is not estimated
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from watershed. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Soos Creek Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the isolated steelhead hatchery yearling program at the Soos Creek Hatchery would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-47). Production under Alternative 1 and Alternative 2 would be 35,000 yearlings (Table H-41). The hatchery production level would be the same under Alternative 4 as under Alternative 1 and Alternative 2 (Table H-41); thus, all three alternatives would have the same risk levels (Table H-43). Under Alternative 3, hatchery production would decrease by 50 percent (17,500 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43).

Table H-47. Impacts to natural-origin steelhead associated with the Soos Creek Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. Facility intake does not meet current standards. Hatchery structures impede passage of naturally produced juveniles and adults. No performance measures or monitoring plan developed. Program not based on adaptive management plan. Facility is not sited to minimize risk of catastrophic fish loss from flooding.

Soos Creek Hatchery Green River Integrated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the Soos Creek Hatchery Green River integrated winter-run steelhead yearling program would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-48). Production under Alternative 1 and Alternative 2 would be 50,000 yearlings (Table H-41). Under Alternative 3 and Alternative 4, hatchery production would not change and, therefore, the risk level would be the same as Alternative 1 and Alternative 2.

Table H-48. Impacts to natural-origin steelhead associated with the Soos Creek Hatchery Green River integrated conservation winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	pHOS is not estimated.
Hatchery Facilities and Operation	Facility intake does not meet current standards. Hatchery structures impede passage of naturally produced juveniles and adults. Program not based on adaptive management plan. Facility not sited to minimize risk of catastrophic fish loss from flooding.

Soos Creek Isolated Summer-run Steelhead Program. Under Alternative 1 and Alternative 2, the Soos Creek isolated summer-run steelhead yearling program would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-49). Production under Alternative 1 and Alternative 2 would be 30,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (15,000 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would not change under Alternative 4 and the risk level would be the same as Alternative 1 and Alternative 2.

Table H-49. Impacts to natural-origin steelhead associated with the Soos Creek Hatchery isolated summer-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. Facility intake does not meet current standards. Hatchery structures impede passage of naturally produced juveniles and adults. No performance measures or monitoring plan developed. Program not based on adaptive management plan. Facility not sited to minimize risk of catastrophic fish loss from flooding.

Icy Creek Hatchery Isolated Winter-run Steelhead Program. Under Alternative 1 and Alternative 2, the Icy Creek isolated winter-run steelhead yearling program would result in moderate risks regarding competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-50). Production under Alternative 1 and Alternative 2 would be 20,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (10,000 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would not change under Alternative 4 and the risk level would be the same as Alternative 1 and Alternative 2 (Table H-43).

Table H-50. Impacts to natural-origin steelhead associated with the Icy Creek Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate trapping facilities available. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate trapping facilities available. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Icy Creek Hatchery Isolated Summer-run Steelhead Program. Under Alternative 1 and Alternative 2, the Icy Creek isolated winter-run steelhead yearling program would result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-43). These impacts considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-51). Production under Alternative 1 and Alternative 2 would be 20,000 yearlings (Table H-41). Under Alternative 3, hatchery production would decrease by 50 percent (10,000 yearlings, Table H-41), which would reduce the competition, genetic, and hatchery facilities and operation risk factors to low ratings (Table H-43). The hatchery production level would not change under Alternative 4 and the risk level would be the same as Alternative 1 and Alternative 2 (Table H-43).

Table H-51. Impacts to natural-origin steelhead associated with the Icy Creek Hatchery isolated summer-run steelhead yearling program by risk category

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate trapping facilities available. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate trapping facilities available. pHOS is not estimated.
Hatchery Facilities and Operation	Program does not avoid transfers into the basin. No performance measures or monitoring plan developed. Program not based on adaptive management plan.

Summary for Steelhead Hatchery Programs. As shown in Table H-43, most steelhead hatcheries would result in moderate risks to natural-origin steelhead from competition, genetic, and hatchery facilities and operation impacts under Alternative 1 and Alternative 2. The risk would decrease to a low risk under Alternative 3 (Table H-43) because of decreases in hatchery production. The risk would not change under Alternative 4 compared to Alternative 1 and Alternative 2 because production levels would not vary among the three alternatives. There are two exceptions: 1) a high risk from the Palmer Ponds Hatchery isolated winter-run steelhead yearling program under Alternative 4 due to its increased production (39 percent increase, Table H-41), and 2) a continued moderate risk under Alternative 3 for the integrated winter-run yearling program from the Soos Creek Hatchery Green River natural-origin stock, because there would be no production change from Alternative 1 and Alternative 2. Results from Table H-43 are incorporated in Table H-42 for steelhead hatchery competition, genetics, and hatchery facilities and operation for the Green River basin.

3.6.2.1.2 Chinook Salmon Hatchery Program

Under Alternative 1 and Alternative 2, 300,000 Chinook salmon yearlings would be released from Icy Creek Hatchery in April each year (Table H-41). The hatchery-origin Chinook salmon yearlings are approximately 6.1 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) when released, and resource competition may occur with the similar size natural-origin steelhead smolts (6.5 inches fork length, Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The hatchery-origin fish are released high in the Green River watershed (RM 48). The relatively large Chinook salmon yearling release number, timing of release, and the release location in the upper watershed are risk factors regarding competition with similarly sized natural-origin steelhead smolts emigrating downstream of the hatchery release site.

Considering the location and magnitude of the hatchery-origin Chinook salmon yearling release, the competition risk posed by the Icy Creek Hatchery Chinook salmon yearling program to natural-origin steelhead would be high under all alternatives (Table H-42). Although the competition effects for Icy Creek Hatchery Chinook salmon yearling releases on natural-origin steelhead would be reduced under Alternative 3, the release number would remain above 100,000 fish; thus, the competition risk would remain high (Table H-42). Under Alternative 4, annual releases would remain unchanged relative to Alternative 1 and Alternative 2 levels, and the competition risk for natural-origin steelhead parr/smolts would remain high (Table H-42).

3.6.2.1.3 Coho Salmon Hatchery Programs

Soos Creek Hatchery Integrated Coho Salmon Yearling Program. Under Alternative 1 and Alternative 2, 600,000 coho salmon yearlings would be released in late April each year from Soos Creek Hatchery (RM 34) (Table H-41). The hatchery-origin coho salmon yearlings are approximately 5.5 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) when released, and resource competition may occur with the natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Coho salmon yearlings released through the program have the potential to compete with natural-origin steelhead smolts during and after the release period as the two species out-migrate seaward in the Green River. Although the release of the coho salmon as yearling smolts that out-migrate relatively rapidly seaward may attenuate any competition risks, the release location relatively high in the watershed may increase the duration and intensity of interaction, and the release timing in April would result in a high competition risk. Although the number of coho salmon yearlings released each year would be reduced by half under Alternative 3 (300,000 fish, Table H-41) relative to the other alternatives

(600,000 fish, Table H-41), competition risks to steelhead posed under Alternative 3 would remain high due to the release location, release timing, and number of fish released. The number of hatchery-origin yearlings released under Alternative 4 would be the same as Alternative 1 and 2; thus, the risk level would also be the same.

Crisp Creek Ponds Hatchery Integrated Coho Salmon Program. Under Alternative 1 and Alternative 2, 200,000 coho salmon yearlings would be released in May each year from Crisp Creek Ponds Hatchery (RM 40) (Table H-41). The hatchery-origin coho salmon yearlings are approximately 5.5 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) when released, and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Coho salmon yearlings released through the program have the potential to compete with natural-origin steelhead smolts during and after the release period as the two species emigrate seaward in the Green River. Although the release of the coho salmon as yearling smolts that out-migrate relatively rapidly seaward may attenuate any competition risks, the release timing, release location relatively high in the watershed may increase the duration and intensity of interaction, and the release timing in May would result in a high competition risk. The number of coho salmon yearlings released each year would be reduced by half under Alternative 3 (100,000 fish, Table H-41) relative to the other alternatives (600,000 fish, Table H-41), which would result in a low competition risk. The number of hatchery-origin yearlings released under Alternative 4 would be the same as Alternative 1 and 2; thus, the risk level would also be the same.

Summary for Coho Salmon Hatchery Programs. For the Soos Creek Hatchery and Crisp Creek Ponds Hatchery, the competition risk levels under Alternative 1 and 2 would be high and thus the overall risk rating for coho competition would be high (Table H-42). Although the risk level for the Crisp Creek Ponds Hatchery would be reduced to low under Alternative 3 due to the decreased production level for this hatchery, the number of fish released through the Soos Creek Hatchery compared to the Crisp Creek Ponds Hatchery (300,000 fish compared to 100,000 fish; Table H-41) would result in a continued high risk level overall (Table H-42). For both hatcheries, the number of hatchery-origin yearlings released under Alternative 4 would be the same as Alternative 1 and 2; thus, the risk level would also be the same as a high risk (Table H-42).

3.6.2.2 Benefits

3.6.2.2.1 Total Return

Winter-run Steelhead Hatchery Programs. Isolated winter-run steelhead hatchery programs and the integrated conservation winter-run steelhead hatchery yearling program in the Green River basin would contribute hatchery-origin adult steelhead to the Duwamish River and Green River, as well as creeks that flow into these rivers for conservation, harvest, and hatchery broodstock purposes at the total return levels, as shown in Table H-52.

Table H-52. Contributions of hatchery-origin winter-run steelhead to total returns in the Green River basin by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Annual smolt release number	270,000	160,000	328,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	2,700	1,600	3,280
Recent year average			
Adult return rate[2]	0.55 percent	0.55 percent	0.55 percent
Adult return	1,485	880	1,804
Projected total return as a percent of adult return goal	**55 percent**	**55 percent**	**55 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases; from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2005]).

[2] The 10 year (1997–2006) return year average estimated percent adult contribution to sport and tribal harvest plus recorded rack returns for early returning winter-run steelhead smolts released through WDFW hatchery programs in the Green River basin. Hatchery contribution data are from WDFW (2008).

The benefits of Green River basin winter-run steelhead hatchery yearling programs to the total return of non-listed steelhead in the basin under all alternatives would be moderate (Table H-43). This is because the 10-year (1997 to 2006) mean adult return for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goal (55 percent) for the basin is greater than 50 percent for all alternatives (Table H-52).

Summer-run Steelhead Hatchery Programs. The isolated summer-run steelhead hatchery yearling programs in the Green River basin would contribute hatchery-origin adult steelhead to the Duwamish River and Green River, including creeks that flow into these rivers for harvest and hatchery broodstock use at the return levels, as shown in Table H-53.

Table H-53. Contributions of hatchery-origin summer-run steelhead to total returns in the Green River basin by alternative.

	Alternative 1 and 2	Alternative 3	Alternative 4
Annual smolt release number	80,000	40,000	80,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	800	800	800
Recent year average			
Adult return rate[2]	0.67 percent	0.67 percent	0.67 percent
Adult return	536	268	536
Projected total return as a percent of adult return goal	**67 percent**	**67 percent**	**67 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases; from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2004]).
[2] The 10 year (1997–2006) return year average estimated percent adult contribution to sport and tribal harvest plus recorded rack returns for hatchery-origin summer-run steelhead smolts released through WDFW hatchery programs in the Green River basin. Hatchery contribution data are from WDFW (2008).

The benefits of Green River basin summer-run steelhead hatchery yearling programs to the total return of non-listed steelhead in the basin under all alternatives would be moderate (Table H-43). This is because the 10-year (1997 to 2006) mean adult return for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult abundance goals (67 percent) for the basin is greater than 50 percent for all alternatives (Table H-53).

Summary for Total Return. The winter-run isolated and integrated conservation yearling and summer-run isolated steelhead hatchery yearling programs in the Green River basin would contribute to moderate total return benefits for all alternatives (Table H-42). Although the summer-run hatchery programs would contribute more fish for harvest, their contribution would be insufficient to raise the benefit level from moderate.

3.6.2.2.2 Viability

All but one of the hatchery steelhead programs in the basin are operated as isolated harvest programs, which propagate non-listed out-of-DPS Skamania summer-run and Chambers Creek lineage winter-run steelhead stocks to augment fisheries harvest. There would be no benefits imparted by those programs to viability parameters for the listed natural-origin winter-run steelhead population in the Green River basin under any of the alternatives.

The Soos Creek Hatchery Green River wild stock steelhead yearling program is operated as an integrated conservation program. Fish produced by the hatchery program are part of the DPS that is listed under the ESA. Although operated to contribute surplus fish for harvest in fisheries, the program would propagate the natural-origin winter-run stock and may benefit population viability parameters (abundance, diversity, and spatial structure) for listed natural-origin Green winter-run steelhead. The program may benefit natural-origin steelhead population abundance by increasing the number of natural-origin spawners and juveniles. The program may benefit natural-origin steelhead population diversity, because the hatchery program would serve as a genetic reserve for the composite population; however, this assumes appropriate hatchery practices are applied that minimize divergence between the hatchery-origin and natural-origin populations. Under all alternatives, hatchery production would be 50,000 yearlings (Table H-41).

The program would collect broodstock randomly over the entire natural-origin steelhead return period, maintain an appropriately sized effective breeding population size in the hatchery program, incorporate natural-origin fish at a high proportion, and apply a factorial mating scheme during spawning. Fish released through the program would likely return predominately to Soos Creek and to mainstem Green River spawning areas in the vicinity of the river's confluence with Soos Creek. Green River population spatial structure may, therefore, be moderately enhanced by the program through extension of natural-origin spawner use into Soos Creek. The program's effects on productivity are unknown, but effects are unlikely to substantially benefit the natural-origin winter-run steelhead population. This is because the primary factors that limit the productivity of the population are likely to be habitat-related (Hard et al. 2014). For these reasons, the effect of the program on natural-origin winter-run steelhead population viability would be a moderate benefit under all alternatives (Table H-42).

3.6.2.3 Summary – Green River Basin

Table H-42 summarizes the risks and benefits for all alternatives pertinent to Green River basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. For the hatchery programs evaluated in the Green River basin, the overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 range from moderate to high with the steelhead hatcheries resulting in moderate risks, and Chinook salmon and coho salmon hatcheries posing high competitive risks. Because of decreased production compared to Alternative 1 and Alternative 2, the steelhead hatcheries would result in low risk under Alternative 3, while the Chinook salmon and coho salmon hatcheries would not result in decreased competition risk. This is because, although production would decrease, the overall production levels for the Chinook salmon and coho salmon programs would remain relatively large, and continue to result in a continued high risk. Increased production would not change risk levels for the steelhead, Chinook salmon, and coho salmon programs, although the Chinook salmon and coho salmon already have high risk levels.

Total return benefits from the hatchery programs in the Green River basin would be moderate for all alternatives because estimated adult returns would be greater than half of the Puget Sound-wide goal for steelhead. Viability benefits from the integrated conservation hatchery program would be moderate under all alternatives because the production level would be the same.

Overall, the decreased production for steelhead hatcheries under Alternative 3 (43 percent decrease, Table H-41) would help to decrease the risk levels for competition, genetics, and hatchery facilities and operation (Table H-42). Production changes for coho salmon hatcheries would not alter the risk level because the risk level would already be high, which is the maximum risk rating.

3.6.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.6.2.4.1 Palmer Ponds Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Palmer Ponds Hatchery isolated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing or terminating the Palmer Pond winter-run steelhead release program; trucking some or all hatchery-origin steelhead smolts from the ponds downstream for release near the mouth of the mainstem river (alter the release strategy); and delaying release of the hatchery-origin winter-run steelhead until after the major natural-origin steelhead smolt out-migration period (which would also help alter the release strategy). Trucking and planting the hatchery-origin steelhead smolts near the mouth of the Green River may increase the portion of hatchery-origin smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the up-river release sites seaward.

Assuming a continued isolated harvest operational intent for the Palmer Ponds winter-run steelhead hatchery program, key genetic risk mitigation measures to reduce effects on the natural-origin winter-run steelhead population may include cessation of out-of-watershed transfers to sustain the hatchery program and creation of a localized early returning Green River hatchery winter-run steelhead broodstock.

Although transition of the Palmer Ponds Hatchery isolated winter-run steelhead yearling program to an integrated conservation program is a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-54 summarizes potential mitigation measures for the Palmer Ponds Hatchery isolated winter-run steelhead program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be moderate and high risks under Alternative 2 and Alternative 4, respectively.

Table H-54. Potential mitigation measures for the Palmer Ponds Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.2 Palmer Ponds – Flaming Geyser Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Palmer Ponds – Flaming Geyser Hatchery isolated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include reducing smolt releases from, or terminating, the Flaming Geyser winter steelhead release program. Strategies to alter current release practices include ceasing on-station releases and, instead, trucking some or all hatchery-origin steelhead smolts from the hatchery downstream for release near the Duwamish estuary, and delaying release of the hatchery-origin winter steelhead until after the majority of natural-origin steelhead smolts have out-migrated downstream. Trucking and planting Flaming Geyser hatchery-origin steelhead smolts near the mouth of the Green River may increase the portion of hatchery smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from up-river release sites seaward.

With continued management of the Flaming Geyser winter steelhead hatchery yearling program as an isolated harvest program, key genetic risk mitigation measures applied to reduce effects on the natural winter steelhead population may include reducing or terminating the isolated hatchery winter-run steelhead release program, and increasing harvest rates to remove, and decrease straying of, hatchery-origin adults from Flaming Geyser steelhead releases.

Although transition of the Palmer Ponds – Flaming Geyser Hatchery isolated winter-run steelhead hatchery yearling program to an integrated conservation program is a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-55 summarizes the potential mitigation measures for the Palmer Ponds – Flaming Geyser Hatchery isolated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4, respectively.

Table H-55. Potential mitigation measures for the Palmer Ponds – Flaming Geyser Hatchery isolated winter-run steelhead hatchery yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, C4, and C9.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, G5, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.3 Palmer Ponds Hatchery Isolated Summer-run Steelhead Program

Key risk mitigation measures for the Palmer Ponds Hatchery isolated summer-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing smolt releases from, or terminating, the Palmer Ponds summer steelhead yearling program. Altering the release strategy could include trucking some or all hatchery-origin summer steelhead smolts from the pond downstream for release near the mouth of the mainstem river (which would alter the release strategy), and delaying release of the hatchery-origin summer steelhead until after the major natural-origin steelhead smolt out-migration period (which would also alter the release strategy).

Key risk reduction measures that may be applied to reduce genetic impacts to the natural-origin winter steelhead population include monitoring hatchery-origin adult summer steelhead spawn timing and contribution to natural spawning; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized Green River hatchery-origin summer steelhead broodstock; maintaining hatchery racks across the entire hatchery-origin steelhead return period; ceasing the practice of recycling adult hatchery-origin fish from hatchery traps to downstream fishery harvest areas; and increasing harvest rates to remove and decrease straying of hatchery-origin adults.

Table H-56 summarizes potential mitigation measures for the Palmer Ponds Hatchery isolated summer-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate risks under Alternative 2 and Alternative 4, respectively.

Table H-56. Potential mitigation measures for the Palmer Ponds Hatchery isolated summer-run steelhead hatchery yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.4 Soos Creek Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Soos Creek Hatchery isolated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include reducing smolt releases from, or terminating, the Soos Creek Hatchery winter-run steelhead release program. Altered release strategies include ceasing on-station releases and, instead, trucking some or all hatchery-origin steelhead smolts from the hatchery downstream for release near the Duwamish estuary, and delaying release of the hatchery-origin winter-run steelhead until after the majority of natural-origin steelhead smolts have emigrated downstream. Trucking and planting hatchery-origin steelhead smolts near the mouth of the Green River may increase the portion of hatchery-origin smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the Soos Creek release site seaward.

Assuming that the Soos Creek Hatchery winter-run steelhead hatchery program continues to be managed with an isolated harvest intent, key genetic risk mitigation measures applied to reduce effects on the natural-origin winter-run steelhead population may include reducing or terminating the hatchery winter-run steelhead release program; ceasing out-of-watershed transfers to sustain the hatchery program; and creating a localized early returning Green River Hatchery winter-run steelhead broodstock.

Although transition of the Soos Creek Hatchery isolated winter-run steelhead yearling program to an integrated conservation program may be included as a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Of additional concern under all alternatives is the standing of the permanent Soos Creek Hatchery water intake and weir as barriers and negative factors for adult steelhead and salmon upstream migration in Soos Creek. This risk factor to steelhead could be mitigated by upgrading the hatchery intake and weir to meet current fish passage standards, which would provide upstream passage for migrating adult steelhead under all operational and flow conditions.

Table H-57 summarizes potential mitigation measures for the Soos Creek Hatchery isolated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4. Reducing or terminating the program would also help to reduce and/or eliminate all risk categories.

Table H-57. Potential mitigation measures for the Soos Creek Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H3, H4, H5, and H6.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.5 Soos Creek Hatchery Green River Integrated Winter-run Steelhead Program

Key risk mitigation measures for the Soos Creek Hatchery Green River integrated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include reducing the number of fish released, delaying release of the winter-run steelhead from Soos Creek Hatchery until after the majority of natural-origin steelhead smolts have out-migrated downstream (which would alter the release strategy), or terminating the program.

With continued management of the Soos Creek Hatchery winter-run steelhead hatchery program as an integrated conservation program, key genetic risk mitigation measures to reduce effects on the natural-origin winter-run steelhead population include developing a plan for monitoring the relative proportion of hatchery-origin winter-run steelhead spawning naturally and contributing to fisheries; applying broodstock collection and mating practices to reduce the likelihood that the hatchery population would diverge genetically from the donor natural-origin winter-run steelhead population; and/or reducing or terminating the hatchery winter-run steelhead release program after a defined period (e.g., three steelhead generations) to decrease the likelihood for hatchery-induced genetic changes in the combined natural-origin stock winter-run steelhead population.

Table H-58 summarizes potential mitigation measures for the Soos Creek Hatchery integrated conservation winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate risks under Alternative 2, Alternative 3, and Alternative 4. These measures would apply to all action alternatives.

Table H-58. Potential mitigation measures for the Soos Creek Hatchery integrated conservation winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C3 and C4.
Genetics	Apply Mitigation Measure G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H2, H3, H5, and H6.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.6 Soos Creek Isolated Summer-run Steelhead Program

Key risk mitigation measures that may be applied under the alternatives to reduce competition impacts include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing smolt releases from, or terminating, the Soos Creek Hatchery summer-run steelhead release program. Altering the release strategy could include trucking some or all hatchery-origin summer-run steelhead smolts from the pond downstream for release near the mouth of the mainstem river, and delaying release of the hatchery-origin summer-run steelhead until after the major natural-origin steelhead smolt out-migration period. Trucking and planting the hatchery-origin summer-run steelhead smolts near the mouth of the Green River may increase the proportion of smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the up-river release site seaward.

Key risk reduction measures that may be applied to reduce genetic impacts to the natural-origin winter-run steelhead population include monitoring hatchery-origin adult summer-run steelhead spawn timing and contribution to natural spawning; reducing or terminating the hatchery summer-run steelhead release program; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized Green River hatchery summer-run steelhead broodstock; maintaining hatchery racks across the entire hatchery-origin steelhead return period; ceasing the practice of adult hatchery-origin fish recycling from hatchery traps to downstream fishery harvest areas; and implementing increased harvest rates to foster removal and decreased straying of arriving mass-marked hatchery-origin adults.

Although transition of the Soos Creek Hatchery isolated winter-run steelhead yearling program to an integrated conservation program may be included as a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-59 summarizes potential mitigation measures for the Soos Creek Hatchery isolated summer-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate risks under Alternative 2 and Alternative 4.

Table H-59. Potential mitigation measures for the Soos Creek Hatchery isolated summer-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, and C4.
Genetics	Apply Mitigation Measures G1, G2, G3, and G4.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H3, H4, H5, and H6.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.7 Icy Creek Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Icy Creek Hatchery isolated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include reducing or terminating the program. Altering the release strategy could include ceasing on-station releases and, instead, trucking some or all hatchery-origin steelhead smolts from the hatchery downstream for release near the Duwamish estuary, and delaying release of the hatchery-origin winter-run steelhead until after the majority of natural-origin steelhead smolts have emigrated downstream. Trucking and planting Icy Creek hatchery-origin steelhead smolts near the mouth of the Green River may increase the portion of smolts surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the up-river release site seaward.

If the Icy Creek Hatchery winter-run steelhead hatchery program continues to be managed with an isolated harvest intent, key genetic risk mitigation measures to reduce effects on the natural-origin winter-run steelhead population include reducing or terminating the hatchery winter-run steelhead release program; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized early returning Green River Hatchery winter-run steelhead broodstock; selection through broodstock collection and mating practices for an earlier return timing for adult hatchery-origin steelhead localized to the river basin; maintaining hatchery racks across the entire hatchery-origin steelhead return period; ceasing the practice of adult hatchery-origin fish recycling from hatchery traps to downstream fishery harvest areas; and increasing harvest to remove and decrease straying of hatchery-origin Icy Creek adults.

Although transition of the Icy Creek Hatchery isolated winter-run steelhead yearling program to an integrated conservation program may be included as a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-60 summarizes potential mitigation measures for the Icy Creek Hatchery isolated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate risks under Alternative 2 and Alternative 4.

Table H-60. Potential mitigation measures for the Icy Creek Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, C4, and C9.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.8 Icy Creek Hatchery Isolated Summer-run Steelhead Program

Key risk mitigation measures for the Icy Creek Hatchery isolated summer-run steelhead yearling program that may be applied under the alternatives to reduce competition risks include implementation of hatchery management actions that create a refuge for natural-origin steelhead smolts from hatchery-origin steelhead competition. These measures could include reducing smolt releases from, or terminating, the Icy Creek Hatchery summer-run steelhead release program. Altering the release strategy could include trucking some or all hatchery-origin summer-run steelhead smolts from the pond downstream for release near the mouth of the mainstem river, and delaying release of the hatchery-origin summer-run steelhead until after the major natural-origin steelhead smolt out-migration period.

Key risk reduction measures that may be applied to reduce genetic impacts to the natural-origin winter-run steelhead population include monitoring hatchery-origin adult summer-run steelhead spawn timing and contribution to natural spawning; reducing or terminating the hatchery-origin summer-run steelhead release program; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized Green River hatchery summer-run steelhead broodstock; maintaining hatchery racks across the entire hatchery-origin steelhead return period; ceasing the practice of adult hatchery-origin fish recycling from hatchery traps to downstream fishery harvest areas; and increasing harvest to remove and decrease straying of hatchery-origin adults.

Although transition of the Icy Creek Hatchery isolated summer-run steelhead yearling program to an integrated conservation program is a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-61 summarizes potential mitigation measures for the Icy Creek Hatchery isolated summer-run steelhead program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be moderate risks under Alternative 2 and Alternative 4.

Table H-61. Potential mitigation measures for the Icy Creek Hatchery isolated summer-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, C4, and C9.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.9 Chinook Salmon Hatchery Program

Table H-62 summarizes potential mitigation measures for the Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling program for the action alternatives. These mitigation measures would help reduce competition risks, which would be rated as high risks under Alternative 2, Alternative 3, and Alternative 4. These measures would apply to all action alternatives; however, mitigation measures that reduce the size of the program would not apply to Alternative 3 because this alternative already includes decreases in hatchery production. Reducing or terminating the program under Alternative 2 and Alternative 3 would help to reduce and/or remove the competition risk.

Table H-62. Potential mitigation measures for the Soos Creek Hatchery/Icy Creek Hatchery integrated fall-run Chinook salmon yearling hatchery program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.6.2.4.10 Coho Salmon Hatchery Programs

Table H-63 summarizes potential mitigation measures for the Soos Creek Hatchery integrated coho salmon yearling program and the Crisp Creek Ponds Hatchery integrated coho salmon yearling program for the action alternatives. These mitigation measures would help reduce competition risks, which would be rated as high risks under Alternative 2, Alternative 3, and Alternative 4. These measures would apply to all action alternatives; however, mitigation measures that reduce the size of the program would not apply to Alternative 3 because this alternative already includes decreases in hatchery production. Trucking and planting Soos Creek Hatchery coho salmon smolts near the mouth of the Green River may increase the portion of hatchery-origin juveniles surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate from the hatchery release site seaward.

Table H-63. Potential mitigation measures for the coho salmon hatchery yearling programs in the Green River basin.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.7 Puyallup River

3.7.1 Introduction

As shown in Table H-1, the Puyallup River basin includes the Puyallup River, Carbon River, White River, and Mowich River watersheds where three natural-origin winter-run steelhead stocks occur, represented in two winter-run populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Puyallup River basin and support hatchery-origin fish that could affect natural-origin steelhead: Puyallup River, White River, Carbon River (including Voights Creek, which is a tributary of the Carbon River), and Mowich River (including Rushingwater Creek, which is a tributary of the Mowich River).

Two steelhead hatchery programs, one Chinook hatchery program, and two coho salmon hatchery programs from three hatchery facilities (Voights Creek Hatchery, White River Hatchery, and Diru Creek Hatchery) have the potential to impact Puyallup River basin steelhead (Table H-64 and Table H-65), and are reviewed in this subsection.

Table H-64. Hatchery programs and categories of effects evaluated for Puyallup River basin steelhead.

		Risk			Benefit	
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Steelhead	Voights Creek Hatchery isolated winter-run steelhead yearling	√	√	√	√	
	White River winter steelhead supplementation (Diru Creek Hatchery and White River Hatchery integrated conservation winter-run steelhead yearling)	√	√	√	√	√
Chinook Salmon	White River Hatchery integrated spring-run Chinook salmon yearling	√				
Coho Salmon	Voights Creek Hatchery integrated coho salmon yearling	√				
	Voights Creek Hatchery and acclimation pond integrated coho salmon yearling	√				

Table H-65. Hatchery salmon and steelhead production in the Puyallup River basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase From Alternative 1 and 2**
Steelhead	Voights Creek Hatchery isolated winter-run steelhead yearling	200,000	100,000	50	200,000	0
	White River winter steelhead supplementation (Diru Creek Hatchery and White River Hatchery integrated conservation winter-run steelhead yearling)	35,000	35,000	0	35,000	0
	TOTAL	**235,000**	**135,000**	**43**	**235,000**	**0**
Chinook Salmon	White River Hatchery integrated spring-run Chinook salmon yearling	90,000	90,000	0	90,000	0
Coho Salmon	Voights Creek Hatchery integrated coho salmon yearling	780,000	390,000	50	1,180,000	51
	Voights Creek Hatchery and acclimation pond integrated coho salmon yearling	200,000	200,000	0	200,000	0
	TOTAL	**980,000**	**590,000**	**40**	**1,380,000**	**41**
All	**TOTAL**	**1,070,000**	**815,000**	**31**	**1,705,000**	**59**

3.7.2 Results

Results for the Puyallup River basin are summarized in Table H-66. The action alternatives would include use of an adaptive management approach, but the results in Table H-66 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-66 is explained in the subsequent subsections for this basin.

Table H-66. Summary of risks and benefits assigned for Puyallup River basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead hatcheries	Moderate	Low	Same as Alternative 1
Chinook salmon hatcheries	High	Same as Alternative 1	Same as Alternative 1
Coho salmon hatcheries	High	Same as Alternative 1	Same as Alternative 1
Genetics	Moderate	Low	Same as Alternative 1
Hatchery Facilities and Operation	Moderate	Low	Same as Alternative 1
Benefits			
Total Return	Low	Same as Alternative 1	Same as Alternative 1
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

3.7.2.1 Risks

3.7.2.1.1 Steelhead Hatchery Programs

One isolated steelhead hatchery program and one integrated conservation steelhead hatchery program result in competition, genetic, and hatchery facilities and operation risks.

Voights Creek Hatchery Isolated Winter-Run Steelhead Program. Under Alternative 1 and Alternative 2, the isolated winter-run steelhead hatchery yearling program at the Voights Creek Hatchery would produce 200,000 fish (Table H-65) and result in competition, genetics, and hatchery facilities and operation types of impacts. These impacts are considered a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation is not met (Table H-67). The hatchery production level would be the same under Alternative 4 as under Alternative 1 and Alternative 2 (Table H-65); thus, all three alternatives would have the same risk levels. Under Alternative 3, hatchery production would decrease by 50 percent (to 100,000 smolts, Table H-65), which would reduce the competition, genetic, and hatchery facilities and operation risks to low.

Table H-67. Impacts to natural-origin steelhead associated with the Voights Creek Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate adult trapping facilities. Smolt releases may interact with natural-origin population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate adult trapping facilities. pHOS is not estimated.
Hatchery Facilities and Operation	No performance measures or monitoring plan developed. Program not based on adaptive management plan. Program does not avoid transfers into the basin. Facility intake does not meet current standards. Facility not sited to minimize risk of catastrophic fish loss from flooding.

White River Winter Steelhead Supplementation (Diru Creek Hatchery and White River Hatchery Integrated Conservation Winter-Run Steelhead) Program. Under Alternative 1 and Alternative 2, the White River winter steelhead supplementation integrated conservation winter-run steelhead hatchery yearling program at the Diru Creek Hatchery and White River Hatchery would produce 35,000 fish (Table H-65) and contribute to competition and hatchery facilities and operation types of impacts. These impacts are considered a moderate risk because at least one BMP for competition and hatchery facilities and operation would not be met (Table H-68). The hatchery production level would be the same under Alternative 3 and Alternative 4 as under Alternative 1 and Alternative 2 (Table H-65); thus, all four alternatives would have the same risk levels.

Table H-68. Impacts to natural-origin steelhead associated with the White River winter steelhead supplementation (Diru Creek Hatchery and White River Hatchery integrated conservation winter-run steelhead yearling) program by risk category.

Risk Category	Impact
Competition	Smolt releases may interact with natural-origin population.
Hatchery Facilities and Operation	Program not based on adaptive management plan.

Summary for Steelhead Hatchery Programs. As shown in Table H-66, the steelhead hatcheries would result in moderate risks to natural-origin steelhead from competition, genetic, and hatchery facilities and operation impacts under Alternative 1 and Alternative 2. The risk would decrease to a low risk under Alternative 3 (Table H-66) because of decreases in hatchery production. The risk would not change under Alternative 4 compared to Alternative 1 and Alternative 2 because production levels would not vary among the three alternatives.

3.7.2.1.2 Chinook Salmon Hatchery Program

Under Alternative 1 and Alternative 2, the White River Hatchery integrated spring-run Chinook salmon yearling program would release a portion of its annual fish production of White River population Chinook salmon as yearlings each year. None of the other hatcheries in the basin would produce Chinook salmon yearlings. The Chinook salmon yearlings would continue to be released from the White River Hatchery in mid-April each year, during the estimated natural-origin winter-run steelhead smolt out-migration period in the basin. As described in the HGMP for this program, the hatchery-origin Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with the similar size natural-origin steelhead smolts (6.5 inches fork length, Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The hatchery-origin Chinook salmon yearlings would continue to be released relatively high in the watershed (RM 23).

The April release timing, the large size of the fish, and the release location in the upper watershed are all risk factors regarding competition with similarly sized natural-origin steelhead smolts emigrating downstream of the hatchery release site. Although the duration of interaction between the species may be low because the hatchery releases of Chinook salmon would be volitionally released as smolts and the fish would likely out-migrate seaward within a few weeks after release, and there may also be a niche separation between Chinook salmon and steelhead (due to food preference and river out-migration area differences), the competition risk from the program under all alternatives would be high (Table H-66). Competition effects of White River Hatchery Chinook salmon yearling releases on natural-origin steelhead would be the same across all alternatives, because the release numbers (90,000 fish, Table H-65) would remain unchanged.

3.7.2.1.3 Coho Salmon Hatchery Programs

Voights Creek Hatchery Integrated Coho Salmon Program. Under Alternative 1 and Alternative 2, 780,000 coho salmon yearlings would be released in April (half of the production) and May (half of the production) each year from Voights Creek Hatchery (RM 4 of the Carbon River, tributary of the Puyallup River at RM 17.8). The hatchery-origin coho salmon yearlings are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length, Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Competition may occur during and after the release period as the two species emigrate seaward in the Carbon and Puyallup Rivers. The location of the hatchery-origin coho salmon release sites may increase the duration and intensity of interaction with natural-origin steelhead, while the release of coho salmon as yearling smolts that out-migrate relatively rapidly seaward may attenuate competition risks.

The large number of coho salmon yearlings released, the release of the hatchery-origin fish in April and May during the primary (April-May) steelhead smolt out-migration period, and the release locations lead to a moderate competition risk level. Although the number of coho salmon yearlings released from Voights Creek Hatchery each year would be reduced by half under Alternative 3 (390,000 fish, Table H-65), the risk would remain moderate due to the large number of fish released. Competition risks for the program would be highest of the alternatives for Alternative 4, with an annual coho salmon yearling release number of 1,180,000 fish. However, the risk would remain moderate due to the release location.

Voights Creek Hatchery and Acclimation Pond Integrated Coho Salmon Program. Under Alternative 1 and Alternative 2, 200,000 coho salmon yearlings would be released into the upper Puyallup River watershed each year through the Voights Creek Hatchery and acclimation pond yearling program (late April-mid May release with an average size of 5.5 inches fork length, and released above RM 44). The number of salmon released would not change among alternatives (Table H-65). Thus, the release location, timing of release, and number of hatchery-origin fish released would result in a high risk for all alternatives.

Summary for Coho Salmon Hatchery Programs. In summary, competition risks to natural-origin steelhead from coho salmon hatchery yearling programs in the Puyallup River basin would be high for all alternatives (Table H-66) because most of the risk factors for the two hatcheries have a high risk rating. The high risk factors for the Voights Creek Hatchery and acclimation pond integrated coho salmon program, coupled with the large release and timing of release under the Voights Creek Hatchery integrated coho salmon yearling program (which are high risk factors), are the primary influences on this summary rating.

3.7.2.2 Benefits

3.7.2.2.1 Total Return

The isolated steelhead hatchery programs in the Puyallup River basin would contribute hatchery-origin adult steelhead to the White River, Carbon River, and Puyallup River for harvest and hatchery broodstock purposes at the return levels as shown in Table H-69. The White River winter-run steelhead supplementation program (Diru Creek Hatchery and White River Hatchery) is not reflected in Table H-69 because there is insufficient information on adult return rates for integrated conservation hatchery programs for steelhead.

Table H-69. Contributions of hatchery-origin steelhead from isolated hatchery programs to total return in the Puyallup River basin by alternative.

	Alternative 1 and 2	**Alternative 3**	**Alternative 4**
Annual smolt release number	235,000	135,000	235,000
Goal			
Smolt-to-adult return rate[1]	1 percent	1 percent	1 percent
Adult return	2,350	1,350	2,350
Recent year average			
Adult return rate[2]	0.18 percent	0.18 percent	0.18 percent
Adult return	423	243	423
Projected total return as a percent of adult return goal	**18 percent**	**18 percent**	**18 percent**

[1] Goal survival rate to adult return for Puget Sound hatchery-origin steelhead yearling releases; from WDFW Puget Sound steelhead HGMPs (e.g., WDFW [2004]).
[2] The 10 year (1997–2006) return year average estimated adult contribution to sport and tribal harvest plus recorded rack returns for hatchery-origin steelhead released through WDFW's Voights Creek Hatchery program. Hatchery contribution data are from WDFW (2008).

The benefits of the Puyallup River basin steelhead hatchery yearling programs to the total return of non-listed steelhead in the basin under all alternatives would be low (Table H-66). This is because the 10-year (1997 to 2006) mean adult return for the steelhead hatchery yearling programs as a percentage of the Puget Sound-wide adult return goals (18 percent) for the basin is less than 50 percent for all alternatives. Although the potential contribution of the White River winter-run steelhead supplementation program (Diru Creek Hatchery and White River Hatchery) is not reflected in the total return information, their contribution is likely small because of the relatively small number of fish released (35,000 fish, Table H-65).

3.7.2.2.2 Viability

The White River winter-run steelhead supplementation program (Diru Creek Hatchery and White River Hatchery) is operated as an integrated conservation program. Fish produced by the hatchery program are part of the DPS that is listed under the ESA. Under all alternatives, hatchery production would be 35,000 yearlings (Table H-65).

The hatchery-origin winter-run steelhead produced by the White River supplementation integrated conservation program may have a beneficial effect on most population viability parameters (abundance, diversity, and spatial structure) for Puyallup River basin natural-origin winter-run steelhead. The program may increase the total abundance of natural-origin White River winter-run steelhead returning to spawn, increasing the number of natural-origin progeny produced annually. This increase would serve as a genetic reserve for the composite population, assuming appropriate hatchery practices would be applied that minimize divergence between the hatchery-origin and natural-origin populations.

The program would collect broodstock randomly over the entire natural-origin steelhead return period, maintain an appropriately sized effective breeding population size in the hatchery program, incorporate natural-origin fish at a high proportion, and apply a factorial mating scheme during spawning. Fish released through the program would likely return to spawning areas in the upper reaches of the White River, Greenwater River, and Clearwater River and their tributaries. Thus, spatial structure of the White River population may be enhanced by the program. The program's effects on productivity are unknown, but any effects are unlikely to substantially benefit the natural-origin winter-run steelhead population. This is because the primary factors that limit productivity are likely to be habitat-related (Hard et al. 2014). For these reasons, the assigned effect of the program on natural-origin winter-run steelhead population viability would be a moderate benefit under all alternatives (Table H-66).

3.7.2.3 Summary – Puyallup River Basin

Table H-66 summarizes the risks and benefits for all alternatives pertinent to Puyallup River basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the five hatchery programs evaluated in the Puyallup River basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 range from moderate to high, with the Chinook salmon and coho salmon hatcheries as a high risk and the steelhead hatcheries as a moderate risk. Reduced hatchery-origin steelhead production under Alternative 3 would decrease competition, genetic, and hatchery facilities and operation risks from the steelhead hatchery programs to a low level. Risks under Alternative 4 would be the same as for Alternative 1 and Alternative 2. Total return benefits from the hatchery programs in the Puyallup River basin would be low for all alternatives because estimated adult returns would be less than half of the Puget Sound-wide goal for steelhead. Viability benefits from the integrated conservation hatchery program would be moderate under all alternatives because the production level would be unchanged.

Overall, the decreased production for steelhead hatcheries under Alternative 3 (43 percent decrease, Table H-65) would help to decrease the risk levels for competition, genetics, and hatchery facilities and operations (Table H-66). The increased production for coho salmon under Alternative 4 (40 percent increase, Table H-65) would not affect the competition risk level because the level was already high under Alternative 1 and Alternative 2 (Table H-66).

3.7.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.7.2.4.1 Voights Creek Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Voights Creek Hatchery isolated winter-run steelhead yearling program that may be applied under the alternatives to reduce the risk of competition impacts to natural-origin steelhead include decreasing smolt releases from, or terminating, the Voights Creek Hatchery winter-run steelhead release yearling program. Altering release strategies include ceasing on-station releases and, instead, trucking some or all hatchery-origin steelhead smolts from the hatchery downstream for release near the Puyallup River estuary, and delaying release of the hatchery winter-run steelhead until after the majority of natural-origin steelhead smolts have out-migrated downstream. Trucking and planting Voights Creek Hatchery coho salmon smolts near the mouth of the Puyallup River may increase the portion of hatchery-origin juveniles surviving to enter Puget Sound by circumventing in-river mortality normally experienced as the fish migrate seaward from the Carbon River release site.

Assuming that the Voights Creek Hatchery winter-run steelhead hatchery program continues to be managed with an isolated harvest intent, key genetic risk mitigation measures could be applied to reduce effects on the natural-origin winter-run steelhead population. These measures include reducing or terminating the hatchery winter-run steelhead release program; ceasing out-of-watershed transfers to sustain the hatchery program and creating a localized early returning Puyallup River hatchery winter-run steelhead broodstock, selecting through broodstock collection and mating practices for an earlier return timing for adult hatchery-origin steelhead localized to the river basin; maintaining hatchery racks across the entire hatchery-origin steelhead return period; ceasing the practice of adult hatchery-origin fish recycling from hatchery traps to downstream fishery harvest areas; and implementing increased harvest rates to foster removal and decrease straying of arriving mass-marked hatchery-origin adults.

Although transition of the Icy Creek Hatchery isolated winter-run steelhead yearling program to an integrated program is a genetic risk mitigation measure, it is uncertain whether an integrated conservation hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Green River basin steelhead.

Table H-70 summarizes the potential mitigation measures for the Voights Creek Hatchery isolated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which would be rated as moderate under Alternative 2 and Alternative 4. These measures would not apply to Alternative 3 because risks are low due to decreased production levels.

Table H-70. Potential mitigation measures for the Voights Creek Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C2, C3, C4, and C9.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H4, H5, and H6.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.7.2.4.2 White River Winter Steelhead Supplementation (Diru Creek Hatchery and White River Hatchery Integrated Conservation Winter-run Steelhead) Program

Key risk mitigation measures for the White River supplementation (Diru Creek Hatchery and White River Hatchery) integrated winter-run steelhead yearling program that may be applied under the alternatives to reduce competition impacts include reducing the number of fish released, delaying release of the winter-run steelhead from White River Hatchery until after the majority of natural-origin steelhead smolts have out-migrated downstream (which would alter the release strategy), or terminating the program.

Table H-71 provides potential mitigation measures for the White River supplementation (Diru Creek Hatchery and White River Hatchery) integrated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition and hatchery facilities and operation risks, which would be rated as moderate under all action alternatives. These mitigation measures would apply to all action alternatives.

Table H-71. Potential mitigation measures for the White River supplementation (Diru Creek Hatchery and White River Hatchery) integrated winter-run steelhead yearling program.

Risk Category	Mitigation Measures
Competition	Apply Mitigation Measures C3 and C4.
Hatchery Facilities and Operation	Apply Mitigation Measure H5.

3.7.2.4.3 Chinook Salmon Hatchery Program

One hatchery yearling program (White River Hatchery integrated spring-run Chinook salmon yearling program) would release Chinook salmon into White River, and the competition risk level would be high under all alternatives (Table H-66).

A key competition mitigation measure is to monitor post-release out-migration behavior and diet composition of White River Hatchery Chinook salmon yearlings. This monitoring would obtain the location and duration of their risk to natural-origin steelhead parr/smolt survival and productivity in the watershed through food resource competition. Based on monitoring results, a consideration would be to convert yearling production to subyearling production. In addition, moving the hatchery-origin fish location to an alternative location that is substantially downstream from the current release site would help to reduce the duration of interaction between natural-origin steelhead smolts and Chinook salmon hatchery-origin fish.

Table H-72 identifies the mitigation measures that would address competition risks. These measures would apply to all action alternatives.

Table H-72. Potential mitigation measures for the White River Hatchery integrated spring-run Chinook salmon yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.7.2.4.4 Coho Salmon Hatchery Programs

Two hatchery yearling programs (Voights Creek Hatchery integrated coho salmon yearling and Voights Creek Hatchery and acclimation pond integrated coho salmon yearling programs) release coho salmon into the Carbon and Mowich Rivers. The competition risk level would be moderate for all alternatives for the Voights Creek Hatchery program and high for all alternatives for the Voights Creek Hatchery and acclimation pond hatchery program (Table H-66).

Table H-73 identifies potential mitigation measures for the coho salmon hatchery programs. These measures would apply to all action alternatives; however, mitigation measures that reduce the size of the program would not apply to the Voights Creek Hatchery integrated coho salmon yearling program (without the acclimation pond) under Alternative 3 because this alternative already includes decreases in hatchery production for this program.

Table H-73. Potential mitigation measures for the coho salmon yearling hatchery programs in the Puyallup River basin.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C6, C7, and C8.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.8 South Sound

3.8.1 Introduction

As shown in Table H-1, the South Sound basin includes the Nisqually River watershed and small streams entering south Puget Sound where five natural-origin winter-run steelhead stocks occur, represented in three populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the South Sound basin and support hatchery-origin fish that could affect natural-origin steelhead: Minter Creek, Chambers Creek, Percival Creek, and the Nisqually River, including Kalama Creek and Clear Creek.

Three Chinook salmon hatchery programs, and three coho salmon hatchery programs from six hatchery facilities (Hupp Springs Hatchery, Chambers Creek Hatchery, Tumwater Falls Hatchery, Clear Creek Hatchery, Kalama Creek Hatchery, and Minter Creek Hatchery) have the potential to impact South Sound basin steelhead (Table H-74 and Table H-75), and are reviewed in this subsection. There are no hatchery programs releasing steelhead in the South Sound basin. Thus, there are no benefits in the basin from steelhead hatchery production.

Table H-74. Hatchery programs and categories of effects evaluated for South Sound basin steelhead.

Species	Hatchery and Program	Risk - Competition
Chinook Salmon	White River spring-run Chinook (Minter Creek Hatchery and Hupp Springs Hatchery) isolated spring-run Chinook salmon yearling	√
	Chambers Creek Hatchery isolated fall-run Chinook salmon yearling	√
	Tumwater Falls Hatchery isolated fall-run Chinook salmon yearling	√
Coho Salmon	Clear Creek Hatchery isolated coho salmon yearling	√
	Kalama Creek Hatchery isolated fall-run coho salmon yearling	√
	Minter Creek Hatchery isolated coho salmon yearling	√

Table H-75. Hatchery salmon and steelhead production in the South Sound basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	Percent Decrease from Alternative 1 and 2	Release Number	Percent Increase from Alternative 1 and 2
Chinook Salmon	White River spring-run Chinook (Minter Creek Hatchery and Hupp Springs Hatchery) isolated spring-run Chinook salmon yearling	85,000	85,000	0	85,000	0
	Chambers Creek Hatchery isolated fall-run Chinook salmon yearling	200,000	200,000	0	2,820,000	1310
	Tumwater Falls Hatchery isolated fall-run Chinook salmon yearling	200,000	200,000	0	200,000	0
	TOTAL	**400,000**	**400,000**	**0**	**3,105,000**	**676**
Coho Salmon	Clear Creek Hatchery isolated fall-run coho salmon yearling	630,000	315,000	50	630,000	0
	Kalama Creek Hatchery isolated fall-run coho salmon yearling	350,000	175,000	50	350,000	0
	Minter Creek Hatchery isolated coho salmon yearling	1,044,000	1,044,000	0	1,044,000	0
	TOTAL	**2,024,000**	**1,534,000**	**24**	**2,024,000**	**0**
All	**TOTAL**	**2,424,000**	**1,934,000**	**20**	**5,129,000**	**112**

3.8.2 Results

Results for the South Sound basin are summarized in Table H-76. The action alternatives would include use of an adaptive management approach, but the results in Table H-76 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-76 is explained in the subsequent subsections for this basin.

Table H-76. Summary of risks and benefits assigned for South Sound basin steelhead by alternative.

Risk	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Chinook salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Coho salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1

3.8.2.1 Risks

3.8.2.1.1 Chinook Salmon Hatchery Programs

White River Spring-run Chinook (Minter Creek Hatchery and Hupp Springs Hatchery) Isolated Spring-Run Chinook Salmon Program. Spring-run Chinook salmon yearlings are produced each year at the Hupp Springs Hatchery and are released in April. A total of 85,000 yearlings (Table H-75) would be released under all alternatives. As described in the HGMP for this program, the hatchery-origin Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with the similarly sized natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The Chinook salmon yearlings are released from the Hupp Springs Hatchery on Minter Creek at RM 3, which is a tributary of Carr Inlet in south Puget Sound. The release is part of a conservation effort for White River spring-run Chinook salmon. The natural-origin steelhead population in Minter Creek is believed to be extirpated (Myers et al. 2014). The number and location of yearlings released would result in a low risk to natural-origin steelhead for all alternatives.

Chambers Creek Hatchery Isolated Fall-Run Chinook Salmon Program. Fall-run Chinook salmon yearlings are produced each year at the Chambers Creek Hatchery and are released in April and May. The natural-origin steelhead population in Chambers Creek is presumed to be extirpated (Myers et al. 2014). Under Alternative 1 and Alternative 2, a total of 200,000 yearlings (Table H-75) would be released in Chambers Creek at RM 0.5, which is a small stream flowing directly into south Puget Sound. Production would not change under Alternative 3 but would increase to 2,820,000 yearlings under Alternative 4 (Table H-75). The number of yearlings released and the release location would result in a low risk to natural-origin steelhead for all alternatives. Although production would increase to 2,820,000 yearlings under Alternative 4, the impact on natural-origin steelhead would remain low because of the release location at RM 0.5 near Puget Sound marine waters.

Tumwater Falls Hatchery Isolated Fall-Run Chinook Salmon Program. Fall-run Chinook salmon yearlings are produced at the Tumwater Falls Hatchery and are released in April. A total of 200,000 yearlings (Table H-75) would be released in Percival Cove, which is at the mouth of Percival Creek (a tributary of Capitol Lake) in the lower Deschutes River, which drains into Bull Inlet in south Puget Sound. Production would not vary among the alternatives (Table H-75). The location of release would result in a low risk to natural-origin steelhead for all alternatives.

Summary for Chinook Salmon Hatchery Programs. Three hatchery yearling programs (White River spring-run Chinook [Minter Creek Hatchery and Hupp Springs Hatchery] isolated spring-run Chinook salmon yearling, Chambers Creek Hatchery isolated fall-run Chinook salmon yearling, Tumwater Falls Hatchery isolated fall-run Chinook Salmon yearling) would release Chinook salmon into the South Sound basin, and the competition risk level would be low for all alternatives (Table H-76), due to release locations.

3.8.2.1.2 Coho Salmon Hatchery Programs

Clear Creek Hatchery Isolated Fall-Run Coho Salmon Program. Fall-run coho salmon yearlings are produced each year at the Clear Creek Hatchery and are released in April. A total of 630,000 yearlings (Table H-75) would be released in Clear Creek, which is a tributary of the Nisqually River at RM 6.3. The coho salmon yearlings are an average size of 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). These hatchery-origin coho salmon yearlings may compete with natural-origin steelhead smolts during and after the release period as the two species commingle in the lower Nisqually River and estuary. Production would not change among Alternative 1, Alternative 2, and Alternative 4 (would be 630,000 fish), but would decrease by 50 percent to 315,000 fish under Alternative 3 (Table H-75). The location of release would result in a low risk to natural-origin steelhead for all alternatives (Table H-76).

Kalama Creek Hatchery Isolated Fall-Run Coho Salmon Program. Fall-run coho salmon yearlings are produced each year at the Kalama Creek Hatchery and are released in April. A total of 350,000 yearlings (Table H-75) would be released in Kalama Creek, which is a tributary of the Nisqually River at RM 9.2. The hatchery-origin coho salmon yearlings are released at an average size of 5.5 inches fork length (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead).

These hatchery-origin coho salmon yearlings may compete with natural-origin steelhead smolts during and after the release period as the two species commingle in the lower Nisqually River and estuary. Production would decrease by 50 percent to 175,000 fish under Alternative 3 but would be the same as Alternative 1 and Alternative 2 under Alternative 4 (Table H-75). The location of release would result in a low risk to natural-origin steelhead for all alternatives.

Minter Creek Hatchery Isolated Fall-run Coho Salmon Program. Fall-run coho salmon yearlings are produced each year at the Minter Creek Hatchery and are released in May to July. A total of 1,044,000 yearlings (Table H-75) would be released in Minter Creek, which is a tributary of northern Carr Inlet in south Puget Sound. The coho salmon are released at RM 0.5 in May through July each year. The coho salmon yearlings are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Production would not change under any of the alternatives (Table H-75). The location of release would result in a low risk to natural-origin steelhead for all alternatives.

Summary for Coho Salmon Hatchery Programs. Three hatchery yearling programs (Clear Creek Hatchery isolated fall-run coho salmon yearling, Kalama Creek Hatchery isolated fall-run coho salmon yearling, and Minter Creek Hatchery isolated fall-run coho salmon yearling) release coho salmon into the South Sound basin, and the competition risk level would be low for all alternatives (Table H-76) due to release locations.

3.8.2.2 Summary – South Sound Basin

Table H-76 summarizes the risks and benefits for all alternatives pertinent to South Sound basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. The action alternatives would include use of an adaptive management approach, but the results in Table H-76 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-76 is explained in the subsequent subsections for this basin.

From the six hatchery programs evaluated in the South Sound basin, overall competition risks to natural-origin steelhead from Chinook salmon and coho salmon hatcheries under all alternatives would be low. This is because the fish would be released low in the watershed. Overall, changes in production under

Alternative 3 and Alternative 4 for Chinook salmon and coho salmon hatcheries would not affect the competition risk levels for natural-origin steelhead.

3.8.2.3 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category. However, for the South Sound basin, there would be no moderate or high risks under any of the alternatives (Table H-76); thus, no mitigation measures are identified.

3.9 Hood Canal

3.9.1 Introduction

As shown in Table H-1, the Hood Canal basin includes the Skokomish River, Duckabush River, Big Quilcene River, and Dewatto River watersheds where six natural-origin winter-run steelhead stocks and two summer-run steelhead stocks occur, represented in four winter-run (includes summer-run) populations. All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Hood Canal basin and support hatchery-origin fish that could affect natural-origin steelhead: Skokomish River including the South Fork of the Skokomish River (Purdy Creek and Rick's Pond are tributaries of the Skokomish River), Duckabush River, Big Quilcene River, Dewatto River, and Finch Creek.

One steelhead hatchery program, two Chinook salmon hatchery programs, and two coho salmon hatchery programs from five hatchery facilities (McKernan Hatchery, Lilliwaup Hatchery, George Adams Hatchery, Hoodsport Hatchery, and Quilcene National Fish Hatchery) have the potential to impact Hood Canal basin steelhead (Table H-77 and Table H-78), and are reviewed in this subsection. For the purposes of the EIS, the two components of the Hood Canal steelhead supplementation program (McKernan Hatchery and Lilliwaup Hatchery) are evaluated separately. In addition, total return benefits were not evaluated due to insufficient information on adult return rates.

Table H-77. Hatchery programs and categories of effects evaluated for Hood Canal basin steelhead.

Species	Hatchery and Program	Risk			Benefit
		Competition	**Genetics**	**Hatchery Facilities and Operation**	**Viability**
Steelhead	McKernan Hatchery integrated winter-run steelhead yearling (part of Hood Canal steelhead supplementation project)	√	√	√	√
	Lilliwaup Hatchery integrated winter-run steelhead yearling (part of Hood Canal steelhead supplementation project)	√	√	√	√
Chinook Salmon	Rick's Pond (George Adams Hatchery) isolated fall-run Chinook salmon yearling	√			
	Hoodsport Hatchery isolated fall-run Chinook salmon yearling	√			
Coho Salmon	George Adams Hatchery isolated coho salmon yearling	√			
	Quilcene National Fish Hatchery integrated coho salmon yearling	√			

Table H-78. Hatchery salmon and steelhead production in the Hood Canal Basin by program and alternative.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Steelhead	McKernan Hatchery integrated winter-run steelhead yearling (part of Hood Canal steelhead supplementation project)	34,900	34,900	0	34,900	0
	Lilliwaup Hatchery integrated winter-run steelhead yearling (part of Hood Canal steelhead supplementation project)	14,550	14,550	0	14,550	0
	TOTAL	**49,450**	**49,450**	**0**	**49,450**	**0**

Table H-78. Hatchery salmon and steelhead production in the Hood Canal Basin by program and alternative, continued.

Species	Hatchery and Program	Release Number for Alternative 1 and 2	Alternative 3		Alternative 4	
			Release Number	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Chinook Salmon	Rick's Pond (George Adams Hatchery) isolated fall-run Chinook salmon yearling	120,000	60,000	50	120,000	0
	Hoodsport Hatchery isolated fall-run Chinook salmon yearling	120,000	120,000	0	120,000	0
	TOTAL	**240,000**	**180,000**	**25**	**240,000**	**0**
Coho Salmon	George Adams Hatchery isolated coho salmon yearling	300,000	150,000	0	300,000	0
	Quilcene National Fish Hatchery isolated early coho salmon yearling	400,000	400,000	0	400,000	0
	TOTAL	**700,000**	**550,000**	**21**	**700,000**	**0**
All	**TOTAL**	**989,450**	**779,450**	**21**	**989,450**	**0**

3.9.2 Results

Results for Hood Canal basin steelhead are summarized in Table H-79. The action alternatives would include use of an adaptive management approach, but the results in Table H-79 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-79 is explained in the subsequent subsections for this basin.

Table H-79. Summary of risks and benefits assigned for Hood Canal basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead hatcheries	Moderate	Same as Alternative 1	Same as Alternative 1
Chinook salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Coho salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Genetics	Negligible	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

3.9.2.1 Risks

3.9.2.1.1 Steelhead Hatchery Programs

Hood Canal (McKernan Hatchery) Integrated Winter-Run Steelhead Supplementation Program. Under Alternative 1 and Alternative 2, the component of the Hood Canal integrated winter-run steelhead hatchery yearling supplementation program at the McKernan Hatchery would produce 34,900 fish (Table H-78) for release into the South Fork of the Skokomish River, and would result in competition impacts. These impacts are considered a moderate risk because at least one BMP for competition is not met (Table H-80). The hatchery production level would be the same under Alternative 3 and Alternative 4 as under Alternative 1 and Alternative 2 (Table H-78); thus, all alternatives would have the same risk levels.

Table H-80. Impacts to natural-origin steelhead associated with the Hood Canal (McKernan Hatchery) integrated winter-run steelhead supplementation yearling program by risk category.

Risk Category	Impact
Competition	Smolt releases may interact with natural-origin population.

Hood Canal (Lilliwaup Hatchery) Integrated Winter-Run Steelhead Supplementation Program. Under Alternative 1 and Alternative 2, the component of the Hood Canal integrated winter-run steelhead hatchery yearling supplementation program at the Lilliwaup Hatchery would produce 14,500 fish (Table H-78) for release into the Dewatto and Duckabush Rivers and result in competition impacts. These impacts would be considered a moderate risk because at least one BMP for competition is not met

(Table H-81). The hatchery production level would be the same under Alternative 3 and Alternative 4 as under Alternative 1 and Alternative 2 (Table H-78); thus, all alternatives would have the same risk levels.

Table H-81. Impacts to natural-origin steelhead associated with the Hood Canal (Lilliwaup Hatchery) integrated winter-run steelhead supplementation yearling program by risk category.

Risk Category	Impact
Competition	Smolt releases may interact with natural-origin population.

Summary for Steelhead Hatchery Programs. One hatchery yearling program (evaluated separately for the McKernan Hatchery and Lilliwaup Hatchery) would release steelhead into the South Sound basin, and the competition risk level would be moderate for all alternatives (Table H-76).

3.9.2.1.2 Chinook Salmon Hatchery Programs

Rick's Pond (George Adams Hatchery) Isolated Fall-run Program. Under Alternative 1 and Alternative 2, the Rick's Pond isolated fall-run Chinook salmon yearlings at the George Adams Hatchery would be released in April and May. A total of 120,000 yearlings (Table H-78) would be released from Rick's Pond, on a tributary of the Skokomish River at RM 2.9. Production would decrease by 50 percent under Alternative 3 (60,000 yearlings, Table H-78) but would be the same as Alternative 1 and Alternative 2 under Alternative 4 (Table H-78). The release location would result in a low risk to natural-origin steelhead for all alternatives.

Hoodsport Hatchery Isolated Fall-run Program. Under Alternative 1 and Alternative 2, fall-run Chinook salmon yearlings would be produced at the Hoodsport Hatchery and released in May. A total of 120,000 yearlings (Table H-78) would be released under all alternatives in Finch Creek (RM 0), a tributary of Hood Canal. Under all alternatives, the release location would result in a low risk to natural-origin steelhead.

Summary for Chinook Salmon Hatchery Programs. Two hatchery programs (Rick's Pond [George Adams Hatchery] isolated fall-run Chinook salmon yearling, and Hoodsport Hatchery isolated fall-run Chinook yearling) would release Chinook salmon into the Hood Canal basin, and the competition risk level would be low for both hatcheries under all alternatives resulting in an overall low risk (Table H-79).

3.9.2.1.3 Coho Salmon Hatchery Programs

George Adams Hatchery Isolated Coho Salmon Program. Fall-run coho salmon yearlings are produced each year at the George Adams Hatchery and are released in April. A total of 300,000 yearlings (Table H-78) are released in Purdy Creek (RM 1.8), which is a tributary of the Skokomish River at RM 4.0. After their release from the hatchery, these hatchery-origin coho salmon may interact with rearing and out-migrating natural-origin Skokomish winter-run steelhead in the Skokomish River and in the river estuary. The hatchery-origin coho salmon are released low in the watershed after April 15. The hatchery-origin coho salmon yearlings are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Production would decrease by 50 percent under Alternative 3 (150,000 yearlings, Table H-78) but would not change compared to Alternative 1, Alternative 2, and Alternative 4 (Table H-78). The release location would result in a low risk to natural-origin steelhead for all alternatives.

Quilcene National Fish Hatchery Isolated Early Coho Salmon Program. Fall-run coho salmon yearlings are produced each year at the Quilcene National Fish Hatchery and are released in April to May each year. The coho salmon yearlings are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1 Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead) where the coho salmon may interact with Quilcene Bay/Dabob Bay stock winter-run steelhead. A total of 400,000 yearlings (Table H-78) are released in Big Quilcene River (RM 2.8). Production would be the same for all alternatives (Table H-78). The release location would result in a low risk to natural-origin steelhead for all alternatives.

Summary for Coho Salmon Hatchery Programs. Two hatchery programs (George Adams Hatchery isolated coho salmon yearling, and Quilcene National Fish Hatchery isolated coho salmon yearling) release coho salmon into the Hood Canal basin, and the competition risk level would be low for both hatcheries under all alternatives resulting in an overall low risk (Table H-79).

3.9.2.2 Benefits

3.9.2.2.1 Viability

Under Alternative 1 and Alternative 2, the Hood Canal steelhead supplementation program (McKernan Hatchery and Lilliwaup Creek Hatchery) would continue to operate as an integrated conservation program. Fish produced by the hatchery program are part of the DPS that is listed under the ESA. Under all alternatives, hatchery production would be 49,450 fish (Table H-78).

Under all alternatives, the hatchery-origin winter-run steelhead produced by the Hood Canal supplementation integrated conservation program may have a beneficial effect on population viability parameters (abundance, diversity, spatial structure, and productivity) for Hood Canal basin natural-origin winter-run steelhead. The program may increase the total abundance of adults and natural-origin progeny, and serve as a genetic reserve, assuming appropriate hatchery practices would be applied that minimize divergence between hatchery-origin and natural-origin fish.

The program would collect broodstock from individual redds created during the natural-origin steelhead return period, maintain separate families of appropriate effective breeding population sizes, incorporate natural-origin fish at a high proportion, and apply a factorial mating scheme during spawning. The program would release fish into different parts of the Hood Canal basin (Skokomish River, Dewatto River, and Duckabush River), thus enhancing spatial structure of steelhead within the basin. The effects of the program on productivity are unknown, but any effects are unlikely to substantially benefit the natural-origin winter-run steelhead population. This is because the primary factors affecting productivity are likely to be habitat-related (Hard et al 2014). For these reasons, the assigned effect of the steelhead program on natural-origin winter-run steelhead viability would be a moderate benefit under all alternatives (Table H-79).

3.9.2.3 Summary – Hood Canal Basin

Table H-79 summarizes the risks and benefits for all alternatives pertinent to Hood Canal basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the five hatchery programs evaluated in the Hood Canal basin, overall risks to natural-origin steelhead would range from negligible to moderate with competition from steelhead hatcheries as a moderate risk under all alternatives. This is because the fish would be released low in the watershed. Overall, changes in production under Alternative 3 and Alternative 4 for Chinook salmon and coho salmon hatcheries would not affect the low competition risk levels for natural-origin steelhead. Viability benefits from the integrated conservation hatchery programs would be moderate under all alternatives because the production levels would be unchanged.

3.9.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

3.9.2.4.1 Hood Canal (McKernan Hatchery) Integrated Winter-run Steelhead Supplementation Program

Key risk mitigation measures for the McKernan Hatchery component of the Hood Canal winter-run steelhead supplementation program may be applied under the alternatives to reduce competition impacts. These measures include reducing the number of fish released, delaying release of 2-year-old winter-run steelhead smolts into the South Fork of the Skokomish River until after the majority of natural-origin steelhead smolts have emigrated downstream (which would alter the release strategy), or terminating the program.

Table H-82 identifies potential mitigation measures for the McKernan Hatchery integrated winter-run steelhead program for the action alternatives. These mitigation measures would help reduce competition risks, which are rated as moderate under all alternatives. These measures would apply to all action alternatives.

Table H-82. Potential mitigation measures for the Hood Canal (McKernan Hatchery) integrated winter-run steelhead supplementation yearling program.

Risk Category	Mitigation Measures
Competition	Apply Mitigation Measures C3 and C4.

3.9.2.4.2 Hood Canal (Lilliwaup Hatchery) Integrated Winter-run Steelhead Supplementation Program

Key risk mitigation measures for the Lilliwaup Hatchery component of the Hood Canal winter-run steelhead supplementation program may be applied under the alternatives to reduce competition impacts. These measures include reducing the number of fish released, delaying release of 2-year-old winter-run steelhead smolts into the South Fork of the Skokomish River until after the majority of natural-origin steelhead smolts have emigrated downstream (which would alter the release strategy), or terminating the program.

Table H-83 identifies potential mitigation measures for the Lilliwaup Hatchery integrated winter-run steelhead supplementation yearly program for the action alternatives. These mitigation measures would help reduce competition risks, which are rated as moderate under all alternatives. These measures would apply to all action alternatives.

Table H-83. Potential mitigation measures for the Hood Canal (Lilliwaup Hatchery) integrated winter-run steelhead supplementation program.

Risk Category	Mitigation Measures
Competition	Apply Mitigation Measures C3 and C4.

3.10 Strait of Juan de Fuca

3.10.1 Introduction

As shown in Table H-1, the Strait of Juan de Fuca basin includes the Elwha River, Dungeness River, and Snow Creek watersheds where five natural-origin winter-run steelhead stocks and two summer-run steelhead stocks occur, represented in four winter-run populations (including summer-run). All are included in the steelhead DPS that is listed as threatened (EIS Subsection 3.2.7, Puget Sound Steelhead DPS).

The following rivers and streams are found within the Strait of Juan de Fuca basin and support hatchery-origin fish that could affect natural-origin steelhead: Elwha River, Dungeness River (includes Gray Wolf Acclimation Pond as a tributary of the river), Morse Creek (tributary of the eastern Strait of Juan de Fuca), and Snow Creek.

Two steelhead hatchery programs, two Chinook salmon hatchery programs, and three coho salmon hatchery programs from five hatchery facilities (Elwha Channel Hatchery, Dungeness Hatchery, Lower Elwha Hatchery, Hurd Creek Hatchery, and Morse Creek Hatchery) have the potential to impact Strait of Juan de Fuca basin steelhead (Table H-84 and Table H-85), and are reviewed in this subsection. For the purposes of this EIS, the two components of the Elwha River summer/fall Chinook salmon hatchery program (Dungeness Hatchery and Hurd Creek Hatchery, and Morse Creek Hatchery) are evaluated separately. Total return benefits are not evaluated, because there is insufficient information on adult return rates, especially for the integrated winter-run steelhead conservation program (Lower Elwha Hatchery).

This analysis is consistent with the recent environmental analysis of effects from Elwha hatchery programs (NMFS 2012a).

Table H-84. Hatchery programs and categories of effects evaluated for Strait of Juan de Fuca basin steelhead.

		Risk			Benefit
Species	**Hatchery and Program**	**Competition**	**Genetics**	**Hatchery Facilities and Operation**	**Viability**
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling	√	√	√	
	Lower Elwha Hatchery integrated winter-run steelhead yearling	√	√	√	√
Chinook Salmon	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	√			
	Elwha Channel/Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling (part of Elwha River summer/fall-run Chinook program)	√			
Coho Salmon	Hurd Creek Hatchery integrated coho salmon yearling (part of Snow Creek coho salmon supplementation program)	√			
	Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	√			
	Lower Elwha Hatchery integrated coho salmon yearling	√			

Table H-85. Hatchery salmon and steelhead production in the Strait of Juan de Fuca basin by program and alternative.

			Alternative 3		Alternative 4	
Species	**Hatchery and Program**	**Release Number for Alternative 1 and 2**	**Release Number**	**Percent Decrease from Alternative 1 and 2**	**Release Number**	**Percent Increase from Alternative 1 and 2**
Steelhead	Dungeness Hatchery isolated winter-run steelhead yearling	10,000	5,000	50	10,000	0
	Lower Elwha Hatchery integrated winter-run steelhead yearling	175,000	175,000	0	175,000	0
	TOTAL	**185,000**	**180,000**	**3**	**185,000**	**0**
Chinook Salmon	Dungeness Hatchery and Hurd Creek Hatchery integrated spring-run Chinook salmon yearling	100,000	100,000	0	100,000	0
	Elwha Channel/Morse Creek Hatchery integrated summer/fall-run Chinook salmon yearling (part of Elwha River summer/fall-run Chinook program)	400,000	400,000	0	400,000	0
	TOTAL	**500,000**	**500,000**	**0**	**500,000**	**0**
Coho Salmon	Hurd Creek Hatchery integrated coho salmon yearling (part of Snow Creek coho salmon supplementation program)	9,000	9,000	0	9,000	0
	Dungeness Hatchery and Hurd Creek Hatchery isolated coho salmon yearling	500,000	250,000	50	500,000	0
	Lower Elwha Hatchery integrated coho salmon yearling	425,000	425,000	0	425,000	0
	TOTAL	**934,000**	**684,000**	**27**	**934,000**	**0**
All	**TOTAL**	**1,619,000**	**1,364,000**	**16**	**1,619,000**	**0**

3.10.2 Results

Results for the Strait of Juan de Fuca basin are summarized in Table H-86. The action alternatives would include use of an adaptive management approach, but the results in Table H-86 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for this basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-86 is explained in the subsequent subsections for this basin.

Table H-86. Summary of risks and benefits for Strait of Juan de Fuca basin steelhead by alternative.

Risk or Benefit	Alternative 1 and 2	Alternative 3	Alternative 4
Risks			
Competition			
Steelhead hatcheries	Moderate	Same as Alternative 1	Same as Alternative 1
Chinook salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Coho salmon hatcheries	Low	Same as Alternative 1	Same as Alternative 1
Genetics	Negligible	Same as Alternative 1	Same as Alternative 1
Hatchery Facilities and Operation	Negligible	Same as Alternative 1	Same as Alternative 1
Benefits			
Viability	Moderate	Same as Alternative 1	Same as Alternative 1

3.10.2.1 Risks

3.10.2.1.1 Steelhead Hatchery Programs

The one isolated program and one integrated conservation steelhead hatchery program result in competition, genetic, and hatchery facilities and operation risks. Results for steelhead programs are summarized in Table H-87. The action alternatives would include use of an adaptive management approach, but the results in Table H-87 do not assume any particular application of adaptive management measures. Instead, potential adaptive management measures for the basin are identified in later subsections. The basis for the differences in hatchery production under the alternatives is described in EIS Subsection 2.4, Alternatives Analyzed in Detail. The reasoning for risks and benefits in Table H-87 is explained in the subsequent subsections for this basin.

Table H-87. Summary of competition, genetic, and hatchery facilities and operation effects for steelhead programs in the Strait of Juan de Fuca basin.

	Alternative 1 and 2	Alternative 3	Alternative 4
Risks (Competition, Genetics, Hatchery Facilities and Operation)			
Dungeness Hatchery isolated winter-run steelhead yearling	Moderate	Low	Same as Alternative 1
Lower Elwha Hatchery integrated conservation winter-run steelhead yearling	Moderate[1]	Same as Alternative 1	Same as Alternative 1

[1] Results from analysis at the 150,000 production level are applied here, only competition risk is moderate; genetics and hatchery facilities and operation risks are negligible.

Dungeness Hatchery Isolated Winter-run Program. Under Alternative 1 and Alternative 2, the isolated steelhead hatchery yearling program at the Dungeness Hatchery would produce 10,000 yearlings (Table H-85) and result in competition, genetics, and hatchery facilities and operation types of impacts (Table H-88). These impacts are a moderate risk because at least one BMP for competition, genetics, and hatchery facilities and operation would not be met (Table H-88). Production would decrease by 50 percent under Alternative 3 (to 5,000 yearlings, Table H-85), which would reduce the risk to low (Table H-87). Under Alternative 4, the hatchery production level would be the same as under Alternative 1 and Alternative 2 (Table H-85); thus, all three alternatives would have the same risk levels (Table H-87).

Table H-88. Impacts to natural-origin steelhead associated with the Dungeness Hatchery isolated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Program does not avoid transfers into the basin. No adequate adult trapping facilities. Smolt releases may interact with natural population. pHOS is not estimated.
Genetics	Local genetically appropriate broodstock is not used and has been in culture more than three generations. Program does not avoid transfers into the basin. All adult returns are not removed from the watershed. No adequate adult trapping facilities. pHOS is not estimated.
Hatchery Facilities and Operation	No performance measures or monitoring plan developed. Program not based on adaptive management plan. Program does not avoid transfers into the basin. Facility intake does not meet current standards.

Lower Elwha Hatchery Integrated Winter-run Program. Under all alternatives, the integrated conservation steelhead hatchery yearling program at the Lower Elwha Hatchery would produce 175,000 yearlings (Table H-85) and result in moderate competition impacts (Table H-87). These impacts would be a moderate risk because at least one BMP would not be met (Table H-102). The hatchery production level would be the same under all alternatives (Table H-86); thus, all three action alternatives would have the same risk levels (Table H-87).

Table H-89. Impacts to natural-origin steelhead associated with the Lower Elwha Hatchery integrated winter-run steelhead yearling program by risk category.

Risk Category	Impact
Competition	Smolt releases may interact with natural-origin population.

Summary for Steelhead Hatchery Programs. Under Alternative 1 and Alternative 2, competition risks to natural-origin steelhead from the steelhead yearling hatchery programs in the Strait of Juan de Fuca basin would be moderate for all alternatives (Table H-87). This is because all of the steelhead hatchery yearling programs in this basin have at least one BMP that would not be met. Similarly, under Alternative 1 and Alternative 2, genetics and hatchery facilities and operation risks would be moderate for the isolated program (Dungeness Hatchery isolated winter-run steelhead program), but negligible for the integrated program (Lower Elwha Hatchery integrated conservation winter-run steelhead program). Because of production decreases under Alternative 3 for the isolated winter-run steelhead yearling program, the competition, genetics, and hatchery facilities and operation risk levels for the program would decrease to low. The risk level would not decrease under Alternative 3 for the integrated conservation program (Lower Elwha Hatchery) because production would not decrease; thus, the risk from that program would remain moderate. Under Alternative 4, production would be the same as under Alternative 1 and Alternative 2; thus, the risk levels would remain the same. In summary, the overall competition risk level would be moderate under all alternatives (Table H-87).

3.10.2.1.2 Chinook Salmon Hatchery Programs

Dungeness Hatchery and Hurd Creek Hatchery Integrated Spring-run Chinook Salmon Program. Under Alternative 1 and Alternative 2, 100,000 hatchery-origin Chinook salmon yearlings would be released from the Dungeness Hatchery and Hurd Creek Hatchery into the Dungeness River (RM 10.5) (Table H-85). Chinook salmon yearlings are released primarily in April. The Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with the similarly sized natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). The Chinook salmon yearlings are released low in the watershed (RM 10.5). The large individual size of the fish is a risk factor regarding competition with similarly sized natural-origin steelhead smolts emigrating downstream of the hatchery release sites. Considering these factors, particularly the lower river hatchery-origin fish release location, the competition risk from the program under Alternative 1 and Alternative 2 would be low. Hatchery-origin Chinook salmon yearling releases from the Dungeness Hatchery and Hurd Creek Hatchery on natural-origin steelhead would have the same competition effects across all alternatives, because the release numbers (100,000 fish, Table H-85) would remain unchanged under the alternatives.

Elwha (Elwha Channel Hatchery/Morse Creek Hatchery) Integrated Summer/Fall-run Chinook Salmon Program. Under Alternative 1 and Alternative 2, 200,000 Chinook salmon yearlings would be released each year during April into the lower Elwha River (RM 3.5) as part of an integrated conservation program for the natural-origin Chinook salmon population. An additional 200,000 Elwha Chinook salmon yearlings would also be released into Morse Creek (RM 1.0), which is a tributary of the eastern Strait of Juan de Fuca, to create a genetic reserve for the Elwha Chinook salmon population during the Elwha and Glines Canyon dam removal period. The Chinook salmon yearlings are approximately 6.1 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1 Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with similarly sized natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). However, the Chinook salmon yearlings would be released low in the Elwha River (RM 3.5) and Morse Creek (RM 1.0) watersheds in March.

The large size of the fish at the time of release, and the limited extent of production area currently available for natural-origin steelhead in the Elwha River are risk factors regarding competition with similarly sized natural-origin steelhead smolts out-migrating in the vicinity of the release sites. Considering these factors, the competition risk to natural-origin Elwha steelhead from the Elwha River portion of the Chinook salmon program under Alternative 1 and Alternative 2 would be low. Competition risks from hatchery-origin Chinook salmon yearling to natural-origin winter-run steelhead from the Morse Creek portion of the Chinook salmon program would also be low for the same reasons. The overall competition effects of Elwha Hatchery Chinook salmon yearling program releases on natural-origin steelhead would be the same (low) across all alternatives, because the release numbers would be the same (Table H-85).

Summary for Chinook Salmon Hatchery Programs. In summary, competition risks to natural-origin steelhead from Chinook salmon hatchery yearling programs in the Strait of Juan de Fuca basin would be low for all alternatives (Table H-86). This is primarily because all Chinook salmon hatchery yearling programs in this basin would release hatchery-origin coho salmon yearlings low in the watershed under all alternatives.

3.10.2.1.3 Coho Salmon Hatchery Programs

Snow Creek (Hurd Creek Hatchery) Integrated Coho Salmon Program. Under Alternative 1 and Alternative 2, 9,000 coho salmon yearlings (Table H-85) would be released during May of each year from the Hurd Creek Hatchery into Crocker Lake of the Snow Creek watershed (located at RM 4 upstream of Discovery Bay). After their release from the hatchery, these hatchery-origin coho salmon may interact with late out-migrating natural-origin Dungeness steelhead of similar size in the lower river and in the river estuary. Considering the lower river release site in the lake, the time of hatchery-origin fish release relative to the primary steelhead smolt out-migration period in Puget Sound (May), and that the coho salmon are released as yearling smolts that would tend to out-migrate seaward relatively rapidly, competition risks posed by the programs to Dungeness steelhead would be low. Hatchery production would not change among the alternatives (Table H-85) and the risk would remain low under all alternatives.

Dungeness Hatchery and Hurd Creek Hatchery Isolated Coho Salmon Program. Under Alternative 1 and Alternative 2, 500,000 coho salmon yearlings (Table H-85) would be released each year from Dungeness Hatchery and Hurd Creek Hatchery into the Dungeness River. The hatchery-origin coho salmon would be released relatively low in the watershed (RM 10.5) after June 1. The coho salmon yearlings are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource competition may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). After their release from the hatchery, these hatchery-origin coho salmon may interact with late out-migrating natural-origin Dungeness steelhead of similar size in the lower river and in the river estuary. Considering the lower river release site, competition risks posed by the programs to Dungeness steelhead would be low. Although the number of steelhead yearlings that would be released under Alternative 3 would be reduced by half compared to Alternative 1 and Alternative 2 (Table H-85), the risk rating would not change. Under Alternative 4, the number released would not change from that released under Alternative 1 and 2 (Table H-85); thus, the risk level also remains the same.

Lower Elwha Hatchery Integrated Coho Salmon Program. Under all alternatives, 500,000 coho salmon yearlings would be released each year from Lower Elwha Hatchery into the Elwha River. After their release from the hatchery, these hatchery-origin coho salmon may interact with late out-migrating natural-origin Elwha steelhead in the very lowest portion of the Elwha River, in estuarine beach lakes, and in the river estuary. The hatchery-origin coho salmon are released low in the watershed (tidal influenced area at RM 0.3) in May. The hatchery-origin coho salmon are approximately 5.5 inches fork length when released (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead), and resource completion may occur with natural-origin steelhead smolts (6.5 inches fork length) (Table 3.2-4 in EIS Subsection 3.2.4.1, Characteristics of Hatchery-origin Salmon and Steelhead). Considering the location of the hatchery-origin coho salmon release site in the lowest portion of the Elwha River, competition risks posed by the programs to Elwha steelhead would be low. Under all alternatives, the number released would not change and risk levels would remain the same (low).

Summary for Coho Salmon Hatchery Programs. In summary, overall competition risks to natural-origin steelhead from coho salmon hatchery yearling programs in the Strait of Juan de Fuca basin would be low under all alternatives (Table H-86). This is primarily because all coho salmon hatchery yearling programs in this basin would release hatchery-origin coho salmon yearlings low in the watershed under all alternatives.

3.10.2.2 Benefits

3.10.2.2.1 Viability

Under all alternatives, one of the two hatchery steelhead programs in the basin would continue to be operated as an isolated harvest program, releasing non-listed out-of-DPS winter-run steelhead to augment the fisheries harvest. There would be no benefits from this program to viability parameters for listed natural-origin winter-run steelhead in the Strait of Juan de Fuca basin under any of the alternatives.

Under all alternatives, the Lower Elwha Hatchery would continue to operate an integrated winter-run steelhead yearling program for conservation purposes. Fish produced by the hatchery program would be part of the steelhead DPS that is listed under the ESA. Under all alternatives, hatchery production would be 175,000 yearlings (Table H-86).

Although operated to eventually contribute surplus fish for harvest in fisheries, the program would propagate the natural-origin winter-run stock primarily for conservation purposes and may benefit population viability parameters (abundance, diversity, and spatial structure) for listed natural-origin Elwha winter-run steelhead. The program may benefit natural-origin steelhead population abundance by increasing the total number of Elwha River-origin fish returning to spawn naturally, thus increasing natural production. The program may also benefit population diversity because the hatchery program may serve as a genetic reserve for the population, assuming appropriate hatchery practices would be applied that minimize divergence between the hatchery-origin and natural-origin populations.

The program would collect adult broodstock randomly over the entire natural-origin steelhead return period, or by mining naturally produced steelhead redds, maintain an appropriately sized effective breeding population size in the hatchery program, incorporate natural-origin fish at a high proportion, and apply a factorial mating scheme during spawning. As dam removal proceeds and fish passage is provided, fish released through the program would likely return to spawning areas throughout the accessible portions of the Elwha River watershed. Elwha steelhead population spatial structure may, therefore, be enhanced by the program through preservation of adult fish that would escape to spawn in areas made accessible by removal of the dams. For these reasons, the effect of the program on natural-origin winter-run steelhead population viability would be a moderate benefit under all alternatives (Table H-87).

3.10.2.3 Summary – Strait of Juan de Fuca Basin

Table H-87 summarizes the risks and benefits for all alternatives pertinent to Strait of Juan de Fuca basin steelhead, absent any modifications to the action alternatives that may become necessary from the application of adaptive management over the long term. From the seven hatchery programs evaluated in the Strait of Juan de Fuca basin, overall risks to natural-origin steelhead under Alternative 1 and Alternative 2 range from negligible to moderate with the Chinook salmon and coho salmon hatcheries as a low competition risk and the steelhead hatcheries as a moderate competition risk. Reduced hatchery-origin steelhead production under Alternative 3 would decrease competition risks from the isolated winter-run steelhead hatchery yearling program (Dungeness Hatchery) to a low level. All risks under Alternative 4 would be the same as under Alternative 1 and Alternative 2. Under all alternatives, viability benefits from the integrated conservation hatchery program would be moderate because the production level would be unchanged from Alternative 1 and Alternative 2.

Overall, the decreased production for the isolated steelhead hatchery program under Alternative 3 (3 percent decrease, Table H-85) would help to decrease the risk levels for competition (Table H-86).

The analysis of risks and benefits for the steelhead DPS and component populations in this EIS applies different methods and terms than those used in the environmental analysis of Elwha hatchery programs (NMFS 2012a). The EIS uses consistent approaches across Puget Sound for each species reviewed, for consistency in compiling information across the project area.

3.10.2.4 Mitigation Measures and Adaptive Management

As described in Subsection 2.3, Mitigation Measures and Adaptive Management, all action alternatives include an adaptive management component, which is not applied under Alternative 1. Potential mitigation measures include existing BMPs that are not currently in use at all hatchery operations, and mitigation measures that would be applied over the long term under adaptive management (including updated and new BMPs). These mitigation measures are intended to reduce risks to natural-origin steelhead from hatchery programs; no measures are identified to increase benefits. However, measures to reduce risks may also affect benefits, particularly the opportunity to harvest hatchery-origin fish. Some mitigation measures in Table H-2 may be repeated if the measures would result in decreasing more than one risk category.

Because hatchery programs affecting Elwha River steelhead previously received authorization under the ESA (NMFS 2012b) and NEPA (NMFS 2012a), no specific mitigation measures are proposed for Elwha hatchery programs in this EIS. Potential general mitigation measures are included that could be applied over the long term under adaptive management (including updated and new BMPs), consistent with NMFS (2012b).

3.10.2.4.1 Dungeness Hatchery Isolated Winter-run Steelhead Program

Key risk mitigation measures for the Dungeness Hatchery isolated winter-run steelhead yearling program may be applied under the alternatives to reduce the risk of competition impacts to natural-origin steelhead. These measures include ceasing on-station releases and, instead, trucking some or all hatchery-origin steelhead smolts from the hatchery downstream for release near the mouth of the river; delaying release of the hatchery-origin winter-run steelhead until after the majority of natural-origin steelhead smolts have emigrated downstream; and reducing or terminating the program.

Under the alternatives, the Dungeness Hatchery winter-run steelhead hatchery program would continue to be managed with the intent of an isolated harvest. Key genetic risk mitigation measures could be applied to reduce the effects of the isolated harvest program on the natural-origin winter-run steelhead population. These mitigation measures include selecting through broodstock collection and mating practices an earlier return timing for adult hatchery-origin steelhead localized to the river basin; ceasing out-of-watershed transfers to sustain the hatchery program; maintaining the Dungeness Hatchery rack across the entire hatchery-origin steelhead return period; implementing increased harvest rates to remove and decrease straying of returning hatchery-origin adults; and reducing or terminating the program.

Although transition of the Dungeness Hatchery isolated winter-run steelhead yearling program to an integrated program may be considered as a genetic risk mitigation measure, it is uncertain whether an integrated hatchery program would exacerbate rather than mitigate genetic risks and be beneficial to the viability of natural-origin Strait of Juan de Fuca basin steelhead.

As part of the mitigation for hatchery facilities and operation risk, of particular concern is the standing of the permanent Dungeness Hatchery water intake on Canyon Creek as a barrier and negative factor for adult steelhead and salmon upstream migration. This risk factor to Dungeness steelhead could be mitigated by upgrading the water intake on Canyon Creek to meet current fish passage standards, providing for upstream passage of migrating adult steelhead under all flow and operational conditions.

Table H-90 summarizes the potential mitigation measures for the Dungeness Hatchery isolated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition, genetic, and hatchery facilities and operation risks, which are rated as moderate risks under Alternative 2 and Alternative 4 (Table H-86). These measures would not apply to Alternative 3 because risks are low.

Table H-90. Potential mitigation measures for the Dungeness Hatchery isolated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C1, C3, C4, and C9.
Genetics	Apply Mitigation Measures G1, G2, G3, G4, and G6.
Hatchery Facilities and Operation	Apply Mitigation Measures H1, H2, H4, and H5.

[1] Refer to Table H-2 for a description of each mitigation measure.

3.10.2.4.2 Lower Elwha Hatchery Integrated Winter-run Steelhead Program

Key general risk mitigation measures for the Lower Elwha Hatchery integrated winter-run steelhead conservation yearling program may be applied under the alternatives over time using adaptive management to reduce competition impacts. These measures include reducing the number of fish released, delaying releases until after the majority of natural-origin steelhead smolts have out-migrated downstream, or terminating the program.

Table H-91 identifies potential mitigation measures for the Lower Elwha Hatchery integrated winter-run steelhead yearling program for the action alternatives. These mitigation measures would help reduce competition risks, which are rated as moderate under all action alternatives. These mitigation measures would apply to all action alternatives.

Table H-91. Potential general mitigation measures for the Lower Elwha Hatchery integrated winter-run steelhead yearling program.

Risk Category	Mitigation Measures[1]
Competition	Apply Mitigation Measures C3 and C4.

[1] Refer to Table H-2 for a description of each mitigation measure.

4.0 Summary

Risk and benefit results for the 10 steelhead river basins are summarized in Table H-92 for Alternative 1 and Alternative 2 (which also represent existing conditions), Table H-93 for Alternative 3, and Table H-94 for Alternative 4. These results by river basin are used to describe overall effects for the Puget Sound Steelhead DPS in EIS Subsection 3.2.7.4, Hatchery Program Risks and Benefits (Steelhead), and Subsection 4.2.6.3, Summaries of Risks and Benefits (Steelhead).

Table H-92. Summary of risks and benefits for the Puget Sound Steelhead DPS by river basin under Alternative 1 and Alternative 2.

	Risk					Benefit	
	Competition by hatchery						
River Basin	**Steelhead**	**Chinook**	**Coho**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Nooksack	Moderate	Low	High	Moderate	Moderate	Low	NA[1]
Skagit	Moderate	High	High	Moderate	Moderate	Low	NA
Stillaguamish	Moderate	NA	Moderate	Moderate	Moderate	Moderate	NA
Snohomish	Moderate	High	High	Moderate	Moderate	High	NA
Lake Washington	NA	NA	High	NA	NA	NA	NA
Green	Moderate	High	High	Moderate	Moderate	Moderate	Moderate
Puyallup	Moderate	High	High	Moderate	Moderate	Low	Moderate
South Sound	NA	Low	Low	NA	NA	NA	NA
Hood Canal	Moderate	Low	Low	Negligible	Negligible	NA	Moderate
Strait of Juan de Fuca	Moderate	Low	Low	Negligible	Negligible	Moderate	Moderate
Average Overall Rating (score)	**Moderate 16/10 = 1.6**	**Moderate 16/10 = 1.6**	**Moderate 23/10 = 2.3**	**Low 12/10 = 1.2**	**Low 12/10 = 1.2**	**Low 12/10 = 1.2**	**Low 8/10 = 0.8**

Note: Risks and benefits under Alternative 1 and Alternative 2 are the same as under existing conditions.
[1] NA = not applicable or not available.

Table H-93. Summary of risks and benefits for the Puget Sound Steelhead DPS by river basin under Alternative 3.

	Risk					Benefit	
	Competition by hatchery						
River Basin	**Steelhead**	**Chinook**	**Coho**	**Genetics**	**Hatchery Facilities and Operation**	**Total Return**	**Viability**
Nooksack	Low	Low	High	Moderate	Moderate	Low	NA[1]
Skagit	Low	High	High	Low	Low	Low	NA
Stillaguamish	Low	NA	Low	Low	Low	Moderate	NA

Table H-93. Summary of risks and benefits for the Puget Sound Steelhead DPS by river basin under Alternative 3 (continued).

River Basin	Risk					Benefit	
	Competition by hatchery			Genetics	Hatchery Facilities and Operation	Total Return	Viability
	Steelhead	Chinook	Coho				
Snohomish	Low	High	High	Moderate	Moderate	High	NA
Lake Washington	NA	NA	High	NA	NA	NA	NA
Green	Low	High	High	Low	Low	Moderate	Moderate
Puyallup	Low	High	High	Low	Low	Low	Moderate
South Sound	NA	Low	Low	NA	NA	NA	NA
Hood Canal	Moderate	Low	Low	Negligible	Negligible	NA	Moderate
Strait of Juan de Fuca	Low	Low	Low	Negligible	Negligible	Moderate	Moderate
Average Overall Rating (score)	**Low 9/10 = 0.9**	**Moderate 16/10 = 1.6**	**Moderate 22/10 = 2.2**	**Low 8/10 = 0.8**	**Low 8/10 = 0.8**	**Low 12/10 = 1.2**	**Low 8/10 = 0.8**

[1] NA = not applicable or not available.

Table H-94. Summary of risks and benefits for the Puget Sound Steelhead DPS by river basin under Alternative 4.

Basin	Risk					Benefit	
	Competition by hatchery			Genetics	Hatchery Facilities and Operation	Total Return	Viability
	Steelhead	Chinook	Coho				
Nooksack	Moderate	Low	High	Moderate	Moderate	Low	NA[1]
Skagit	Moderate	High	High	Moderate	Moderate	Low	NA
Stillaguamish	Moderate	NA	Moderate	Moderate	Moderate	Moderate	NA
Snohomish	Moderate	High	High	Moderate	Moderate	High	NA
Lake Washington	NA	NA	High	NA	NA	NA	NA
Green	Moderate	High	High	Moderate	Moderate	Moderate	Moderate
Puyallup	Moderate	High	High	High	High	Low	Moderate
South Sound	NA	Low	Low	NA	NA	NA	NA
Hood Canal	Moderate	Low	Low	Negligible	Negligible	NA	Moderate
Strait of Juan de Fuca	Moderate	Low	Low	Negligible	Negligible	Moderate	Moderate
Average Overall Rating (score)	**Moderate 16/10 = 1.6**	**Moderate 16/10 = 1.6**	**Moderate 23/10 = 2.3**	**Low 13/10 = 1.3**	**Low 13/10 = 1.3**	**Low 12/10 = 1.2**	**Low 8/10 = 0.8**

[1] NA = not applicable or not available.

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Appendix I

Socioeconomic Impact Methods

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This appendix describes the socioeconomics analysis area, methods, and data used to characterize the affected environment in Environmental Impact Statement (EIS) Subsection 3.3, Socioeconomics, and to conduct the analysis of socioeconomic effects described in EIS Subsection 4.3, Socioeconomics. The analysis of socioeconomic impacts considers predicted salmon and steelhead harvest-related effects within the socioeconomic analysis area, and hatchery operations-related effects, including changes in hatchery production costs, associated with the alternatives.

1.0 Analysis Area

The socioeconomic baseline and analysis characterizes harvest of salmon and steelhead across the socioecomic analysis area as described in EIS Subsection 4.3.2, Analysis Area (Socioeconomics). The analysis area for socioeconomic impacts includes the EIS project area (EIS Subsection 1.4, Project and Analysis Area) (EIS Figure 1.4-1), and extends to include marine areas of the Strait of Juan de Fuca west of the Elwha River. The socioeconomic analysis area encompasses the 12 counties forming the Puget Sound region (Figure I-1), and analyses use economic information from Clallam, Jefferson, Mason, and Thurston counties, parts of which are in areas that do not drain into the Puget Sound basin (EIS Figure 3.3-1). The socioeconomic analysis area includes the 10 major salmon management catch reporting areas (catch areas 4B through 13) and their subareas (Figure I-2), as designated by Washington State statute (WAC 220-22-030). Thus the socioeconomic analysis analysis area is larger than the EIS project area shown in EIS Figure 1.4-1.

The production of salmon at hatcheries in the project area contributes to fisheries along the Washington and Oregon coasts, and to more distant coastal fisheries in British Columbia and Alaska (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife [PSIT and WDFW] 2004). As shown in this appendix, the contribution of Puget Sound hatchery-origin Chinook salmon and coho salmon to salmon fisheries in Southeast Alaska, British Columbia, and the coastal waters of Washington, Oregon, and California varies by location.

Based on pre-season catch estimates for coho salmon and post-season catch estimates for Chinook salmon from the Fishery Regulation Assessment Model (FRAM) over the 2002 through 2006 period, Puget Sound Chinook salmon and coho salmon provide a minor contribution to fisheries in Southeast Alaska. In addition, fisheries along the coastal waters of Washington, Oregon, and California, Chinook salmon annually contributed from less than 1 to 7 percent, and coho salmon contributed from 5 to 10 percent of the total commercial and recreational catch, respectively during the same time period.

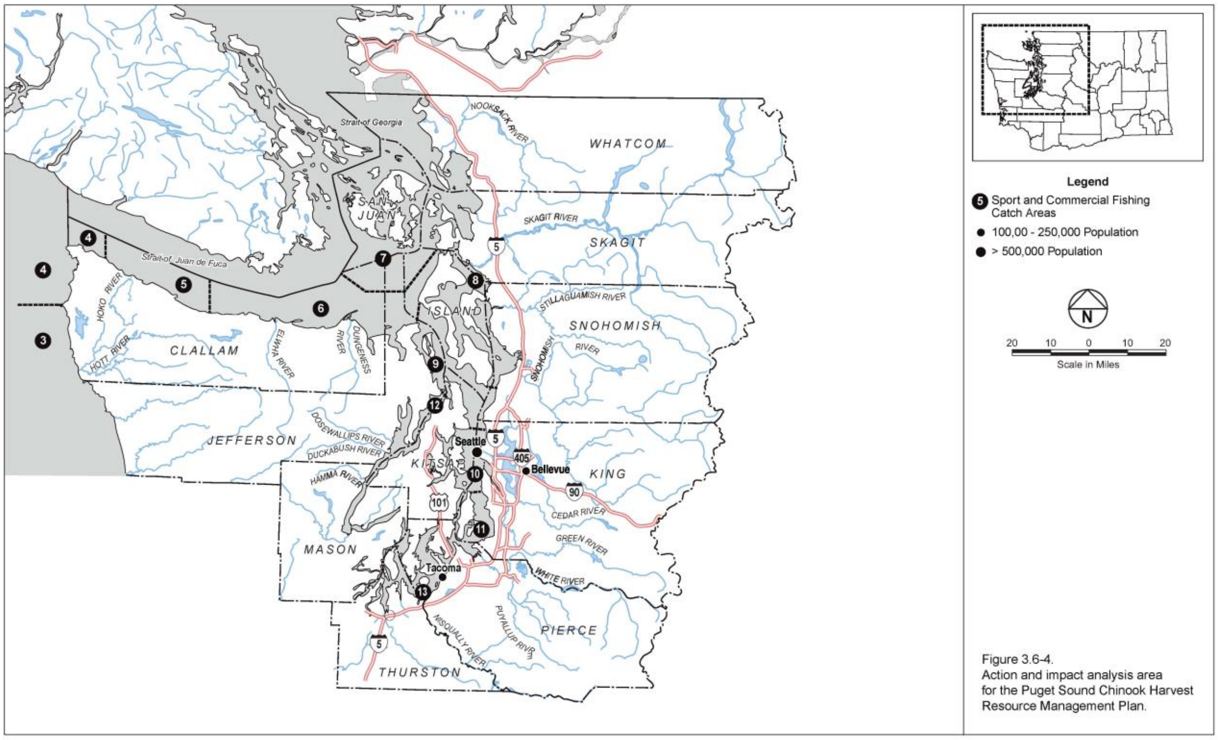

Figure I-1. Socioeconomic analysis area.

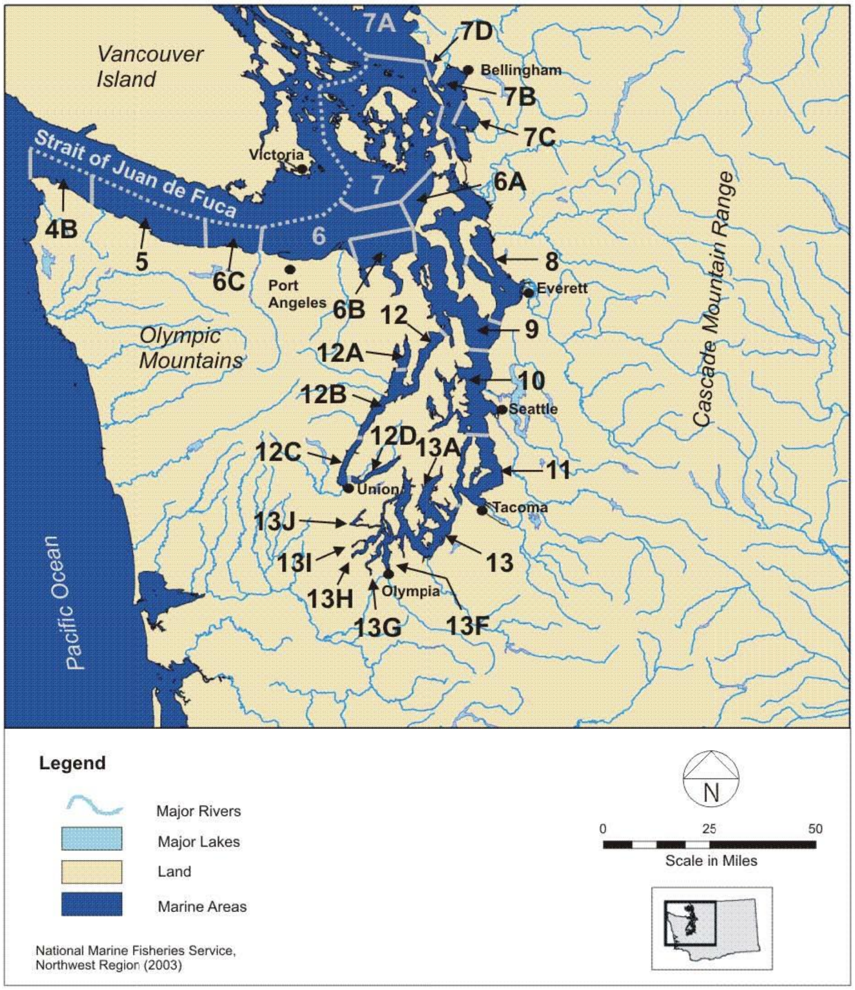

Figure I-2. Puget Sound salmon management marine catch reporting areas in the socioeconomic analysis area.

In British Columbia commercial and recreational fisheries, the contribution of Chinook salmon from Puget Sound hatcheries annually ranged from 4 to 17 percent, whereas contributions of coho salmon ranged from 3 to 17 percent from 2002 to 2006 (W. Beattie, Northwest Indian Fisheries Commission, memorandum sent to Tom Wegge, April 15, 2010, regarding Puget Sound hatchery production caught outside of Puget Sound).

The harvest percentages for these areas likely overestimate the actual contributions of Puget Sound hatchery-origin fish because FRAM only includes fisheries along the west coast of the Southeast Alaska archipelago (i.e., outside fisheries); FRAM coverage of British Columbia fisheries includes ‘tidewaters’, which are terminal fisheries near the mouths of rivers. Thus, although the contributions of Puget Sound hatchery-origin Chinook salmon and coho salmon are meaningful to the annual salmon harvest in those locations (particularly in British Columbia fisheries), management targets and actual catch in their fisheries are determined independent of the abundance of hatchery-origin fish originating from the project area. Consequently, any changes in production at Puget Sound hatcheries would be expected to have minor effects on fisheries outside of Puget Sound and are not quantitatively evaluated in this socioeconomic analysis.

As described above for Puget Sound Chinook salmon and coho salmon, other salmon species produced in Puget Sound (pink, sockeye and chum salmon) are also harvested along the outer coast of Washington, Oregon, British Columbia, and Alaska. Similarly, most of the commercial and recreational harvest of these species occurs in Puget Sound marine and freshwater areas. Therefore harvest data from coastal areas outside the socioeconomics analysis area is not used for the socioeconomic analysis. In addition, changes in production at Puget Sound hatcheries under the alternatives analyzed in this EIS would not be expected to have substantial effects on fisheries outside of Puget Sound. Steelhead are not targeted with the exception of small commercial, ceremonial, and subsistence fisheries in terminal areas of Puget Sound.

2.0 Salmon and Steelhead Harvest-related Effects

An Excel workbook with linked worksheets, referred to as the Economic Impact Model, was developed by TCW Economics to assess harvest-related and hatchery operations-related effects under each EIS alternative.

Data and values in the worksheets in this appendix are organized by subregion (EIS Subsection 3.3.1, Introduction, and EIS Subsection 4.3.2, Analysis Area). The subregions are the north Puget Sound subregion, consisting of Whatcom, Skagit, Snohomish, Island and San Juan Counties; the south Puget Sound subregion, consisting of King, Pierce, Thurston, Mason, and Kitsap Counties; and the Strait of Juan de Fuca subregion, consisting of Clallam and Jefferson Counties (Figure I-1). The analytical purpose of the subregions is to measure the economic impacts (e.g., generation of jobs and personal income) of fishing activity and hatchery operations in the socioeconomic analysis area. The relationship of the major river systems to counties and corresponding subregions in the socioeconomic analysis area is shown in Table 3.9-1 in EIS Subsection 3.3.1, Introduction.

2.1 Commercial Harvest and Recreational Trips and Catch

The analysis of effects on commercial fisheries is based on estimates of salmon and steelhead harvest, and the effects on recreational fisheries are based on estimates of angler.

2.1.1 Commercial Fisheries

The EIS Technical Workgroup estimated salmon (Chinook salmon, coho salmon, sockeye salmon, pink salmon, and chum salmon) and steelhead harvests for analyzing the effects in commercial fisheries throughout the analysis area. Harvest estimates are developed for each of the alternatives. For baseline conditions (and Alternative 1), estimates of harvest (2002 to 2006 averages) are used to characterize harvest conditions in the socioeconomic analysis area instead of modeled estimates. The number of fish (both natural-origin and hatchery-origin) predicted to be caught was estimated for the following five combined marine and freshwater catch areas in the socioeconomic analysis area: catch area 5 and 6, catch area 7, catch area 8 and 9, catch area 10, 11, and 13, and catch area 12 (Figure I-2).

For the socioeconomic impact assessment, the harvest estimates in the combined marine/freshwater catch areas are divided between marine and freshwater fisheries. This was done by applying the percentage distribution from 2002 to 2006 of salmon and steelhead caught in marine and freshwaters to the predicted harvest under the alternatives in each catch area. These percentages are shown in Table I-1. The resulting marine harvest is allocated between tribal and nontribal harvesters using average 2002 to 2006 catch data. The split between tribal and non-tribal harvesters is necessary to separately evaluate environmental justice effects on tribes and non-tribal fishers (Subsection 3.4, Environmental Justice, and Subsection 4.4, Environmental Justice). The tribal and non-tribal percentages of marine harvest by catch area are shown in Table I-2 (note that only tribes commercially harvest salmon and steelhead in freshwater areas in the socioeconomic analysis area).

The harvest estimates for marine and freshwater fisheries in each catch area are assigned to counties in the three subregions. For the commercial marine fisheries, the predicted harvest in each catch area is assigned to counties based on the average proportion of harvest landed in different port areas from 2002 to 2006. Ports are then assigned to the counties where they are located, and county-level percentages of harvest for each species are calculated. The resulting percentages are used to generate county-level landings under each alternative as shown in Table I-3. It should be noted that assigning harvest to ports and counties based on landings may distort related county-level economic effects. Marine harvest may be landed in one county and processed in another, spreading effects across county boundaries. However, a practical approach to assigning harvest to counties was needed because the landing, buying, and processing relationship differs among species and years.

For commercial freshwater fisheries (tribal), the estimates of harvest in each catch area are assigned to counties and subregions based on the location of the county where each river mouth is located. It is recognized that assigning the freshwater harvest to each river-mouth by county likely distorts county-level effects, but a practical approach to the harvest assignment is necessary. Percentages of harvest in each catch area attributable to individual counties are developed for each species. These percentages are presented in Table I-4.

2.1.2 Recreational Fisheries

For recreational fisheries, estimates of fishing trips (instead of harvest) are used to estimate economic effects. The number of recreational fishing trips made to each catch area is allocated to counties based on the proportion of the 2005 sport harvest of salmon in each catch area (Table I-5) associated with different angler counties of origin based on WDFW Catch Record Card data. These percentages, which are not species-specific, are shown in Table I-6. The percentages are applied to the trip estimates for each catch area to assign trips to individual counties in the three subregions.

For freshwater recreational fisheries, estimates of salmon and steelhead harvest in each catch area are assigned to counties based on modeled FRAM harvest estimates for each river system. Harvest is assigned to a particular county based on the terminus location of each river system. Percentages for each species and catch area are presented in Table I-7, and are applied to the harvest estimates for each alternative to allocate freshwater recreational harvest by county.

2.2 Gross and Net Economic Values

2.2.1 Commercial Fisheries

Estimates of tribal and non-tribal commercial harvest are converted to gross and net economic values using different factors. For estimating gross economic values (ex-vessel values), the number of fish harvested in each county under the alternatives is first converted to pounds (dressed weight). The following pounds-per-fish factors by species are used in the conversion:

- Chinook salmon, 10.8 pounds
- Coho salmon, 6.4 pounds
- Sockeye salmon, 4.6 pounds
- Pink salmon, 3.2 pounds
- Chum salmon, 7.7 pounds
- Steelhead, 7.1 pounds

Although the commercial fish ticket database is likely the original data source, the sources referenced for identifying the pounds-per-fish conversion factors include:

- Weights for Chinook and coho: WDFW (in an Excel file provided to the EIS socioeconomics team)
- Weights for sockeye, pink, and chum salmon: 2004 to 2008 catch data provided by the EIS Technical Workgroup (Excel file). For consistency with price data used in the modeling of effects, round weight is adjusted to dressed weight based on a factor of 83.2 percent, based on the percentage difference between Chinook salmon and coho salmon round and dressed weights.
- Weight for steelhead: average of weight range for steelhead listed on WDFW's Salmon Facts information guide web page: http://wdfw.wa.gov/outreach/fishing/salmon.htm. For consistency with price data used in the modeling of effects, round weight is adjusted to dressed weight based on a factor of 83.2 percent, based on the percentage difference between Chinook salmon and coho salmon round and dressed weights.

Once commercial harvest is converted to pounds, per pound ex-vessel prices for each species are applied to the resulting tribal and non-tribal commercial harvests to estimate the total ex-vessel value of commercial salmon and steelhead harvest in each subregion. For all subregions, prices (in 2007 dollars) based on 2007 to 2009 averages are used to convert estimated harvest to total ex-vessel harvest values. These prices are as follows:

- Chinook salmon, $2.35 per pound
- Coho salmon, $1.52 per pound
- Sockeye salmon, $1.88 per pound
- Pink salmon, $0.25 per pound
- Chum salmon, $0.73 per pound
- Steelhead, $1.57 per pound

Net economic values (net personal income) associated with the commercial harvest are estimated. Per-fish factors for Puget Sound salmon and steelhead, derived from draft analysis for the Mitchell Act EIS

(The Research Group [2009]; in Appendix B, Table B.2, in [NMFS 2010]), are used as the basis for estimating the net economic values below.

- Chinook salmon, $17.60 per fish
- Coho salmon, $6.46 per fish
- Sockeye salmon, $5.71 per fish
- Pink salmon, $0.53 per fish
- Chum salmon, $3.71 per fish
- Steelhead, $7.36 per fish

2.2.2 Recreational Fisheries

For recreational fisheries, gross economic value is defined in terms of total trip-related expenditures by recreational fishers, and net economic values are defined as the net willingness to pay by recreational anglers (over and above expenditures) for recreational fishing opportunities. Estimates described above of recreational marine angler trips are used with different economic factors to estimate angler spending and net economic values for recreational fisheries.

Estimates of marine recreational trips from the EIS Technical Workgroup are used to estimate marine recreational values. For freshwater recreational fishing, harvest estimates from the EIS Technical Workgroup are converted to angler trips for estimating angler spending and net economic values. A trips per fish-caught factor of 4.16 is used for all salmon species, and a trips per-fish caught factor of 8.33 is used for steelhead. Data provided by WDFW on freshwater sport fishing catch effort in western Washington streams over the 2003 to 2007 period are used to develop these factors.

To convert trips to angler expenditures, a per-trip expenditure factor of $70.43 is applied to the estimated number of recreational fishing trips originating from each county. Mode-specific (charter, private boat, shoreline) estimates of expenditures per trip are not used for this calculation. The per-trip expenditure factor used was developed by The Research Group (2009) for the Mitchell Act draft EIS (in Appendix B, Table B.2, in the draft socioeconomic section of NMFS [2010]).

To estimate net economic values (willingness to pay for fishing over and above expenditures) associated with the recreational fishing, a factor derived from a review of past studies of anglers' net willingness to pay for salmon fishing is used (Boyle et. al 1998). This factor, adjusted to 2007 dollars using the consumer price index, is $59.12 per angler day of salmon and steelhead fishing, and is applied to trip estimates for each county. For the analysis, it is assumed that an angler trip is equivalent to an angler day.

2.3 Subregional and Local Economic Impacts

Harvest-related subregional economic impacts are generated by economic activity associated with commercial harvests and sport fishing activities. Estimates of subregional economic impacts associated with these activities are expressed in terms of personal income and jobs generated in counties in each of the three subregions in the socioeconomic analysis area.

2.3.1 Personal Income

To estimate total (direct and indirect) personal income generated by salmon and steelhead commercial (including tribal and non-tribal) and recreational trips fishing under each alternative, species-specific personal income factors are applied to pounds of commercial landings and recreational fishing trips. The subregional personal income factors (in 2007 dollars) used to convert commercial harvest (in pounds) and recreational fishing trips to personal income impacts in each county and subregion are shown in Table A-8. Data sources for the subregional personal income factors include:

- Commercial harvest (per pound): factors generated by Ed Waters using information from the Fishery Economic Assessment Model (FEAM).
- Recreational fishing trips (per angler trip): FEAM charter and private boat trip impact factors for 2007 from the PFMC in file "Tables CH IV Econ Sup" (factors for charter and private boats are weighted based on boat-type trip distributions over the 2004 to 2008 period for each subregion, as reported in PFMC [2008]).

Subregional personal income is measured as personal income accruing to households. It measures the contribution to personal income under current (or changed) conditions. Because dynamic changes in the economy over time are not considered, the use of these personal income factors is not considered a valid approach to measuring long term effects on the economy from changes in abundance of fish available for harvest.

2.3.2 Jobs

Jobs (full-time and part-time; direct and indirect) generated by commercial (including tribal and non-tribal) and recreational fisheries in each subregion are estimated by applying an earnings-per-job factor to the estimated total personal income generated in each subregion. The earnings-per-job factors for each subregion are calculated by dividing total earnings in each subregion in 2007 by total jobs, as reported by the Bureau of Economic Analysis[1] (BEA) (BEA Table CA05N: Personal Income by Major Source and Earnings by NAICS Industry; BEA Table CA25N: Total Full- and Part-Time Employment by NAICS Industry). The resulting earnings-per-job factors are presented in Table I-9. The estimated personal income totals for each county are then divided by the earnings-per-jobs factors for each county to estimate jobs.

3.0 Hatchery Operations Effects

Hatchery operations effects, including effects on production costs, hatchery jobs, and personal income are evaluated. This subsection describes the methods and data used to conduct these analyses under the alternatives.

3.1 Hatchery Operations Cost Values

The number of hatchery fish produced at salmon and steelhead hatcheries in the project area varies under the alternatives; consequently, the costs of hatchery production also vary by alternative. The assessment of hatchery operations costs considers baseline costs, and changes in the baseline costs associated with the changes in fish production under the alternatives. Hatchery operations costs under the alternatives consider only variable costs (i.e., those costs that change in response to changes in hatchery production).

Costs to produce hatchery-origin fish are estimated by the Northwest Indian Fisheries Commission (D. Schmitt, pers. comm., Northwest Indian Fisheries Commission, February 17, 2010) for salmon and steelhead hatchery facilities in Puget Sound. Facility-specific and average production costs are presented in Tables I-10 through I-13.

Operational costs at salmon and steelhead hatcheries in the project area vary depending on the species and are estimated under each alternative based on available information on per-species costs of producing 1,000 juveniles. A report entitled *Hatchery Performance Summary Tables - Puget Sound and Coastal Salmon and Steelhead Facilities* (WDFW 2009), is the primary source of this cost

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[1] BEA earnings and employment data include tribal employees (T. Wegge, pers. comm., February 25, 2013).

information. Species-specific total cost estimates are applied to the different levels of hatchery production under the alternatives.

WDFW (2009) includes cost information pertinent to WDFW's hatchery programs that are analyzed in this EIS. An underlying assumption is that state and tribal operational costs for hatcheries in the project area are similar. This assumption is required because information is not available on operational costs specific to tribal programs. The assumption, however, is considered reasonable because fish culture practices and facility needs to produce juveniles are similar regardless of the hatchery operator. It is unlikely that the cost to produce 1,000 salmon and steelhead varies significantly between state and tribal facilities, particularly if the cost per species is averaged among the tribal programs.

WDFW (2009) provides information on costs per adult produced, and the number of adults produced from specific state hatchery production objectives (i.e. facility, species, and run). Multiplication of these two values provides the operational cost of producing the hatchery production objective. For some releases of hatchery-origin fish, the cost per adult is not available and therefore does not contribute towards the estimates. Weighted averages are calculated to ensure that program size disparities do not influence the final estimate of cost per 1,000 fish. The operational cost include routine administration and mass marking costs but not capital costs.

Hatchery releases of Chinook salmon occur at two stages, at the subyearling and yearling stages. Due to the significantly higher cost to rear juveniles to the yearling stage, cost estimates are developed independently for the two stages. Two subyearling coho salmon programs are excluded from the analysis because there is no basis to develop a cost estimate for this release stage for that species. It is assumed that because programs are not mass marked and feed costs are minimal, the absence of the operational costs for the two coho salmon programs are unlikely to affect comparisons among the alternatives at subregional scales. Two Chinook salmon programs do not incur mass marking costs. Because such marking can comprise a significant cost item, these programs are assumed to be marked to ensure that they did not unduly influence the overall estimate.

3.2 Subregional Economic Impacts

Hatcheries support the economy in the socioeconomic analysis area by directly employing workers and from economic activity generated by procuring goods and services needed for hatchery operations. In addition, expenditures on hatchery labor (jobs) and the procurement of goods and services for hatchery operation produce indirect effects on employment and personal income in subregional economies.

The analysis of hatchery operations-related effects is based on the estimates of annual hatchery costs under each alternative, which are as follows:

- Alternative 1 and Alternative 2: $12.6 million
- Alternative 3: $10.0 million
- Alternative 4: $15.4 million

To assess hatchery operations-related effects on the economies in the socioeconomic analysis area, hatchery operation costs are compiled for the three subregions (but not counties) based on the location of hatchery facilities within each subregion. Direct hatchery employment is estimated using a factor of 11.6 jobs (full- and part-time) per $1 million of hatchery operations costs. This factor is based on full-time-equivalent (FTE) employment data for WDFW hatcheries, adjusted to full- and part-time jobs. This direct employment factor is then applied to hatchery operations expenditures in each subregion to arrive at estimates of direct hatchery operations-related employment for each subregion under the alternatives.

Total employment (direct and indirect) from hatchery operations is estimated using an employment multiplier generated by an IMPLAN model (Minnesota IMPLAN Group 2008) for Washington State, for the sector that includes aquaculture industries (animal production, except cattle, poultry, and eggs). The statewide multiplier of 1.47 total jobs per direct job for this sector is applied to the south Puget Sound subregion but is adjusted downward to 1.39 (a 5 percent reduction) for the north Puget Sound subregion, and to 1.32 (a 10 percent reduction) for the Strait of Juan de Fuca subregion, to reflect the smaller economies of these subregions. These multipliers are applied to the direct employment estimates for each subregion to generate estimates of total hatchery operations-related employment in each subregion.

For Alternative 3 (decreased production) and Alternative 4 (increased production), it is assumed that changes in hatchery operational costs are entirely attributable to changes in the procurement of goods and services needed to achieve the production levels under the alternatives. No change in direct employment (jobs) at hatchery facilities is assumed to occur under Alternative 3 and Alternative 4. Differences in employment due to hatchery-related procurement expenditures under Alternative 3 and Alternative 4 are estimated by allocating changes in subregional hatchery costs among six expenditure categories: repair and maintenance, supplies, vehicle rental, utilities, fish food, and pathology services. Allocations to the expenditure categories are made based on percentage allocations of costs derived from budget information for the Yakama Nation's Klickitat Hatchery (A. Purcell, pers. comm., National Marine Fisheries Service, June 22, 2009). It is assumed that these costs are similar for all hatchery operations in the project area. Differences in hatchery operation costs for each subregion by alternative are then input to appropriate industrial sectors in the IMPLAN input-output model for Washington, and the model is run to generate estimates of total employment (jobs) generated by procurement expenditures.

According to WDFW budget data, the average labor cost per job is about $50,000, or about $43,600 when converted to represent full- and part-time jobs. This personal income-per-job factor is applied to the direct employment estimates to arrive at estimates of direct hatchery operations personal income for each subregion. Indirect income generated by hatchery operations is estimated using the following average earnings per job for each subregion, derived from Bureau of Economic Analysis data (BEA Table CA05N: Personal Income by Major Source and Earnings by NAICS Industry; BEA Table CA25N: Total Full- and Part-Time Employment by NAICS Industry) for the counties in each subregion:

- north Puget Sound subregion, $46,100
- south Puget Sound subregion, $57,200
- Strait of Juan de Fuca subregion, $31,900

These earning averages (Table I-9) are applied to the estimated indirect jobs to arrive at an estimate of secondary personal income for each subregion, which is then added to direct hatchery operations personal income to arrive at an estimate of total personal income for each subregion.

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Table I-1. Percentage distributions of commercial harvest between marine and freshwater areas in salmon management catch areas by species (2002 to 2006).

Species	Catch Area 5 and 6[1]		Catch Area 7[2]		Catch Area 8 and 9[2]		Catch Area 10, 11 and 13[3]		Catch Area 12[1]	
	Marine (Percent)	Freshwater (Percent)	Marine (Percent)	Freshwater (Percent)	Marine (Percent)	Freshwater (Percent)	Marine (Percent)	Freshwater (Percent)	Marine (Percent)	Freshwater (Percent)
Chinook salmon	100.0	0.0	89.5	10.5	92.2	7.8	42.3	57.7	87.2	12.8
Coho salmon	91.5	8.5	92.8	7.2	73.3	26.7	42.0	58.0	85.8	14.2
Sockeye salmon	100.0	0.0	100.0	0.0	29.6	70.4	100.0	0.0	0.0	0.0
Pink salmon	100.0	0.0	100.0	0.0	94.8	5.2	64.8	35.2	0.0	0.0
Chum salmon	100.0	0.0	95.2	4.8	87.5	12.5	88.7	11.3	98.3	1.7
Steelhead	42.1	57.9	50.0	50.0	4.9	95.1	0.3	99.7	0.0	0.0

Source: Data from W. Beattie (Northwest Indian Fisheries Commission) (file = 2002-06 comm catch 5-04-09.xls).

[1] Strait of Juan de Fuca subregion.

[2] North Puget Sound subregion.

[3] South Puget Sound subregion.

Table I-2. Percentage distributions of non-tribal and tribal commercial harvest by salmon management marine catch area and species (2002 to 2006).

Species	Catch Area 5 and 6[1]		Catch Area 7[2]		Catch Area 8 and 9[2]		Catch Area 10, 11 and 13[3]		Catch Area 12[1]	
	Non-tribal (Percent)	**Tribal (Percent)**	**Non-tribal (Percent)**	**Tribal (Percent)**	**Non-tribal (Percent)**	**Tribal (Percent)**	**Non-tribal (Percent)**	**Tribal (Percent)**	**Non-tribal (Percent)**	**Tribal (Percent)**
Chinook salmon	0.0	100.0	40.2	59.8	0.0	100.0	0.1	99.9	0.0	100.0
Coho salmon	0.0	100.0	25.5	74.5	5.0	95.0	1.1	98.9	11.7	88.3
Sockeye salmon	0.0	100.0	35.3	64.7	0.0	100.0	0.0	100.0	0.0	0.0
Pink salmon	0.0	100.0	54.9	45.1	59.5	40.5	0.0	100.0	0.0	0.0
Chum salmon	0.0	100.0	48.4	51.6	59.9	40.1	80.6	19.4	85.0	15.0
Steelhead	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	0.0
Total	**0.0**	**100.0**	**46.3**	**53.7**	**48.4**	**51.6**	**70.3**	**29.7**	**77.7**	**22.3**

Source: Data from W. Beattie (Northwest Indian Fisheries Commission) (file = 2002-06 comm catch 5-04-09.xls).
[1] Strait of Juan de Fuca subregion.
[2] North Puget Sound subregion.
[3] South Puget Sound subregion.

Table I-3. Commercial marine percentage allocation factors (tribal and nontribal) by county (and port), salmon management catch area, and species from 2002-2006.

Catch Area and County or Area	**Chinook Salmon (Percent)**	**Coho Salmon (Percent)**	**Sockeye Salmon (Percent)**	**Pink Salmon (Percent)**	**Chum Salmon (Percent)**	**Steelhead (Percent)**
5 and 6						
Whatcom						
Skagit						
Snohomish						
Island						
San Juan						
King	0.0	4.2	0.0	0.0	1.3	0.0
Pierce						
Thurston						
Mason						
Kitsap						
Clallam	99.9	91.8	98.8	100.0	98.7	100.0
Jefferson	0.1	0.0	1.2	0.0	0.0	0.0
Northern WA Coast		4.0				
Oregon						
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
7						
Whatcom	48.5	94.6	71.0	67.7	85.4	100.0
Skagit	46.4	3.2	13.5	17.0	6.4	
Snohomish	0.4		5.9	0.8	2.5	
Island	0.4		0.3		0.0	
San Juan	0.9	1.2	0.8	0.2	0.1	
King	1.5	0.5	5.3	7.8	2.8	
Pierce			0.1	1.3	0.6	
Thurston					0.3	
Mason						
Kitsap			0.1			
Clallam			1.0			
Jefferson	0.3		0.3	0.3		
Northern WA Coast	1.5	0.5	1.3	2.7	1.1	
Oregon	0.1		0.4	2.2	0.8	
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table I-3. Commercial marine percentage allocation factors (tribal and nontribal) by county (and port), salmon management catch area, and species from 2002-2006 (continued).

Catch Area and County or Area	Chinook Salmon (Percent)	Coho Salmon (Percent)	Sockeye Salmon (Percent)	Pink Salmon (Percent)	Chum Salmon (Percent)	Steelhead (Percent)
8 and 9						
Whatcom	2.6	25.1		28.8	24.0	100.0
Skagit	13.0	20.9		46.6	12.8	
Snohomish	15.7	19.9	100.0	2.9	11.1	
Island		0.7			0.6	
San Juan	3.3				0.1	
King	63.4	21.8		6.6	32.6	
Pierce	1.5	0.4			8.3	
Thurston					1.0	
Mason	0.3	4.0			0.3	
Kitsap		0.1				
Clallam		0.4			0.5	
Jefferson	0.2	5.9			0.2	
Northern WA Coast		0.8			7.1	
Oregon				15.1	1.4	
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
10, 11 and 13						
Whatcom	0.2	20.3		0.7	28.9	
Skagit	0.4	1.6			8.3	
Snohomish		0.8		0.4	8.4	
Island					0.1	
San Juan					0.1	
King	37.5	12.6	87.6	98.5	35.7	
Pierce	20.8	9.2	5.5		3.2	100.0
Thurston	9.5	6.8		0.4	1.0	
Mason	14.3	35.7	0.1		1.7	
Kitsap	16.3	0.2	6.1			
Clallam	0.3	8.6	0.6		0.2	
Jefferson			0.1		0.1	
Northern WA Coast	0.5	0.6			11.7	
Oregon	0.2	3.6			0.6	
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table I-3. Commercial marine percentage allocation factors (tribal and nontribal) by county (and port), salmon management catch area, and species from 2002-2006 (continued).

Catch Area and County or Area	Chinook Salmon (Percent)	Coho Salmon (Percent)	Sockeye Salmon (Percent)	Pink Salmon (Percent)	Chum Salmon (Percent)	Steelhead (Percent)
12						
Whatcom		5.6	0.0	0.0	33.3	0.0
Skagit		1.3	0.0	0.0	7.6	0.0
Snohomish	3.9	0.7	0.0	0.0	4.5	0.0
Island			0.0	0.0	0.1	0.0
San Juan	0.7		0.0	0.0		0.0
King	0.2	5.4	0.0	0.0	35.3	0.0
Pierce			0.0	0.0	0.6	0.0
Thurston	3.4		0.0	0.0	0.5	0.0
Mason	76.9	73.3	0.0	0.0	12.2	0.0
Kitsap			0.0	0.0		0.0
Clallam			0.0	0.0		0.0
Jefferson	13.8	11.4	0.0	0.0	1.2	0.0
Northern WA Coast	1.1	0.4	0.0	0.0	3.3	0.0
Oregon		1.9	0.0	0.0	1.4	0.0
Total	**100.0**	**100.0**	**0.0**	**0.0**	**100.0**	**0.0**

Source: Percentages are based on harvest data from W. Beattie (Northwest Indian Fisheries Commission) (file = 2002-06 comm catch 5-04-09.xls).

Table I-4. Commercial freshwater percentage allocation factors (tribal only) by salmon management catch areas, county, and species under the alternatives (2002 to 2006).

Catch Area	County	Alternative 1 and 2			Alternative 3			Alternative 4		
		Chinook Salmon (Percent)	**Coho Salmon (Percent)**	**Other (Percent)**	**Chinook Salmon (Percent)**	**Coho Salmon (Percent)**	**Other (Percent)**	**Chinook Salmon (Percent)**	**Coho Salmon (Percent)**	**Other (Percent)**
5 and 6	Clallam		65.5	65.5		50.8	50.8		65.6	65.6
	Jefferson		34.5	34.5		49.2	49.2		34.4	34.4
7	Whatcom	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8 and 9	Skagit	93.6	93.6	93.6	93.8	93.8	93.8	93.6	93.6	93.6
	Snohomish	6.4	6.4	6.4	6.2	6.2	6.2	6.4	6.4	6.4
10, 11 and 13	King	27.2	80.9	64.0	33.0	83.4	69.0	25.4	82.6	69.0
	Pierce	10.3	18.6	16.0	13.5	16.1	15.4	9.6	16.7	15.0
	Thurston	62.5	0.5	20.1	53.5	0.5	15.6	65.1	0.7	15.9
12	Mason	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: EIS Technical Workgroup estimates for river systems for each alternative.

Table I-5. Recreational salmon and steelhead harvest from Puget Sound marine and freshwater salmon management catch areas by species (2002 to 2006).

Catch Area and Species	Number of Fish					
	2002	**2003**	**2004**	**2005**	**2006**	**Average**
5 and 6						
Chinook salmon	2,739	4,798	4,554	2,717	5,695	4,100.6
Coho salmon	36,249	42,411	48,664	32,746	12,932	34,600
Sockeye salmon	0	20	8	40	23	18
Pink salmon	35	56,482	63	32,664	0	17,849
Chum salmon	12	14	24	60	17	25
Steelhead	943	904	1,219	1,182	1,028	1,055
TOTAL	**39,978**	**104,629**	**54,532**	**69,409**	**19,695**	**57,647.6**
7						
Chinook salmon	11,048	6,621	3,057	7,123	10,921	7,754
Coho salmon	7,243	4,196	2,686	2,157	620	3,380
Sockeye salmon	71	39	6	156	157	86
Pink salmon	19	8,044	23	2,362	48	2,099
Chum salmon	2,251	1,092	2,192	2,620	1,713	1,974
Steelhead	285	333	527	316	321	356
TOTAL	**100,880**	**229,590**	**117,562**	**153,559**	**53,177**	**130,951.2**
8 and 9						
Chinook salmon	5,294	4,961	3,647	3,713	5,466	4,616
Coho salmon	28,706	44,442	31,854	24,682	7,819	27,501
Sockeye salmon	20	685	529	100	485	364
Pink salmon	147	168,624	1,392	56,931	16	45,422
Chum salmon	7,765	2,035	4,099	1,459	2,135	3,499
Steelhead	8,744	10,866	11,912	6,392	9,804	9,544
TOTAL	**50,676**	**231,613**	**53,433**	**93,277**	**25,725**	**90,946**
10, 11 and 13						
Chinook salmon	19,442	19,287	13,631	16,245	21,964	18,114
Coho salmon	21,397	40,443	28,845	26,435	14,769	26,378
Sockeye salmon	36,368	116	19,424	19	54,268	22,039
Pink salmon	26	14,680	78	34,265	218	9,853
Chum salmon	9,581	4,471	5,546	3,331	6,544	5,895
Steelhead	839	775	1,269	1,087	1,131	1,020
TOTAL	**87,653**	**79,772**	**68,793**	**81,382**	**98,894**	**83,299**

Table I-5. Recreational salmon and steelhead harvest from Puget Sound marine and freshwater salmon management catch areas by species (2002 to 2006) (continued).

Catch Area and Species	Number of Fish					
	2002	2003	2004	2005	2006	Average
12						
Chinook salmon	4,340	4,760	5,017	7,140	7,587	5,769
Coho salmon	13,179	12,275	15,141	12,417	5,652	11,733
Sockeye salmon	0	0	0	0	6	1
Pink salmon	0	3,147	0	542	6	739
Chum salmon	4,437	4,387	1,737	2,148	2,446	3,031
Steelhead	69	68	101	35	46	64
TOTAL	**197,343**	**184,193**	**159,594**	**185,058**	**213,543**	**187,947**
Puget Sound Total[1]						
Chinook salmon	42,863	40,427	29,906	36,938	51,633	40,353
Coho salmon	106,774	143,767	127,190	98,437	41,792	103,592
Sockeye salmon	36,459	860	19,967	315	54,939	22,508
Pink salmon	227	250,977	1,556	126,764	288	75,962
Chum salmon	24,046	11,999	13,598	9,618	12,855	14,423
Steelhead	10,880	12,946	15,028	9,012	12,330	12,039
TOTAL	**221,249**	**460,976**	**207,245**	**281,084**	**173,837**	**268,877**

Source: Data compiled by W. Beattie (Northwest Indian Fisheries Commission) from WDFW Catch Record Card estimates for Puget Sound (file = Sport catch 2002-06 4-20-09.xls).

[1] Catch includes fish originating from the project area (Puget Sound) that are landed in ports located outside of Puget Sound, including ports along the Washington coast.

Table I-6. Non-tribal recreational marine harvest percentage allocation factors (all species) by county for salmon management catch areas.

County	**Catch Area**				
	5 and 6 (Percent)	**7 (Percent)**	**8 and 9 (Percent)**	**10, 11, and 13 (Percent)**	**12 (Percent)**
Whatcom	1.2	28.6	0.8	0.1	0.0
Skagit	1.4	25.1	2.6	0.1	0.9
Snohomish	8.6	11.2	42.3	8.5	5.4
Island	2.5	3.8	23.8	0.1	0.1
San Juan	0.0	15.9	0.1	0.0	0.1
King	22.9	11.8	17.2	41.6	15.1
Pierce	17.3	1.0	1.2	29.3	9.5
Thurston	6.2	0.2	0.6	6.6	12.6
Mason	2.8	0.0	0.1	3.5	15.3
Kitsap	8.0	0.4	7.7	9.7	19.5
Clallam	26.1	1.1	0.4	0.1	8.2
Jefferson	3.0	0.9	3.1	0.3	13.5
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Washington Department of Fish and Wildlife, sport fish database.

Table I-7. Recreational freshwater harvest allocation factors (percentages) by county within salmon management catch areas by alternative.

Catch Area	County	Freshwater Area	Alternatives 1 and 2						Alternative 3						Alternative 4					
			Chinook (Percent)	Coho (Percent)	Pink (Percent)	Sockeye (Percent)	Chum (Percent)	Steelhead (Percent)	Chinook (Percent)	Coho (Percent)	Pink (Percent)	Sockeye (Percent)	Chum (Percent)	Steelhead (Percent)	Chinook (Percent)	Coho (Percent)	Pink (Percent)	Sockeye (Percent)	Chum (Percent)	Steelhead (Percent)
5 and 6	Clallam	Strait of Juan de Fuca misc.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
7	Whatcom	Nooksack-Samish	100.0	100.	100.0	100.0	100.0	100.0	100.0	100.0	100.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8 and 9	Skagit	Skagit	23.0	47.3	48.0	100.0	45.8	8.9	48.6	47.3	48.0	100.0	45.8	8.9	23.0	47.3	48.0	100.0	45.8	13.6
	Snohomish	Stillaguamish, Snohomish	77.0	52.7	52.0	0.	54.2	91.1	51.4	52.7	52.0	0.0	54.2	91.1	77.0	52.7	52.0	0.0	54.2	86.4
10, 11 and 13	King	Lake Washington, Green	4.8	45.3	3.0	100.0	7.7	75.5	5.2	45.3	3.0	100.0	7.7	72.7	5.3	45.3	3.0	100.0	7.7	84.0
	Pierce	Puyallup, Chambers	45.2	52.2	95.3	0.0	5.6	20.5	40.7	52.2	95.3	0.0	5.6	19.6	53.3	52.2	95.3	0.0	5.6	13.4
	Thurston	Nisqually, Misc. Area 13	50.0	2.5	1.7	0.0	86.7	4.0	54.1	2.5	1.7	0.0	86.7	7.8	41.5	2.5	1.7	0.0	86.7	2.6
12	Mason	Skokomish, Hood Canal misc.	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: EIS Technical Workgroup, recreational harvest estimates for river systems for each alternative.

Table I-8. Subregional economic impact factors (SEI): income impacts per pound of commercially landed salmon and steelhead, and per recreational trip in marine and freshwater areas (in 2007 dollars).

Subregion and Area	Tribal Commercial						Non-tribal Commercial					Recreational
	Chinook Salmon ($)	Coho Salmon ($)	Sockeye Salmon ($)	Pink Salmon ($)	Chum Salmon ($)	Steelhead ($)	Chinook Salmon ($)	Coho Salmon ($)	Sockeye Salmon ($)	Pink Salmon ($)	Chum Salmon ($)	All Species ($)
North Puget Sound												
Marine	2.38	1.85	2.36	1.63	1.63	6.60	2.38	1.85	2.36	1.63	1.63	86.85
Freshwater	2.33	1.85	2.36	1.63	1.63	6.60	2.33	$1.85	2.36	1.63	1.63	33.03
South Puget Sound												
Marine	2.56	2.04	2.60	1.63	1.63	2.49	2.56	2.04	2.60	1.63	1.63	86.85
Freshwater	2.56	2.04	$2.60	1.63	1.63	2.49	2.56	2.04	2.60	1.63	1.63	33.03
Strait of Juan de Fuca												
Marine	2.05	1.61	2.13	1.33	1.32	2.04	2.05	1.61	2.13	1.33	1.32	86.85
Freshwater	2.09	1.64	2.13	1.33	1.32	2.04	2.09	1.64	2.13	1.33	1.32	33.03

Sources: For tribal and non-tribal commercial subregional economic impact (SEI) factors: income impact coefficients were developed by Ed Waters (file = PS_Salmon_Coeffs_010-21-2009.xls). For recreational SEI factors: 2007 factors in PFMC (2008) in file "Tables CH IV Econ Sup". For marine recreational trips, 2007 factors for charter and private boats were weighted based on trip boat-type trip distributions over the 2004-08 period for each port area. For freshwater trips, the 2007 figure for private recreational trips was used.

Table I-9. Earnings per job (in 2007 dollars) by subregion and county.

Subregion and County	Earnings Per Job ($)	Population Size (Number)	Weighted Earnings Per Job ($)
North Puget Sound			46,097
Whatcom County	38,895	192,353	
Skagit County	41,835	115,898	
Snohomish County	49,710	674,406	
Island County	42,962	80,975	
San Juan County	26,054	15,182	
South Puget Sound			57,190
King County	64,540	1,850,714	
Pierce County	48,622	773,105	
Thurston County	43,025	238,166	
Mason County	34,047	56,859	
Kitsap County	47,712	238,160	
Strait of Juan de Fuca			31,937
Clallam County	33,019	70,317	
Jefferson County	29,328	29,159	

Source: Bureau of Economic Analysis, April 2009. Table CA05N Personal Income by Major Source and Earnings by NAICS Industry; Table CA25N Total Full-time and Part-time Employment by NAICS Industry.

Table I-10. Characteristics of Puget Sound Chinook salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses.

						Alternatives 1 and 2		Alternative 3		Alternative 4	
Hatchery Operator	**HGMP Name**	**Chinook Salmon Population Recovery Category of Release Watershed[1]**	**Hatchery Program Type[2]**	**Life Stage[3] at Release**	**Cost Multiplier**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**
San Juan County											
WDFW	Glenwood Springs Fall	3	IsH	SY	98.65	300	29,595	300	29,595	300	29,595
WDFW	Glenwood Springs Fall	3	IsH	Y	409.96	250	102,490	250	102,490	250	102,490
						San Juan County Totals	**132,085**		**132,085**		**132,085**
Skagit County											
WDFW	Marblemount Falls	1	Research	SY	98.65	222	21,900	222	21,900	222	21,900
WDFW	Marblemount Springs	1	Research	SY	98.65	250	24,663	250	24,663	250	24,663
WDFW	Marblemount Summers	1	Research	SY	98.65	200	19,730	200	19,730	200	19,730
WDFW	Marblemount Springs	1	Research	Y	409.96	150	61,494	150	61,494	150	61,494
WDFW	Samish Yearling Fall	3	IsH	Y	409.96	100	40,996	100	40,996	100	40,996
WDFW	Samish Fingerling Fall	3	IsH	SY	98.65	4000	394,600	4,000	394,600	4000	394,600
						Skagit County Totals	**563,383**		**563,383**		**563,383**
Snohomish County											
Tribal	Stillaguamish Summer	1	InR	SY	98.65	0	0	0	0	0	0
Tribal	Tulalip Bay Spring	3	IsH	Y	409.96	0	0	0	0	40	16,398
Tribal	Tulalip Bay falls	3	IsH	SY	98.65	0	0	0	0	200	19,730
Tribal	Tulalip Bay Summer	3	IsH	SY	98.65	1700	167,705	1,700	167,705	1700	167,705
Tribal / WDFW	Whitehorse Summer	1	InR	SY	98.65	220	21,703	220	21,703	420	41,433
WDFW	Wallace Yearling Summer	1	InH	Y	409.96	250	102,490	125	51,245	500	204,980
WDFW	Wallace Fingerling Summer	1	InH	SY	98.65	1000	98,650	500	49,325	1000	98,650
						Snohomish County Totals	**390,548**		**289,978**		**548,896**

Table I-10. Characteristics of Puget Sound Chinook salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

						Alternatives 1 and 2		Alternative 3		Alternative 4	
Hatchery Operator	**HGMP Name**	**Chinook Salmon Population Recovery Category of Release Watershed[1]**	**Hatchery Program Type[2]**	**Life Stage[3] at Release**	**Cost Multiplier**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**
Whatcom County											
Tribal	Lummi Bay Fall	1?	InH	SY	98.65	1000	98,650	500	49,325	1000	98,650
Tribal	Lummi Bay Fall	3	IsH	SY	98.65	1000	98,650	1,000	98,650	1000	98,650
Tribal / WDFW	Skookum CK. Spring	1	InR	SY	98.65	200	19,730	200	19,730	200	19,730
WDFW	Kendall Creek Spring	1	InR	SY	98.65	150	14,798	150	14,798	150	14,798
WDFW	Kendall Creek Spring	1	InR	SY	98.65	600	59,190	600	59,190	600	59,190
						Whatcom County Totals	**291,018**		**241,693**		**291,018**
						North Puget Sound Tribal Totals	**365,005**		**315,680**		**401,133**
						North Puget Sound Tribal/WDFW Totals	**41,433**		**41,433**		**61,163**
						North Puget Sound WDFW Totals	**970,595**		**870,025**		**1,073,085**
						NORTH PUGET SOUND SUBREGION TOTALS	**1,377,033**		**1,227,138**		**1,535,382**
King County											
Tribal	Keta Creek Fall	1	InH	SY	98.65	600	59,190	300	29,595	600	59,190
Tribal	White River Spring	1	InR	Y	409.96	90	36,896	90	36,896	90	36,896
Tribal	White River Spring	1	InR	SY	98.65	260	25,649	260	25,649	260	25,649
Univ	Univ of WA Fingerling	3	IsH	SY	98.65	180	17,757	180	17,757	180	17,757
WDFW	Issaquah Fingerling	3	IsH	SY	98.65	2000	197,300	2,000	197,300	2000	197,300
WDFW	Soos Creek Yearling	1	InH	Y	409.96	300	122,988	150	61,494	300	122,988
WDFW	Soos Creek Fingerling	1	InH	SY	98.65	3200	315,680	1,600	157,840	3200	315,680
						King County Totals	**775,460**		**526,531**		**775,460**

Table I-10. Characteristics of Puget Sound Chinook salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Cost Multiplier	Alternatives 1 and 2		Alternative 3		Alternative 4	
						Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Kitsap County											
Tribal	Grover's Ck and satellite Fall	3	IsH	SY	98.65	50	4,933	50	4,933	50	4,933
Tribal	Grover's Ck& satellite Fall	3	IsH	SY	98.65	150	14,798	150	14,798	350	34,528
Tribal	Grover's Ck& satellite Fall	3	IsH	SY	98.65	2000	197,300	2,000	197,300	2000	197,300
Tribal	Grover's Ck& satellite Fall	3	IsH	Y	409.96	150	61,494	150	61,494	150	61,494
Tribal	Grover's Ck& satellite Fall	3	IsH	SY	98.65	500	49,325	500	49,325	500	49,325
						Kitsap County Totals	**327,849**		**327,849**		**347,579**
Mason County											
WDFW	George Adams Fingerling Fall	2	InH	SY	98.65	3800	374,870	1,900	187,435	3800	374,870
WDFW	Hamma Hamma Fall	2	InH	SY	98.65	70	6,906	70	6,906	70	6,906
WDFW	Hoodsport Yearling Fall	3	IsH	Y	409.96	120	49,195	120	49,195	120	49,195
WDFW	Rick's Pond Yearling Fall	2	InH	Y	409.96	120	49,195	60	24,598	120	49,195
WDFW	Hoodsport Fingerling Fall	3	IsH	SY	98.65	2800	276,220	2,800	276,220	2800	276,220
						Mason County Totals	**756,386**		**544,353**		**756,386**

Table I-10. Characteristics of Puget Sound Chinook salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Cost Multiplier	Alternatives 1 and 2		Alternative 3		Alternative 4	
						Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Pierce County											
Tribal	Clark's Creek Fall	2	InR	SY	98.65	200	19,730	100	9,865	200	19,730
Tribal	Clark's Creek Fall	2	InH	SY	98.65	200	19,730	100	9,865	800	78,920
Tribal	Clear Ck Fall	2	InH	SY	98.65	3400	335,410	1,700	167,705	3700	365,005
Tribal	White R. Spring Acclimated	1	InR	SY	98.65	840	82,866	840	82,866	840	82,866
WDFW	Chambers Creek Yearling Fall	3	IsH	SY	98.65	200	19,730	200	19,730	2820	278,193
WDFW	Chambers Creek Yearling Fall	3	IsH	Y	409.96	200	81,992	200	81,992	200	81,992
WDFW	Garrison Springs Fingerling Fall	3	IsH	SY	98.65	850	83,853	850	83,853	850	83,853
WDFW	Garrison Springs Fingerling Fall	3	IsH	SY	98.65	300	29,595	300	29,595	300	29,595
WDFW	Hupps Springs White River	3	IsR	SY	98.65	250	24,663	250	24,663	250	24,663
WDFW	Hupps Springs White River	3	IsR	Y	409.96	85	34,847	85	34,847	85	34,847
WDFW	Minter Creek Fingerling Fall	3	IsH	SY	98.65	1800	177,570	1,800	177,570	1800	177,570
WDFW	Voights Creek Fall	2	InH	SY	98.65	1600	157,840	800	78,920	1600	157,840
						Pierce County Totals	**1,067,825**		**801,470**		**1,415,073**

Table I-10. Characteristics of Puget Sound Chinook salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Cost Multiplier	Alternatives 1 and 2		Alternative 3		Alternative 4	
						Release Number by Program (thousands)	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**
Thurston County											
Tribal	Kalama Creek Fall	2	InR	SY	98.65	600	59,190	300	29,595	600	59,190
WDFW	Tumwater Falls yearlings	3	IsH	Y	409.96	200	81,992	200	81,992	200	81,992
WDFW	Tumwater Falls fingerlings	3	IsH	SY	98.65	3800	374,870	3,800	374,870	5800	572,170
Thurston County Totals							**516,052**		**486,457**		**713,352**
South Puget Sound Tribal Totals							**966,510**		**719,885**		**1,075,025**
South Puget Sound WDFW Totals							**2,459,305**		**1,949,018**		**2,915,068**
South Puget Sound University Totals							**17,757**		**17,757**		**17,757**
SOUTH PUGET SOUND SUBREGION TOTALS							**3,443,572**		**2,686,660**		**4,007,850**
Clallam County											
WDFW	Dungeness Spring	1	InR	SY	98.65	100	9,865	100	9,865	100	9,865
WDFW	Elwha summer/fall	1	InR	SY	98.65	2500	246,625	2,500	246,625	2500	246,625
WDFW	Dungeness Spring	1	InR	Y	409.96	100	40,996	100	40,996	100	40,996
WDFW	Elwha summer/fall	1	InR	Y	409.96	400	163,984	400	163,984	400	163,984
Clallam County Totals							**461,470**		**461,470**		**461,470**
STRAIT OF JUAN DE FUCA SUBREGION (all WDFW) TOTALS							**461,470**		**461,470**		**461,470**
Puget Sound Region Totals							**5,282,075**		**4,375,269**		**6,004,702**

Source: D. Schmitt, Northwest Indian Fisheries Commission, March 23, 2010.

[1] Chinook salmon population recovery categories for release watersheds are from WDFW and Puget Sound Treaty Tribes (2004) and Puget Sound Treaty Tribes and WDFW (2004). See EIS Subsection 2.2.2, Hatchery Management Goal and Strategies for details.

[2] Program types: IsH – isolated harvest; IsR – isolated recovery; InR – integrated recovery; InH – integrated harvest; research.

[3] Life stages at release: SY – subyearling; Y – yearling.

Table I-11. Characteristics of Puget Sound coho salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses.

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Island County										
WDFW	Mukilteo Net Pen	3	IsH	Y	20	6,775	20	6,775	20	6,775
WDFW	Oak Harbor Net Pens	3	IsH	Y	30	10,163	30	10,163	30	10,163
WDFW	Possession Point	3	IsH	Y	50	16,938	50	16,938	50	16,938
					Island County Totals	**33,875**		**33,875**		**33,875**
San Juan County										
WDFW	Glenwood springs	3	IsH	SY	10	0	10	0	10	0
WDFW	Glenwood springs	3	IsH	Y	100	33,875	100	33,875	100	33,875
WDFW	San Juan Net pens	3	IsH	Y	15	5,081	15	5,081	15	5,081
					San Juan County Totals	**38,956**		**38,956**		**38,956**
Skagit County										
WDFW	Baker Lake	1	InH	Y	60	20,325	30	10,163	60	20,325
WDFW	Baker Lake	1	InH	SY	120	0	60	0	310	0
WDFW	Marblemount	1	InH	Y	250	84,688	125	42,344	250	84,688
WDFW	Marblemount	1	InH	Y	100	33,875	50	16,938	100	33,875
					Skagit County Totals	**138,888**		**69,444**		**138,888**
Snohomish County										
Tribal	Stillaguamish Coho	1	InH	Y	54	18,293	27	9,146	54	18,293
Tribal	Tulalip Bay Coho	3	IsH	Y	1,000	338,750	1,000	338,750	3,000	1,016,250
WDFW	Laebugton Net Pen	3	IsH	Y	25	8,469	25	8,469	25	8,469
WDFW	Wallace Creek	1	InH	Y	150	50,813	75	25,406	300	101,625
					Snohomish County Totals	**416,324**		**381,771**		**1,144,636**

Table I-11. Characteristics of Puget Sound coho salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Whatcom County										
Tribal	Lummi Coho	1	InH	Y	1,000	338,750	500	169,375	2,000	677,500
Tribal	Lummi Coho	3	InH	Y	1,000	338,750	1,000	338,750	2,000	677,500
WDFW	Kendall Creek	1	InH	Y	300	101,625	150	50,813	300	101,625
WDFW	Whatcom Creek	3	IsH	Y	5	1,694	5	1,694	5	1,694
					Whatcom County Totals	**780,819**		**560,631**		**1,458,319**
					North Puget Sound Tribal Totals	**1,034,543**		**856,021**		**2,389,543**
					North Puget Sound WDFW Totals	**374,319**		**228,656**		**425,131**
					NORTH PUGET SOUND SUBREGION TOTALS	**1,408,862**		**1,084,677**		**2,814,674**
King County										
WDFW	Issaquah	3	IsH	Y	450	152,438	450	152,438	450	152,438
WDFW	Marine Tech	3	IsH	Y	10	3,388	10	3,388	10	3,388
WDFW	Marine Tech	3	IsH	SY	15	5,081	15	5,081	15	5,081
WDFW	Ballard Net Pens	3	IsH	Y	30	10,163	30	10,163	30	10,163
WDFW	Des Moines Net Pen	3	IsH	Y	30	10,163	30	10,163	30	10,163
WDFW	Portage Bay	3	IsH	Y	90	30,488	90	30,488	90	30,488
WDFW	Soos Creek	1	InH	Y	600	203,250	300	101,625	600	203,250
Tribal	Keta Creek Coho	1	InH	Y	500	169,375	250	84,688	500	169,375
Tribal	Elliot Bay Net Pens	3	IsH	Y	395	133,806	395	133,806	395	133,806
					King County Totals	**718,150**		**531,838**		**718,150**

Table I-11. Characteristics of Puget Sound coho salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Kitsap County										
Tribal	Agate Pass Net-pens	NA	IsH	Y	600	203,250	600	203,250	600	203,250
Tribal	Port Gamble Net Pens	3	IsH	Y	400	135,500	400	135,500	600	203,250
					Kitsap County Totals	**338,750**		**338,750**		**406,500**
Mason County										
WDFW	George Adams	2	IsH	Y	300	101,625	150	50,813	300	101,625
WDFW/Tribal	South Sound Net Pens	3	IsH	Y	2,600	880,750	2,600	880,750	3,200	1,084,000
					Mason County Totals	**982,375**		**931,563**		**1,185,625**
Pierce County										
Tribal	Clear Creek Coho	2	IsH	Y	630	213,413	315	106,706	630	213,413
Tribal	Crisp Creek Coho	1	InH	Y	200	67,750	100	33,875	300	101,625
Tribal	Puyallup Tribe Acclimation Coho	1	InR	Y	200	67,750	200	67,750	200	67,750
WDFW	Minter Creek	3	IsH	Y	1,044	353,655	1,044	353,655	1,044	353,655
WDFW	Voight's Creek	2	IsH	Y	780	264,225	390	132,113	1180	399,725
					Pierce County Totals	**966,793**		**694,099**		**1,136,168**
Thurston County										
Tribal	Kalama Creek Coho	2	IsH	Y	350	118,563	175	59,281	350	118,563
					Thurston County Totals	**118,563**		**59,281**		**118,563**
					South Puget Sound Tribal Totals	**1,109,406**		**824,856**		**1,211,031**
					South Puget Sound Tribal/WDFW Totals	**880,750**		**880,750**		**1,084,000**
					South Puget Sound WDFW Totals	**1,134,474**		**849,924**		**1,269,974**
					SOUTH PUGET SOUND SUBREGION TOTALS	**3,124,630**		**2,555,530**		**3,565,005**

Table I-11. Characteristics of Puget Sound coho salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Clallam County										
Tribal	Lower Elwha Coho	1	InH	Y	750	254,063	375	127,031	750	254,063
WDFW	Dungeness	1	IsH	Y	500	169,375	250	84,688	500	169,375
Clallam County Totals						**423,438**		**211,719**		**423,438**
Jefferson County										
Tribal	Quilcene Net Pens	3	IsH	Y	200	67,750	200	67,750	450	152,438
USFW	Quilcene	3	IsH	Y	400	135,500	400	135,500	400	135,500
WDFW	Snow Creek	3	IsH	Y	0	0	0	0	0	0
WDFW	Snow Creek	3	IsH	SY	0	0	0	0	0	0
WDFW	Snow Creek	3	IsH	Y	0	0	0	0	0	0
WDFW	Snow Creek	3	IsH	SY	0	0	0	0	0	0
WDFW	Snow Creek	3	InR	Y	0	0	0	0	0	0
WDFW	Snow Creek	3	InR	SY	0	0	0	0	0	0
Jefferson County Totals						**203,250**		**203,250**		**287,938**
Strait of Juan de Fuca Tribal Totals						**321,813**		**194,781**		**406,500**
Strait of Juan de Fuca WDFW Totals						**169,375**		**84,688**		**169,375**
Strait of Juan de Fuca USFWS Totals						**135,500**		**135,500**		**135,500**
STRAIT OF JUAN DE FUCA SUBREGION TOTALS						**626,688**		**414,969**		**711,375**
Puget Sound Region Totals						**5,160,179**		**4,055,176**		**7,091,054**

Source: D. Schmitt, Northwest Indian Fisheries Commission, March 23, 2010.
[1] Chinook salmon population recovery categories for release watersheds are from WDFW and Puget Sound Treaty Tribes (2004) and Puget Sound Treaty Tribes and WDFW (2004). See EIS Subsection 2.2.2, Hatchery Management Goal and Strategies for details.
[2] Program types: IsH – isolated harvest; InR – integrated recovery; InH – integrated harvest.
[3] Life stages at release: SY – subyearling; Y – yearling.

Table I-12. Characteristics of Puget Sound sockeye, pink, and chum salmon hatchery programs and estimated production costs by alternative used in socioeconomics anlayses.

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Skagit County										
Tribal	Upper Skagit Fall Chum	1	InH	Fry	400	2,392	400	2,392	400	2,392
WDFW	Baker Lake Sockeye	1	InH	Fry	1000	30,020	1000	30,020	1000	30,020
				Skagit County Totals		**32,412**		**32,412**		**32,412**
Snohomish County										
Tribal	Stillaguamish Chum	1	InH	Fry	250	1,495	250	1,495	250	1,495
Tribal	Tulalip Chum	3	IsH	Fry	8,000	47,840	8,000	47,840	12,000	71,760
				Snohomish County Totals		**49,335**		**49,335**		**73,255**
Whatcom County										
Coop	Whatcom Creek Chum	3	IsH	Fry	2,000	11,960	2,000	11,960	4,000	23,920
Coop	Whatcom Creek Pink	3	IsH	Fry	1000	1,840	1000	1,840	1000	1,840
				Whatcom County Totals		**13,800**		**13,800**		**25,760**
				North Puget Sound Tribal Totals		**51,727**		**51,727**		**75,647**
				North Puget Sound WDFW Totals		**30,020**		**30,020**		**30,020**
				North Puget Sound Coop Totals		**13,800**		**13,800**		**25,760**
				NORTH PUGET SOUND SUBREGION TOTALS		**95,547**		**95,547**		**131,427**
King County										
Tribal	Keta Creek Fall Chum	1	InH	Fry	2,000	11,960	2,000	11,960	2,000	11,960
WDFW	Cedar River Sockeye	1	InH	Fry	16,000	480,320	16,000	480,320	16,000	480,320
				King County Totals		**492,280**		**492,280**		**492,280**

Table I-12. Characteristics of Puget Sound sockeye, pink, and chum salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Kitsap County										
Tribal	Cowling Creek Hatchery and Satellite Facilities, Fall Chum (Dogfish)	3	InH	Fry	500	2,990	500	2,990	500	2,990
Tribal	Grovers Fall Chum	3	InH	Eggs	500	2,990	500	2,990	1,200	7,176
Tribal	North Hood Canal Fall Chum	3	IsH	Fry	500	2,990	500	2,990	500	2,990
				Kitsap County Totals		**8,970**		**8,970**		**13,156**
Mason County										
Tribal	Skokomish Hatchery Fall Chum	3	IsH	Fry	2,500	14,950	2,500	14,950	2,500	14,950
WDFW	Hoodsport Fall Chum	3	IsH	Fry	12,000	71,760	12,000	71,760	15,000	89,700
WDFW	Skokomish Fall Chum	2	InH	Fry	10,000	59,800	10,000	59,800	15,000	89,700
WDFW	Hoodsport Pink	3	IsH	Fry	500	920	500	920	1000	1,840
				Mason County Totals		**147,430**		**147,430**		**196,190**
Pierce County										
Tribal	Diru Creek Fall Chum	1	InH	Fry	2,000	11,960	2,000	11,960	2,000	11,960
WDFW	Minter Creek Fall Chum	3	InH	Fry	2,000	11,960	2,000	11,960	2,000	11,960
				Pierce County Totals		**23,920**		**23,920**		**23,920**
				South Puget Sound Tribal Totals		**47,840**		**47,840**		**52,026**
				South Puget Sound WDFW Totals		**624,760**		**624,760**		**673,520**
				SOUTH PUGET SOUND SUBREGION TOTALS		**672,600**		**672,600**		**725,546**

Table I-12. Characteristics of Puget Sound sockeye, pink, and chum salmon hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Clallam County										
Tribal	Elwha River Fall Chum	1	InR	Fry	35	209	35	209	35	209
Tribal	Lower Elwha Fall Chum	1	InR	Eggs	75	449	75	449	75	449
Clallam County Totals						**658**		**658**		**658**
STRAIT OF JUAN DE FUCA SUBREGION TOTALS (ALL TRIBAL)						**658**		**658**		**658**
Puget Sound Region Totals						**768,805**		**768,805**		**857,631**

Source: D. Schmitt, Northwest Indian Fisheries Commission, March 23, 2010.

[1] Chinook salmon population recovery categories for release watersheds are from WDFW and Puget Sound Treaty Tribes (2004) and Puget Sound Treaty Tribes and WDFW (2004). See EIS Subsection 2.2.2, Hatchery Management Goal and Strategies for details.

[2] Program types: IsH – isolated harvest; InR – integrated recovery; InH – integrated harvest.

Table I-13. Characteristics of Puget Sound steelhead hatchery programs and estimated production costs by alternative used in socioeconomics analyses.

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
Skagit County										
WDFW	Barnaby Slough winter	1	IsH	Y	200	119,036	100	59,518	200	119,036
WDFW	Marblemount winter	1	IsH	Y	334	198,790	167	99,395	364	216,646
WDFW	Whatcom Creek winter	3	IsH	Y	35	20,831	35	20,831	35	20,831
					Skagit County Totals	**338,657**		**179,744**		**356,513**
Snohomish County										
WDFW	Reiter Pond summer	1	IsH	Y	250	148,795	125	74,398	250	148,795
WDFW	Reiter Pond winter	1	IsH	Y	250	148,795	125	74,398	250	148,795
WDFW	Tokul winter	1	IsH	Y	185	110,108	93	55,054	185	110,108
WDFW	Wallace winter	1	IsH	Y	20	11,904	10	5,952	20	11,904
WDFW	Whitehorse Pond summer	1	IsH	Y	70	41,663	35	20,831	70	41,663
WDFW	Whitehorse Pond winter	1	IsH	Y	150	89,277	75	44,639	150	89,277
					Snohomish County Totals	**550,542**		**275,271**		**550,542**
Whatcom County										
WDFW	Kendall Creek winter	1	IsH	Y	150	89,277	75	44,639	150	89,277
WDFW	Whatcom Creek winter (Whatcom Creek)	3	IsH	Y	5	2,976	5	2,976	10	5,952
					Whatcom County Totals	**92,253**		**47,614**		**95,229**
					NORTH PUGET SOUND SUBREGION TOTALS (ALL WDFW)	**981,452**		**502,630**		**1,002,283**

Table I-13. Characteristics of Puget Sound steelhead hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)	Release Number by Program (thousands)	Cost ($)
King County										
Tribal / WDFW	White River Supplementation winter	1	InR	Y	35	20,831	35	20,831	35	20,831
WDFW	Green River Winter	1	InR	Y	50	29,759	50	29,759	50	29,759
WDFW	Palmer Ponds summer	1	IsH	Y	50	29,759	25	14,880	50	29,759
WDFW	Palmer Ponds summer	1	IsH	Y	30	17,855	15	8,928	30	17,855
WDFW	Palmer Ponds winter (Flaming Geyser)	1	IsH	Y	15	8,928	8	4,464	15	8,928
WDFW	Palmer Ponds winter	1	IsH	Y	150	89,277	75	44,639	208	123,797
WDFW	Palmer Ponds winter (Icy Creek)	1	IsH	Y	20	11,904	10	5,952	20	11,904
WDFW	Palmer Ponds winter (Soos Creek)	1	IsH	Y	35	20,831	18	10,416	35	20,831
King County Totals						**229,144**		**139,867**		**263,665**
Mason County										
WDFW	Hamma Hamma winter	2	InR	Y	5	2,857	2	1,428	5	2,857
Mason County Totals						**2,857**		**1,428**		**2,857**
Puyallup County										
WDFW	Voight's Creek winter	2	IsH	Y	200	119,036	100	59,518	200	119,036
Puyallup County Totals						**119,036**		**59,518**		**119,036**
South Puget Sound Tribal/WDFW Totals						**20,831**		**20,831**		**20,831**
South Puget Sound WDFW Totals						**330,206**		**179,982**		**364,726**
SOUTH PUGET SOUND SUBREGION TOTALS						**351,037**		**200,814**		**385,558**

Table I-13. Characteristics of Puget Sound steelhead hatchery programs and estimated production costs by alternative used in socioeconomics analyses (continued).

Hatchery Operator	HGMP Name	Chinook Salmon Population Recovery Category of Release Watershed[1]	Hatchery Program Type[2]	Life Stage[3] at Release	Alternatives 1 and 2		Alternative 3		Alternative 4	
					Release Number by Program (thousands)	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**	**Release Number by Program (thousands)**	**Cost ($)**
Clallam County										
Tribal	Lower Elwha winter	1	IsH	Y	150	89,277	75	44,639	150	89,277
WDFW	Dungeness winter	1	IsH	Y	10	5,952	5	2,976	10	5,952
Clallam County Totals						**95,229**		**47,614**		**95,229**
Strait of Juan de Fuca Tribal Totals						**89,277**		**44,639**		**89,277**
Strait of Juan de Fuca WDFW Totals						**5,952**		**2,976**		**5,952**
STRAIT OF JUAN DE FUCA SUBREEGION TOTALS						**95,229**		**47,614**		**95,229**
Puget Sound Region Totals						**1,427,718**		**751,058**		**1,483,070**

Source: D. Schmitt, Northwest Indian Fisheries Commission, March 23, 2010.

[1] Chinook salmon population recovery categories for release watersheds are from WDFW and Puget Sound Treaty Tribes (2004) and Puget Sound Treaty Tribes and WDFW (2004). See EIS Subsection 2.2.2, Hatchery Management Goal and Strategies for details.

[2] Program types: IsH – isolated harvest; InR – integrated recovery; InH – integrated harvest.

[3] Life stage at release – Yearling.

Puget Sound Hatcheries Draft EIS

Appendix J

Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities

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This appendix provides information in support of the water quality components of Environmental Impact Statement (EIS) Subsection 3.6, Water Quality and Quantity, and EIS Subsection 4.6, Water Quality and Quantity.

1.0 Water Quality Parameters

Industries, including hatcheries, that use and return water from streams for operations may affect several water quality parameters when the water is returned to the aquatic system (known as effluent), particularly if the water use is for supporting biological organisms, such as fish. Water quality parameters that can be altered in effluent include temperature, ammonia, organic nitrogen, total phosphorus, biochemical oxygen demand (BOD), pH, and solids levels (Sparrow 1981; Washington State Department of Ecology [Ecology] 1989; Kendra 1991; Cripps 1995; Bergheim and Åsgård 1996; Michael 2003). Chemicals within hatchery effluents that are used to support biological organisms include antibiotics (a therapeutic), fungicides, and disinfectants (Boxall et al. 2004; Pouliquen et al. 2009; Martinez-Bueno et al. 2009). Other chemicals and organisms that could potentially be released in effluent include polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT) and its metabolites (Missildine et al. 2005; Hatchery Scientific Review Group [HSRG] 2009), pathogens (HSRG 2005, 2009), steroid hormones (Kolodziej et al. 2004), anesthetics, pesticides, and herbicides. In addition, removal of water for hatchery uses also affects stream flow.

This appendix describes each of these water quality parameters, explains how the parameter is transported from hatcheries into the aquatic system, and discusses potential effects on receiving waters. The water quality parameters discussed are transported from hatcheries to the aquatic system through discharges of hatchery water used for operations, decomposition of hatchery-origin salmon carcasses placed in streams to enhance nutrient levels, and releases of hatchery-origin salmon into receiving streams. Discharges from hatchery facilities are regulated under the Clean Water Act, as discussed later in this subsection, while planting of carcasses and release of hatchery-origin fish into streams are not regulated.

Industry effluent has the potential to affect the health and productivity of receiving waters. Hatchery facility waste products include uneaten food, fecal matter, soluble metabolites (e.g., ammonia), algae, parasitic microorganisms, drugs, and other chemicals (Kendra 1991; Bergheim and Åsgård 1996; Idaho Department of Environmental Quality [IDEQ] 2008; Ecology 2010a). Fish hatchery facility wastewater commonly includes suspended solids and settleable solids (those that settle out of suspension), as well as nutrients, such as various forms of nitrogen (e.g., ammonia) and phosphorus (Michael 2003). Some of the chemical or physical parameters having the greatest potential to impact receiving waters are temperature, nitrogen, phosphorus, dissolved oxygen, pH, and solids, as described below (IDEQ 2002; U.S. Environmental Protection Agency [EPA] 2008).

Some water quality parameters can be improved by decomposition of the carcasses of spawned-out salmon at the facility site (from hatchery-origin adults that return to a hatchery facility or net pen but are not collected), hatchery-origin adults that spawn naturally, and hatchery-origin carcasses that are deliberately placed in streams. The direct placement of spawned-out carcasses in a watershed is, in part, a response to research demonstrating that carcasses from adult salmon and steelhead that died after spawning historically represented a critical contribution of marine-derived nutrients (particularly phosphorus) to the overall productivity of both the aquatic and terrestrial ecosystem (Cederholm et al. 2000).

1.1 Temperature

The temperature of receiving waters adjacent to hatcheries can be altered by the discharge of warmer or colder water from these facilities. Salmon and steelhead require specific temperatures for growth, maintenance, and reproduction at the hatcheries. Water temperatures that fluctuate dramatically or move beyond the optimal range for each salmon life stage can impart stress, thereby reducing production efficiency, increasing disease susceptibility, and altering waste generation within the facility (IDEQ 2002). Thus, hatcheries may release water with a temperature that is optimum for hatchery operations, but differs from the receiving environment.

In addition, some hatchery facility effluents are diverted to settling basins before discharge to receiving waters. With little or no flow, water temperature within these settling basins could be increased by solar insulation prior to discharge (Kendra 1991), with the amount of increase dependent on the retention time of water in the basin. When these hatchery facility effluents are released into nearby water bodies, there may be impacts on the receiving water bodies if the effluent is warmer than the receiving water. The extent of the effect would depend on the absolute temperature difference, the volume of effluent released, and the size (water volume) of the receiving water body. To minimize this effect when temperature of the receiving water is a concern, effluent discharge permits for hatcheries may specify effluent temperature limits, either just prior to discharge, or at the downstream end of a mixing zone in the receiving water. Prior monitoring of several hatcheries in Washington indicated that effluent from hatchery facilities would not have a reasonable potential to exceed water quality standards for temperature (Ecology 2010a).

1.2 Nutrients

Nutrients, such as various forms of nitrogen and phosphorus, are a commonly recognized constituent of hatchery facility wastewater (Michael 2003). Nitrogen and phosphorus are recognized as potential limiting factors in many aquatic systems (Michael 2003); the amount of these nutrients in an aquatic system helps to determine the amount of aquatic plant growth. Elevated levels of these nutrients encourage the growth of aquatic plants, which then changes the aquatic habitat. In addition, the growth of the aquatic plants results in consumption of oxygen that fish and other native plants also need to survive (Kendra 1991; IDEQ 2008). An increase in nutrients could also change macrobenthic (e.g., insect) communities (species presence and/or abundance) downstream from effluent discharges, potentially affecting the availability of preferred prey resources (Camargo 1992).

In addition to nutrient concentrations in discharged effluent, nutrient levels in the receiving environment are affected through the release of organic matter (uneaten food, feces, and dead fish) in effluent, which also occurs through the decomposition of spawned-out or deliberately placed salmon carcasses. As organic matter decomposes, it consumes oxygen in the process and releases additional nutrients (nitrogen [as nitrate-nitrite and ammonia] and phosphorus) to the environment. Ammonia forms ammonium ion (NH_4^+) and un-ionized ammonia (NH_3), which could be harmful or lethal to aquatic organisms. This toxic, un-ionized fraction varies with pH, temperature, and salinity, and it increases as the pH and temperature increase (IDEQ 2002). The decomposition of spawning salmon carcasses also results in the release of nutrients (primarily phosphorus) (Washington Department of Fish and Wildlife [WDFW] 2004); however, such releases are considered beneficial because they are gradual, spread out over larger areas, and only occur during the spawning season (Cederholm et al. 2000). In contrast, hatcheries operate throughout the year, and the effluent discharge typically occurs at a single location. Thus, there are temporal and spatial components to natural delivery of these nutrients by spawning fish that nutrient delivery through wastewater does not duplicate (Michael 2003).

Most of the nutrients of concern in hatchery facility effluent are associated with solids (i.e., they are the result of organic matter from uneaten food and feces) in the effluent (Ecology 2010a). Investigations of treatment options have identified the process of settling solids (which allow removal of such solids) as the most cost-effective method to reduce the amount of nutrients in the effluent to an acceptable level (McLaughlin 1981; Michael 2003). Hatchery facilities typically use settling ponds to reduce the solids in their discharge effluent. With adequate removal of solids, there is a low risk of water quality violations from nutrients (Ecology 2010a). However, the risk of nutrient impairment from effluent discharged into a stream also depends on the physical and chemical characteristics of that stream.

1.3 Dissolved Oxygen

By far, oxygen is the most important dissolved gas in an aquatic environment because it is necessary to support life. Depleted dissolved oxygen levels could adversely affect receiving waters by reducing productivity and usable habitat for aquatic species. Tolerances for dissolved oxygen conditions vary widely by aquatic species. While most aquatic organisms could survive brief periods at low oxygen levels, prolonged exposure could have adverse effects on organisms not adapted for such conditions (IDEQ 2002). Reduced dissolved oxygen could cause stress, making organisms less competitive and productive, and in severe cases, could result in direct mortality (Ecology 2005a).

Dissolved oxygen levels in an aquatic system could be reduced directly through the release of nutrients (nitrogen and phosphorus) from organic matter into the water column (Piedrahita et al. 1996). Indirectly, dissolved oxygen could be reduced by the decomposition of organic matter in hatchery facility effluent discharged into receiving waters or through the decomposition of salmon carcasses. The decomposition process uses oxygen, which is typically referred to as BOD. While not a specific compound, BOD is a measure of the amount of oxygen consumed by this biological process. It is used in modeling to assess the potential reduction of dissolved oxygen in receiving water caused by effluent discharge (Ecology 2010a).

In the late 1980s, Ecology conducted a survey showing that several hatchery facilities exceeded water quality criteria for BOD (Ecology 1989; Kendra 1991). Consequently, changes in Washington's National Pollutant Discharge Elimination System (NPDES) permit requirements included individual best management practices (BMPs) and waste handling plans that, when complied with, help ensure that water quality criteria for dissolved oxygen are not exceeded (Ecology 2010a). Subsequent monitoring by Ecology for temperature and dissolved oxygen in hatchery facility effluent showed that applying the recommended BMPs resulted in meeting water quality standards for these two parameters (Ecology 2010a). This led Ecology to drop temperature and dissolved oxygen as monitoring requirements from subsequent NPDES permits (Ecology 2010a).

1.4 pH

The term pH is a measure of hydrogen ion concentration, and is important because aquatic organisms could be harmed when conditions lead to pH levels outside their normal tolerance range in their environment (IDEQ 2002). Changes in pH likely arise from primary production (algal growth via photosynthesis) within hatcheries (Kendra 1991). Effluent with a lower pH than the receiving water is more acidic, while effluent with a higher pH is more basic than the receiving water. Release of excess nutrients in effluent can also cause excess growth of periphyton (attached algae) in streams (Ecology 2009). Decreases in pH can lead to increased toxicity of certain chemicals, including ammonia and nitrite.

1.5 Sediment (Turbidity, Total Suspended Solids, and Settleable Solids)

Sediment in streams is assessed by turbidity, which is the measure of light blocked and scattered by particles (cloudiness) in the water column. In effluent, sediment is measured as total suspended solids (TSS) (which is the amount [mass] of particles suspended in the water column) and settleable solids, which is the amount of particles that fall out of suspension and accumulate at the bottom of the water column (sedimentation). Effluent discharged from the operation and maintenance of hatcheries could increase sediments in downstream water (turbidity), as well as sedimentation rates, by flushing uneaten feed, feces, and dead fish when cleaning raceways and holding ponds to the downstream receiving environment (Kendra 1991; Williams et al. 2003).

Settling solids (i.e., allowing solids to fall to the bottom of a holding basin) has been shown to be an effective method to reduce solids in effluent (Michael 2003). Hatcheries typically use settling ponds to reduce the settleable solids and TSS levels in their discharge effluent. Relative to the dissolved components of waste, such as phosphorus and ammonia, solids are much easier to capture and remove from the aquaculture operation prior to effluent discharge (IDEQ 2002). Offline settling basins are used to capture particles of organic matter and prevent such releases into receiving waters.

1.6 Persistent Organic Pollutants (Fish Tissue)

While in the marine environment, salmon can ingest PCBs and store them in their body fat (Bonneville Power Administration [BPA] and Confederated Tribes of the Colville Reservation [CTCR] 2007). Several studies by National Oceanic and Atmospheric Administration (NOAA) Fisheries indicated that juvenile salmon can accumulate toxicants, including PCBs and DDTs, during downstream migration and smolting (e.g., Johnson et al. 2007a,b; Meador et al. 2009; Sloan et al. 2010). Feed or supplements used by hatcheries may also be a source of PCBs and DDTs (Maule et al. 2007; Maule 2009). Distribution of hatchery-origin carcasses in streams could result in the release of PCBs and DDTs into the freshwater aquatic system as the carcasses decompose (Missildine et al. 2005). However, the likelihood of PCB and DDT release from salmon carcasses would likely be similar between hatchery-origin and natural-origin salmon and steelhead since these fish would be exposed to the same toxicants in river, estuary, and ocean environments. Thus, hatcheries are not considered a contributor of PCBs and/or DDTs to water indirectly through fish decomposition and resulting releases into the water column. The exception may be Puget Sound Chinook salmon that are partially resident in Puget Sound, and comprise about 4 percent of all Chinook salmon that occur in Puget Sound. These fish accumulate substantially higher concentrations of PCBs than other hatchery stocks (O'Neill and West 2009).

1.7 Pathogens

While hatcheries conduct regular screening for pathogens and diseases (parasites, viruses, and bacteria), and follow prescriptive measures to control the spread of such pathogens, some pathogens are released in hatchery facility effluent or from the inadvertent release of affected fish. Fish pathogens include infectious pancreatic necrosis virus, infectious hematopoietic necrosis virus, viral hemorrhagic septicemia virus, furunculosis (*Aeromonas salmonicida*), enteric redmouth (*Yersinia ruckeri*), whirling disease (*Myxobolus cerebralis*), salmonid ceratomyxosis (*Ceratomyxa shasta*), and *Renibacterium salmoninarum* (causative agent of bacterial kidney disease [BKD]) (Naylor et al. 2005; NWIFC and WDFW 2006).

Although salmon carcasses could also result in the introduction of pathogens into the aquatic system (U.S. Fish and Wildlife Service [USFWS] 1999; LaPatra 2003; HSRG 2005, 2009; Naylor et al. 2005), there is little evidence that demonstrates that this is a common occurrence (USWFS 1999; LaPatra 2003). Furthermore, as discussed above, outside of the hatchery facility, hatchery-origin and natural-origin salmon and steelhead would be exposed to the same pathogens; thus, the likelihood of pathogens being in hatchery-origin carcasses would be about the same as that which occurs in natural-origin carcasses.

1.8 Steroid Hormones

Hatchery facility effluent has the potential to contribute steroid hormones to receiving waters. Like other vertebrate animals, salmon naturally produce and excrete steroid hormones, and wastewater treatment practices employed by most aquaculture facilities are unlikely to remove these hormones (Kolodziej et al. 2004). Kolodziej et al. (2004) detected the endogenous steroids estrone, testosterone, and androstenedione in the raceways and effluents of three fish hatcheries at concentrations near 1 mg/L. Such concentrations may be high enough to affect fish behaviors in hatcheries (Colman et al. 2009). Steroid hormones from wastewater treatment plant effluent and stormwater runoff are present in receiving waters at concentrations sufficient to affect fish at some sites in Puget Sound, inducing the abnormal production of vitellogenin (egg yolk protein) in male English sole and juvenile salmon (Johnson et al. 2008; Peck et al. 2011). However, it is unlikely that releases of these hormones in hatchery effluents are sufficient to affect water quality of the receiving waters, but there is limited monitoring data and no current effluent discharge limits or water quality standards for steroid hormones.

1.9 Chemicals Used in Hatchery Programs

Fish hatcheries use a broad spectrum of chemicals such as commercial antibiotics, fungicides, and disinfectants for the control of bacterial and fungal disease agents associated with fish aquaculture. The types and amounts of chemicals used at a hatchery facility depend on site-specific conditions, fish culture practices, species of fish, and types of parasites or disease organisms being treated.

The discharge of treated waters in raceways to receiving environments results in the release of these chemicals to downstream receiving waters. Several of the antibiotics used in aquaculture have been detected in receiving waters and sediment downstream of fish farms (Boxall et al. 2004; Pouliquen et al. 2009; Martinez-Bueno et al. 2009). Although concentrations observed in the water column are usually well below those toxic to fish and invertebrates, they could impact naturally occurring algae and bacteria (Boxall et al. 2004). Additionally, there are some reports of antibiotic resistance and other problems in river systems with high inputs of these compounds.

Several Federal agencies have approved hatchery facilities to use a broad spectrum of commercial antibiotics, fungicides, and disinfectants. The use of these federally regulated products requires hatchery personnel to follow manufacturer-identified conditions under which the product is expected to be effective and safe. Discharge of these chemicals is not expected to cause receiving water toxicity if use is consistent with product labels, Food and Drug Administration (FDA) regulations, and effluent discharge permit requirements mandating BMPs (Ecology 2010a; EPA 2008). Effluent discharge permits also require regular reporting of hatchery chemical use to monitor proper use (Ecology 2010b; EPA 2009). Adherence to label recommendations, regulations, and effluent discharge permit requirements also minimizes levels of other hatchery chemicals for which water quality criteria have not been established, as well as the potential for the development of antibiotic resistance in receiving waters.

2.0 Applicable Hatchery Facility Regulations and Compliance

Hatchery facilities must comply with all applicable Federal, state, and tribal water quality standards for effluent discharges and Federal and state regulations on use of chemicals and fish food. This subsection discusses the Federal, state, and tribal regulations applicable to water quality and describes how hatchery facilities in Puget Sound (i.e., analysis area) comply with these regulations.

2.1 Federal Regulations

The direct discharge of hatchery facility effluent is regulated by the EPA under the Clean Water Act through NPDES permits. For discharges from hatcheries not located on Federal or tribal lands within Washington, the EPA has delegated its regulatory oversight to Washington State. However, Washington State is responsible for certifying that NPDES-permitted projects located on Federal lands (but not on tribal lands) comply with state water quality standards. This is accomplished through Clean Water Act section 401 water quality certification. As a result of this certification, hatchery facilities that are in compliance with water quality standards, and thus their NPDES permits, are considered not to cause or contribute to a violation of water quality standards.

EPA defines concentrated aquatic animal production facilities as point sources subject to the NPDES permit program (40 Code of Federal Regulations [CFR] §122.24). These facilities include hatcheries, fish farms, and other facilities that contain, grow, or hold salmon in ponds, raceways, or other similar structures that discharge at least 30 days per year and produce more than 20,000 harvest weight pounds of salmon per year or feed more than 5,000 pounds of food during the calendar month of maximum feeding. Washington also uses this definition to identify hatchery facilities that require an NPDES permit (Washington Administrative Code [WAC] 173-221A-100). Facilities that do not meet the minimum threshold requirements are not considered point sources, but EPA or Ecology may designate such a facility as a significant contributor of pollution and require it to obtain NPDES permit coverage. Other facilities that do not require NPDES permit coverage must still comply with state water quality and groundwater standards.

NPDES permits are typically renewed on a 5- or 10-year basis, and permit limits may be revised to reflect changes in water quality standards or treatment technologies. New or modified permits may be required at other times if a permitted facility expands, increases production, or modifies processes so that discharges of pollutants increase or the nature of the discharged pollutants changes. A new or modified permit may also be required if a facility is located within a watershed for which one or more pollutant limits are established. These pollutant limits, or total daily maximum loads (TMDLs), are discussed below.

EPA Region 10 issued a general NPDES permit for Federal aquaculture facilities and aquaculture facilities in Indian Country within the boundaries of the State of Washington, which became effective August 1, 2009 (EPA 2009). This permit was closely based on Washington's previous upland fin-fish hatchery and rearing general permit, which was effective from June 1, 2005, through July 31, 2010 (Ecology 2005b).

For TSS and settleable solids, EPA's general permit includes the same discharge limits and sampling frequencies as Washington's general permit. EPA's general permit also includes limits on total residual chlorine for all discharge types, while Washington's general permit only includes a limit on total residual chlorine for discharges of rearing vessel disinfection water (these limits only apply when chlorine is being used).

Since EPA had not issued a general permit for federal and tribal aquaculture facilities in Washington before 2009, additional requirements were included to support future analyses of water quality effects for development of future issuances of its general permit. Additional discharge monitoring requirements include disinfectants (other than chlorine), copper (or other anti-fouling agents, when used), and hardness (only when copper monitoring is required) in hatchery effluent and ammonia, temperature, and pH in offline settling basin discharges to receiving waters that are impaired for ammonia or total nitrogen. Surface water monitoring requirements include ammonia, pH, and temperature immediately upstream of offline settling basins that discharge directly to surface waters, as well as copper and hardness when copper compounds are applied.

PCBs, which were included in paint and caulk prior to their banning in the late 1970s, have recently been found in several hatcheries, including the Leavenworth National Fish Hatchery in eastern Washington. EPA Region 10 is concerned that PCBs in paint or caulk may be an issue in other Washington aquaculture facilities (EPA 2008). To address this concern, EPA's general permit requires hatcheries to include information on painted and caulked surfaces that regularly contact process water when they apply for general permit coverage.

Washington (Ecology) is also responsible for issuing and enforcing NPDES permits. The EPA administers NPDES permits for all projects on Federal and tribal lands; however, Native American tribes may adopt their own water quality standards for permits on tribal lands. State and tribal water quality standards are discussed separately below. The EPA (2004) established national effluent limitation guidelines for concentrated aquatic animal production facilities that produce more than 100,000 pounds of aquatic animals per year in flow-through or recirculating systems. These guidelines address the discharge of TSS, BOD, and nutrients (69 Fed. Reg. 51891, August 23, 2004). EPA determined that narrative guidelines were most appropriate and chose not to establish nationwide quantitative limits. This decision, in part, was to allow greater flexibility for states that had already adopted suspended sediment and BOD limits for hatchery operations. Additionally, the EPA chose not to establish numeric discharge limits for any antibiotics, fungicides, or disinfectants used in hatchery operations, choosing instead to require concentrated aquatic animal production facilities to follow existing Federal and state guidance concerning the safe handling and storage of these materials.

Fish hatcheries are approved by several Federal agencies to use a broad spectrum of commercial antibiotics, fungicides, and disinfectants to control bacterial and fungal disease agents associated with fish aquaculture. The use of these federally regulated products requires hatchery personnel to follow manufacturer-identified conditions under which the product could be expected to be effective and safe. Labels for approved products describe uses allowed by law. Any departure from the directions and conditions on the product label or on special state labels could be a legal violation. The use of hatchery treatment chemicals is closely regulated by EPA, and each hatchery operation has reporting requirements concerning their use. Discharge of these chemicals is not expected to cause receiving water toxicity if use is consistent with product labels, FDA regulations, and NPDES permit requirements mandating BMPs (Ecology 2010a; EPA 2008). State-specific water quality standards for hatchery treatment chemicals are discussed below.

As part of administering elements of the Clean Water Act, Washington is required to assess water quality in streams, rivers, and lakes. These assessments are published in what are referred to as the 305(d) report and the 303(d) list (the numbers referring to the relevant sections of the original Clean Water Act text). The 305(d) report reviews the quality of all waters of the state, while the 303(d) list identifies specific water bodies considered impaired (based on a specific number of exceedances of state water quality criteria in a specific segment of a water body). For water bodies that fail to meet state water quality standards, Federal law requires the state to identify sources of pollution to those water bodies and develop a Water Quality Improvement Report to address those pollutants. The Water Quality Improvement Report establishes limits on the pollutants (TMDLs) that can be discharged to a water body while still meeting state standards.

Of the specific parameters impairing water quality in segments of Puget Sound rivers, several are potentially associated with hatchery production. As stated above, hatchery facilities that are in compliance with their NPDES permits, and thus water quality standards, are considered not to cause or contribute to a violation of water quality standards. Hatchery facilities that do not meet the minimum threshold for obtaining NPDES permit coverage are also considered to not cause or contribute to a violation of water quality standards if they comply with water quality standards. However, the amounts of these chemicals being discharged into receiving waters from hatchery facilities do contribute to the total pollutant loads of those receiving waters and downstream waters.

For hatchery facilities covered under Washington State's previous general NPDES permit, the most common permit violations during the previous permit period were TSS limit exceedances from offline settling basins, which occurred during extreme high water events that caused high flow volumes to flush influent solids through the systems without allowing them to settle (Ecology 2010a). Monitoring data reported between January 2006 through January 2010 by the 82 active reporting facilities showed 129 permit violations, which included 6 facilities for settleable solids exceedances, 31 facilities for non-reporting or non-sampling events, and 92 facilities for TSS exceedances (Ecology 2010a). There are currently 37 Puget Sound hatchery facilities operating under active NPDES permits (29 state facilities, 7 tribal facilities, and 1 federal facility). For these facilities, queries of Ecology's Water Quality Permitting and Reporting Information System and EPA's Permit Compliance System database identified

12 reported effluent limit exceedances between January 2011 and November 2012 from eight facilities: 10 facilities for TSS from three state and four tribal facilities, 1 facility for settleable solids from a tribal facility, and 1 facility for total residual chlorine from a federal facility. None of these facilities discharge directly into water body segments that are impaired for turbidity or dissolved oxygen; however, two facilities (Issaquah Hatchery and Tulalip Creek Ponds) discharge upstream of water body segments with dissolved oxygen impairments (Issaquah Creek and Tulalip Bay, respectively).

For hatchery facilities that do not meet the minimum threshold for NPDES permit coverage, monitoring of effluent is not required. Consequently, the potential for these facilities to contribute to receiving water impairment by exceeding water quality criteria is unknown.

Additionally, any hatchery facility covered by an older NPDES permit may have discharge limits that do not address current water quality conditions or treatment technologies, possibly resulting in higher loads being discharged to receiving waters than would be allowed under a new permit. Currently, only one Puget Sound hatchery facility is not operating under a current NPDES permit. The South Sound Net Pens permit expired in 2007, but was extended until a renewed permit is issued.

2.2 State Regulations

Washington State has primary responsibility for the health and protection of the state’s water quality, but it depends primarily on EPA to develop and promulgate proposed water quality standards. The state has established water quality standards consisting of 1) designated uses for the water body, 2) water quality criteria (numeric pollutant concentrations and narrative requirements) to protect designated uses, 3) an antidegradation policy, and 4) general policies addressing implementation issues, such as low flows, mixing zones, and variances.

Provided below is specific information regarding Washington’s NPDES permits, including criteria, monitoring requirements, and compliance. There are currently no specific water quality criteria for steroid hormones. The state does not have specific water quality criteria for hatchery treatment chemicals and considers applications following manufacturer and Federal guidelines as meeting water quality objectives. All hatcheries within Puget Sound are currently in compliance with their NPDES permits; however, violations of effluent limits do occur, as discussed above.

Ecology reissued its *Upland Fin-Fish Hatching and Rearing Waste Discharge NPDES General Permit* effective August 1, 2010 (Ecology 2010b). This permit covers every upland fin-fish hatching or rearing facility within the jurisdiction of Ecology (as defined in WAC 173-221A-100 and described above). Hatchery facilities that are not land-based, such as net pens, as well as other facilities for which the general permit does not apply (e.g., facilities with TMDL wasteload allocations) are covered by individual NPDES permits. Only one of the Puget Sound net pen facilities meets the threshold for NPDES coverage; the South Sound Net Pens facility is covered under an individual industrial NPDES permit. Ecology's Water Quality Permitting and Reporting Information System reports no permit violations for this facility.

Washington's general permit (Ecology 2010b) established monthly averages and instantaneous maxima for settleable solids and TSS in the rearing ponds, raceway discharges, and any offline settling basin discharges, as well as an instantaneous maximum for total residual chlorine in discharges of rearing vessel disinfection water.

The *Upland Fin-Fish Hatching and Rearing NPDES General Permit* does not allow violation of the state's groundwater standards (Chapter 173-200 WAC). Ecology has determined that a properly operated upland fin-fish hatching and rearing facility poses little potential to impact state groundwater quality standards; however, this permit does not authorize a violation of these standards. Ecology may require facilities with the potential to violate these standards to obtain coverage under an individual permit, require additional sampling and groundwater monitoring, and/or require rearing and pollution abatement ponds to be lined, if necessary (Ecology 2010a). Currently, no Puget Sound hatchery facilities operate under individual NPDES permits for groundwater discharge. All effluent limit violations reported between January 2011 and November 2012 were for hatchery facilities that discharge to surface water bodies.

Washington has adopted surface water quality standards for turbidity, temperature, ammonia, dissolved oxygen, and pH. The numeric standards (both upper and lower in the case of pH) have been revised for these parameters in the last 10 years to be more protective of salmon and steelhead. Nutrient standards are primarily narrative and are aimed at minimizing production of algae when excess nitrates and phosphorus are present. Washington also regulates settleable solids and TSS in hatchery facility effluent discharges. For water bodies identified as having impaired water quality, Washington requires discharge permittees, including hatchery facility operators, to comply with state water quality standards for each pollutant considered to be causing a violation of water quality. For a facility that discharges to an impaired water body with a TMDL or other control plan for a pollutant with an effluent limitation in the general permit, individual NPDES permit coverage may be required if the general permit does not provide the level of protection required by the TMDL or control plan. The Puyallup Hatchery is the only Puget Sound hatchery facility currently covered under an individual NPDES permit to implement approved TMDLs

(BOD, ammonia, and residual chlorine). No effluent limit violations were reported at the Puyallup Hatchery between January 2011 and November 2012.

Washington requires effluent monitoring, recording, and reporting for each hatchery facility to verify that its treatment process is functioning correctly and effluent limitations are being achieved. In a 1988 survey of 19 trout and salmon hatchery facilities, Ecology found levels of BOD that sometimes exceeded state water quality standards. This survey spurred modifications of the general upland NPDES permit under which these facilities operate (Ecology 2010a), resulting in the application of effluent limits for solids (both settleable solids and TSS) to reduce the levels of organic matter introduced to the environment and minimize the downstream BOD levels. Due to concerns raised by this study (Ecology 1989; Kendra 1991), Ecology initiated specific monitoring for temperature and dissolved oxygen in hatchery facility effluent. The results of this additional monitoring showed that these facilities do not have reasonable potential to exceed water quality standards for these parameters (Ecology 2010a). This led Ecology to drop temperature and dissolved oxygen as monitoring requirements from subsequent NPDES permits (Ecology 2010a).

Ecology’s current NPDES permit requires monitoring of TSS (Ecology 2010b). Effects from hatchery facility effluent discharges on the downstream macrobenthic community have been observed in other salmon and trout rearing facilities in the United States and internationally (Kendra 1991; Camargo 1992; Selong and Helfrich 1998). Partly in response to these types of studies, investigations of treatment options have identified settling solids as the most cost-effective method to improve effluent quality to acceptable levels (McLaughlin 1981; Michael 2003). Most of the nutrients of concern are associated with solids, which are effectively removed in settling ponds. Washington’s NPDES permits have instituted requirements for controlling sediment discharges, believing that solids in effluent are the best indication of how well a facility is complying with its permit (Ecology 2010a).

The type and quantity of salmon carcasses that could be placed in the environment are under the control of specific state programs independent of hatchery program funding and management. In Washington, the WDFW has a specific program aimed at placing salmon carcasses in selected streams to increase marine-derived nutrients in streams based on historical levels of salmon escapement (WDFW 2004). While this program establishes guidelines for carcass distribution, the actual number distributed is independent of individual hatchery program production. Program guidelines include steps for minimizing the potential for violating water quality standards for nutrients as a result of carcass distribution. These include avoiding streams or stream reaches with identified water quality constraints for nutrients, obtaining approval from Ecology for placement in stream reaches that are impaired by excess nutrients, not depositing carcasses during poor water quality conditions, placing carcasses in terrestrial riparian zones, and monitoring (Cramer 2012). Also, most of the contaminants in the bodies of returning salmon are likely acquired during their time at sea, so that the potential for pollutants from hatchery-origin salmon carcasses to impact water quality would be similar to that from natural-origin fish (outside of the potential for resident Chinook salmon, which comprise 4 percent of all Chinook salmon in Puget Sound to carry an increased amount of contaminants).

2.3 Tribal Water Quality Standards

Twelve Native American Tribes manage hatcheries and satellite facilities located within Puget Sound: the Lower Elwha Klallam Tribe, Lummi Nation, Muckleshoot Indian Tribe, Nisqually Indian Tribe, Port Gamble S'Klallam Tribe, Puyallup Tribe of Indians, Skokomish Tribal Nation, Squaxin Island Tribe, Stillaguamish Tribe of Indians, Suquamish Tribe, Tulalip Tribes, and Upper Skagit Indian Tribe. Of these, the Lummi, Puyallup, and Port Gamble S'Klallam Tribes are responsible for certifying NPDES-permitted projects located on tribal lands and have EPA-approved water quality standards. The Tulalip Tribe is also responsible for certifying NPDES-permitted projects located on its tribal lands, but does not currently have EPA-approved water quality standards.

The Tribal Fish Health Manual (Northwest Indian Fisheries Commission [NWIFC] 2006), which includes *The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWIFC and WDFW 2006), provides guidance to tribal hatchery staff for producing healthy, quality fish and reducing the discharge of pollutants (solids, drugs, and chemicals) in tribal hatchery effluent. As noted above, four tribal hatchery facilities have reported effluent limit exceedances between January 2011 and November 2012. These include seven TSS exceedances and one settleable solids exceedance.

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Appendix K

Chemicals Used in Hatchery Operations

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Hatchery operations routinely use a variety of chemicals to maintain a clean environment for the production of disease-free fish. These chemicals and safe handling requirements for the chemicals are described in this appendix. A brief description of commonly used chemicals in hatchery facilities and operations is provided below. In addition, a literature review is provided describing the potential for toxic contaminants in salmon and steelhead. This appendix provides information in support of Environmental Impact Statement (EIS) Subsection 3.7, Human Health, and EIS Subsection 4.7, Human Health.

1.0 Commonly Used Hatchery Chemicals

Common chemicals used in hatchery operations are disinfectants, therapeutics, anesthetics, pesticides and herbicides, and feed additives.

1.1 Disinfectants

Disinfectants are primarily used to clean equipment throughout hatchery facilities and may also be used to treat fish diseases. Hatchery facility workers are typically exposed to these chemicals through skin contact or inhalation during cleaning activities. However, Federal and state occupational safety and health programs (e.g., Occupational Safety and Health Act [OSHA], Washington State Industrial Safety and Health Act [WISHA]) ensure safe workplaces and require personal protective equipment and procedures (e.g., gloves, use of proper ventilation procedures, and/or respiratory protection in enclosed spaces). Following directions on product labels and using other hatchery-specific safety measures reduces chemical exposure to safe levels. Some common disinfectants used in hatchery operations are described below.

- **Chlorine (sodium hypochlorite).** Sodium hypochlorite is used for cleaning tanks and equipment and is the active component in chlorine. This compound may also be used to destroy fish fry that are infected with a disease.
- **Chloramine T.** Chloramine T is used for disinfecting tanks and equipment, and the treatment of bacterial gill diseases in salmon and steelhead. The active component is chlorine.
- **Formalin.** Formalin is a saturated aqueous solution of formaldehyde. It is used as a general disinfectant and is effective against fungal or parasitic infections.
- **Hydrogen peroxide.** Hydrogen peroxide is used as a general disinfectant and is effective against fish parasites (e.g., sea lice).
- **Iodophor.** Iodophor is a form of stabilized iodine employed as a general disinfectant. It is used to disinfect fish eggs and is effective against some bacteria and viruses.

- **Quaternary ammonium compounds (Hyamine).** Ammonium compounds or topical disinfectants are used to remove parasites from fish and have detergent and antibacterial properties.

1.2 Therapeutics

Therapeutics, which include antibiotics, are chemicals or veterinary medicines designed to be effective against parasitic, bacterial, or viral infections in fish. The most commonly used therapeutics in salmon and steelhead hatchery operations are:

- **Amoxicillin.** Amoxicillin is generally used as a veterinary antibiotic.
- **Erythromycin.** Erythromycin is generally used as a veterinary antibiotic.
- **Florfenicol.** Florfenicol is generally used as a veterinary antibiotic.
- **Oxytetracycline (terramycin).** Terramycin is widely used as an antibiotic. Oxytetracycline may be applied orally in fish feed or as a bath and is effective against a wide range of bacteria.
- **Potassium permanganate.** Potassium permanganate is primarily used as a bath treatment for fungal infections of finfish. It may also be used to alleviate acute oxygen shortage and to remove organic contaminants in fish ponds.
- **Penicillin.** Penicillin is generally used as a veterinary antibiotic.
- **ROMET®.** ROMET® is typically applied in fish feed and used to control a variety of bacterial infections.
- **Sulfamethazole trimethoprim.** Sulfamethazole trimethoprim is generally used as a veterinary antibiotic.
- **Vaccines.** Vaccines are generally used to treat viral diseases. There are a variety of vaccines available to treat animals in aquaculture. Salmon may be given vaccines to treat furunculosis, vibriosis, or yersiniosis. These vaccines are generally not considered a potential risk for human health since viral diseases of fish are typically not pathogenic to humans (World Health Organization [WHO] 1999), and the potential for exposure is minimal. The primary exposure pathway tends to be through accidental needle-stick injury (Douglas 1995; Leira and Baalsrud 1997).

Therapeutics typically are only applied when fish health specialists have determined that a disease is present in fish rearing in hatcheries. Human exposure to these chemicals typically would occur through skin contact by hatchery workers during application of the compound or through accidental needle pricks during vaccinations. However, Federal and state occupational safety regulations (e.g., Occupational Safety and Health Act of 1970 [29 United States Code [USC] 651 et seq.]) are in place to prevent these types of accidents.

Outside of the use of therapeutic chemicals in the workplace, there are two primary environmental concerns with the use of therapeutics in hatchery facility operations:

1. Therapeutic substances are not 100 percent absorbed by the fish and may be excreted into the holding water (Texas Agricultural Extension Service 1994; Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection [GESAMP] 1997; Milewski 2001). Government agencies typically do not regulate disposal of chemicals in fish waste products; therefore, there is a potential for these chemicals to enter the environment surrounding the hatcheries (Texas Agricultural Extension Service 1994; GESAMP 1997; Milewski 2001). Federal Clean Water Act and state surface water regulations prevent the discharge of chemicals at concentrations that may pose a threat to human health. However, water quality regulations currently do not exist for all veterinary products, medicines, or their by-products when incompletely metabolized. The environmental persistence of therapeutic substances varies, and some may degrade in a few hours to a few months (GESAMP 1997). Antibiotics used at hatcheries have been detected in receiving waters downstream of aquaculture operations (Boxall et al. 2004; Pouliquen et al. 2009; Martinez-Bueno et al. 2009). Moreover, studies suggest these compounds may persist in sediments (Pouliquen et al. 2009; Martinez-Bueno et al. 2009).

   Therapeutics are typically applied infrequently and at low doses (GESAMP 1997). The use of therapeutics is governed by the Federal Drug Administration (FDA) through the Animal Medicinal Drug Use Clarification Act of 1994 (21 Code of Federal Regulations [CFR] 530), which does not permit extra-label use of drugs that are administered through feed (MacMillan et al. 2006). Currently, the volume of therapeutics released from hatcheries and the potential risks associated with these releases are unknown. Concentrations that have been reported in receiving waters near fish farms and hatcheries in other parts of the United States and in Europe are usually well below those toxic to fish and invertebrates (Boxall et al. 2004). It is expected that limited use of veterinary medicines following label instructions in U.S. fish hatcheries poses minimal risk to human health and the environment (GESAMP 1997; MacMillan et al. 2006), although locally high concentrations could occur depending on the nature of the receiving environment.

2. The use of antibiotics may increase the potential for the development of resistance in certain strains of bacteria (Burka et al. 1997; GESAMP 1997; WHO 1999). Therefore, overuse of antibiotics could render them ineffective for control of some bacteria. Resistant bacteria that infect fish have the potential to transfer resistant genetic material to bacteria that infect non-fish organisms (e.g., humans). Genetic bacterial resistance may occur by the movement of plasmids (i.e., genetic elements independent of the chromosome) between bacteria. This type of transfer has been demonstrated in a number of microorganisms (Burka et al. 1997; GESAMP 1997; WHO 1999; Cabello 2006). Therefore, the improper use of antibacterial antibiotics may cause resistance in bacterial pathogens that can infect humans (Burka et al. 1997; GESAMP 1997; WHO 1999; Cabello 2006). The use of therapeutics is governed by the FDA through the Animal Medicinal Drug Use Clarification Act of 1994 (21 CFR 530), which does not permit therapeutics for uses not specified in the drug's label (MacMillan et al. 2006). Adhering to this regulation and drug label recommendations minimizes the potential for the development of antibiotic resistance.

1.3 Anesthetics

Anesthetics are commonly used to immobilize fish during egg or milt collection, to calm fish during transportation, or during treatment with other therapeutics. They are typically applied or used at low concentrations and, thus, represent a low risk to human health (GESAMP 1997) when handled using general safety precautions (i.e., Federal OSHA or state WISHA regulations) and following label requirements. Some common anesthetics used in hatchery operations are:

- **Benzocaine.** Benzocaine is used during egg or milt stripping or during preparation for transport.
- **Tricaine methanesulfonate (MS-222).** MS-222 is used as a general sedative and applied as a bath in the holding tanks.

1.4 Pesticides and Herbicides

A wide variety of aquatic pesticides and herbicides is used in hatchery facility operations to protect fish from parasites and remove nuisance organisms, weeds, or algae. Due to their toxicity, a number of these chemicals are not approved for use in the United States. For hatcheries, pesticides and herbicides are typically highly toxic and are used in small concentrations to control algae growth or aquatic weed growth. Commonly used algaecides approved for use in the United States may contain various forms of copper. Some common aquatic herbicides include dichlobenil, diquat, endothall, fluridone, glyphosate, 2,4-dichlorophenoxyacetic acid, and 2-butoxyethyl ester. These products may be hazardous to human health if prolonged or accidental exposure (i.e., inhalation, ingestion, or dermal contact) occurs because these compounds may be toxic at certain concentrations. Some of these products have bacteria as the active ingredient (e.g., Microbe Lift and Liquid Live Micro-organism) rather than a chemical ingredient to reduce the growth of pests. These products are typically less toxic to human health than synthetic chemicals. Safety measures on the product label and the material safety data sheet (MSDS) provide directions for proper use and applications. These safety measures, along with Federal OSHA and state WISHA regulations, serve to limit human exposure to potentially hazardous concentrations.

1.5 Feed Additives

While in hatchery facilities, hatchery-origin fish are fed with commercial diets containing fish oil and fish meal that can be from sources anywhere in the world. These feeds are known sources of toxic contaminants (Jacobs et al. 2002a; Carlson and Hites 2005; Maule et al. 2007; Johnson et al. 2010). The potential risk to human health from these contaminants is discussed further in Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish.

Hatcheries may also use fish food that is supplemented with a variety of dietary additives. Fish raised and released from hatcheries are only fed (including dietary additives) while they are juveniles, which differs from fish raised in aquaculture farms that consume feeds and additives throughout their life. These additives may consist of artificial or natural pigments, fish oils, and/or vitamins. For example, astaxanthin and canthaxanthin are carotenoids commonly used in aquaculture to artificially color the flesh of salmon during the later stages of growth, since farm-raised fish tend to be less colorful than hatchery- or natural-origin fish. Vitamin C and Vitamin E are widely used to enhance the disease resistance of fish stocks. Exposure to feed additives from hatchery-origin fish is considered to be of low risk to human health because the concentrations used in hatcheries are typically below levels that would result in adverse health effects (GESAMP 1997).

1.6 Miscellaneous Chemicals

A variety of other chemicals are typically used at salmon and steelhead hatcheries. These chemicals are considered nonhazardous and, when used within the product label requirements and following OSHA regulations, are not expected to pose a risk to human health.

- **Anhydrous (3thyl) alcohol.** Ethyl alcohol is one of two chemicals used in a solution used to check the fertilization of eggs.
- **Lime (Type S).** Lime is widely used to neutralize acidity and increase total alkalinity of grow-out ponds.

- **Salt (sodium chloride).** Salt can be used to remove parasites or prevent stress during transport of fish.
- **Sodium thiosulfate.** Sodium thiosulfate is used to neutralize chlorine and iodophor prior to discharging wastewater.

2.0 Toxic Contaminants in Hatchery-origin Fish

Seafood consumption by humans is generally promoted due to the nutritional value of fish products. For example, fish contain elevated levels of omega-3 fatty acids, which are considered beneficial to the cardiovascular system (Mayo Clinic 2014). However, concerns have been raised that farm-raised and hatchery-origin fish may contain toxic contaminants (WHO 1999; Easton et al. 2002; Jacobs et al. 2002a; Jacobs et al. 2002b; Hites et al. 2004) that pose a health risk to consumers. Sources of contaminants in fish include chemicals or therapeutics, contamination of the nutritional supplements or feeds, and/or contamination of the environment where the fish are reared or released (Easton et al. 2002; Jacobs et al. 2002a; Jacobs et al. 2002b; Hites et al. 2004; Carlson and Hites 2005; Johnson et al. 2007; Maule et al. 2007; Kelly et al. 2008; Johnson et al. 2010). The contaminants of primary concern are those that are persistent in the environment and are known to accumulate in the tissues of fish (e.g., methylmercury, dioxins, dichlorodiphenyltrichloroethane [DDT] and its metabolites, or polychlorinated biphenyls [PCBs]) (Easton et al. 2002; Jacobs et al. 2002a; Jacobs et al. 2002b; Hites et al. 2004; Johnson et al. 2007; Maule et al. 2007; Kelly et al. 2008; Johnson et al. 2010).

Commercial diets fed to farm-raised and to hatchery-origin fish are known sources of toxic contaminants. Contaminant concentrations (e.g., pesticides, PCBs) measured in farm-raised fish are higher than in natural-origin fish (Hites et al. 2004; Hamilton et al. 2005), and the use of commercial feed in hatchery facilities may also contribute to higher concentrations of organic pollutants in hatchery-reared fish compared to their natural-origin counterparts (Johnson et al. 2007).

Hites et al. (2004) found that farm-raised salmon contained substantially more chemical pollutants than fish caught in the wild. This study suggested that these pollutants were originating from fish pellets that contain the dried and compressed body parts and toxicants from several whole fish, which they compared to a natural-origin salmon that eats a few bites of a single fish. In recent studies completed by Johnson et al. (2007), high concentrations of both PCBs and DDTs, comparable to those observed in farmed salmon, were found in juvenile hatchery-origin Chinook salmon. The authors attributed this effect in part to high body fat levels in hatchery-reared juveniles, which facilitates the uptake of lipid soluble contaminants, but concluded that there was too little information on contaminant concentrations in different lots of feed and in fish from different hatcheries, and concentrations were potentially too variable to determine how fish feed affects contaminant levels in hatchery-origin fish. The authors stated that more comprehensive sampling of fish and feed from hatcheries would be needed to determine the extent of the problem in the Pacific Northwest (which includes the project area). In a more recent study (Johnson et al. 2010), subyearling Chinook salmon were sampled from eight hatcheries that release juvenile salmon into the Columbia River. Concentrations of PCBs and DDTs were found to be lower than those reported from previous studies (i.e., in Johnson et al. 2007), and were generally comparable to levels observed in juvenile salmon from minimally contaminated rural estuaries. Contaminant concentrations were higher in the earlier study, in part, because the fish sampled were older and larger than those sampled in the more recent study, but the differences could also be related to differences in contaminant concentrations in feed or in the hatchery environment.

Various investigations have examined the amount of organic contaminants in commercial fish feeds, and found elevated levels of PCBs, polycyclic aromatic hydrocarbons [PAHs], and pesticides (Easton et al. 2002; Jacobs et al. 2002a; Jacobs et al. 2002b; Hites et al. 2004; Neergaard 2004; Carlson and Hites 2005). In a study of contaminants in fish feeds used at National Fish Hatcheries, Maule et al. (2007) found contaminants present, although generally at lower concentrations than those reported by the investigators cited above. The U.S. Geological Survey (USGS) and U.S. Fish and Wildlife Service (USFWS) have continued studying contaminants in feeds and fish (USGS 2012) at several Federal hatcheries in the USFWS Pacific Region to 1) evaluate and compare overall contaminant levels, 2) identify temporal differences in contaminant levels found in various feed forms, 3) evaluate contaminant levels and bioaccumulation rates of different commercial diets in various life-stage history classes, 4) assess the re-distribution of contaminants during smoltification, and 5) simulate the release of fish from a hatchery by fasting fish and monitoring the mobilization and re-distribution of contaminants.

Another potential source of contaminants for hatchery-origin fish includes construction materials found within hatcheries. For example, PCBs identified in fish from the Leavenworth National Fish Hatchery in the Columbia River basin were found to be related to the paint lining fish tanks (Cornwall 2005). Some hatchery facilities in Puget Sound were constructed in the early to mid-1900s and may contain chemicals in historical building materials (e.g., paint) that are banned in current materials. Other sampling for toxic substances is ongoing at national fish hatcheries (Cornwall 2005), and the U.S. Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System (NPDES) general permit for Federal and tribal facilities requires hatcheries to include information on painted and caulked surfaces that regularly contact process water when they apply for general permit coverage (EPA 2009). While the potential for exposure of hatchery-raised fish to contaminants in building materials exists, further incidents have not been reported.

While hatchery-origin fish may contain chemicals of concern, the risks to humans from consumption of contaminants in hatchery-origin fish remain uncertain. The potential for human exposure to contaminants in fish is directly tied to the frequency of consuming fish (EPA 1999). Thus, consumer groups that eat large amounts of fish may have a higher potential for exposure to contaminants. Current information on consumption patterns suggests that some groups of people may consume greater quantities of fish than the general population (often termed subsistence consumers) (EPA 1999; ODEQ 2008; Ecology 2013). However, information is not available to determine what proportion of the diet of subsistence consumers comes from hatchery-origin or farm-raised fish. In addition, not all the contaminants in hatchery-origin fish are derived from hatchery facilities and their operation.

Migrating and rearing salmon and steelhead encounter and accumulate additional contaminants in the rivers, estuaries, and oceans that they inhabit (Missildine et al. 2005; Johnson et al. 2007). It is unknown what proportion of contaminants present in hatchery-origin fish originates from hatcheries and what proportion originates after release. It is also unknown whether those contaminant levels pose a risk to human health. Johnson et al. (2010) suggested that the greatest accumulation of contaminants in the bodies of hatchery-origin juvenile salmon that feed and rear in urban areas occurs after the fish are released from hatcheries. In contrast, for juvenile hatchery-origin fish that are released into relatively uncontaminated rural areas, hatcheries can be a primary source of contaminants. Contaminants accumulated during hatchery rearing would probably contribute very little to concentrations of contaminants in returning adult salmon, since concentrations acquired only during the relatively short juvenile rearing period would be diluted as the fish grew larger to adulthood. Studies suggest that, for returning adult salmon, most of the contaminants present in their bodies are acquired during their time at sea (Kelly et al. 2007; Cullon et al. 2009; O'Neill and West 2009). An exception would be resident Chinook salmon that rear in Puget Sound (about 4 percent of Chinook salmon releases), and may carry a heavier load of contaminants than other salmon that spend more time at sea. Outside of resident Chinook salmon, there is no available information that demonstrates hatchery-origin fish have a greater proportion of contaminates than natural-origin fish, and thus, it is assumed that hatchery-origin salmon and steelhead do not present a greater threat of contamination than natural-origin salmon and steelhead. The Washington Department of Fish and Wildlife currently monitors toxic contaminants in fish and other organisms, as a member of the Puget Sound Ecosystem Monitoring Program.

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