Marine Nearshore

The following write-up relies heavily on the Review Draft of the *State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9).* January 2001 (Review Draft) for the WRIA 8 and 9 Nearshore Technical Committee.

Overview

The city of Seattle's marine nearshore area extends from North 145th Street south to Brace Point in West Seattle and includes approximately 30 miles of Puget Sound shoreline. The nearshore environment in the city of Seattle includes areas within both WRIA 8 and WRIA 9. Approximately 8 miles of shoreline is within Elliott Bay and 2.5 miles of shoreline is within Shilshole Bay.

The nearshore environment in Puget Sound possesses an extremely productive and dynamic ecosystem. Tides, currents, wave action, and intermixing of salt with freshwater create a complex physical environment situated at the juncture between land and water. The marine nearshore environment encompasses the area from upland bluffs, banks, and beaches, and the lower limit of the photic (light penetration) zone, which varies with season and climatic conditions. Some define the lower limit of the photic zone at approximately 100 feet below the Mean Lower Low Water (MLLW) line. The nearshore area includes a wide variety of upland, marine, and estuary habitats including marine riparian areas, backshore areas, beaches, tidal marshes, tidal flats, eelgrass meadows, kelp forests, and exposed habitats. Terrestrial habitats along the shoreline such as bluffs, sand spits, and coastal wetlands are also included within the nearshore environment, as well as the tidally-influenced region found within the lower sections of mainstem rivers and coastal streams.

Historical Modifications

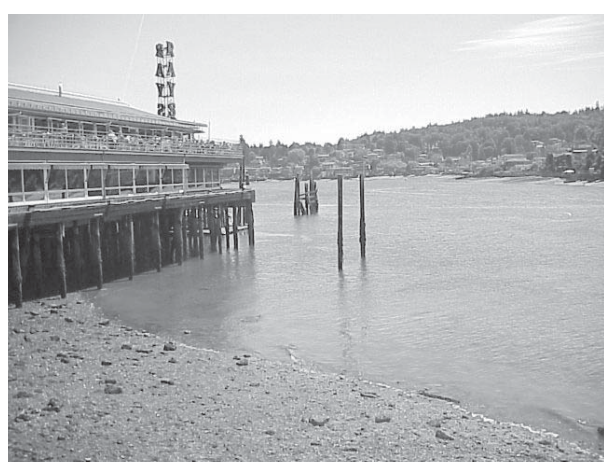
Physical Changes

Human alteration to the nearshore environment has been occurring in Seattle since at least the late 1800's. These activities included extensive filling within Elliott Bay and other areas to increase the city's land base, bank hardening along a significant portion of the shoreline areas for a railroad right-of-way and for property protection, and construction of commercial piers and marinas. The combination of these historic habitat losses and the cumulative impacts of urban development have resulted in major changes to the shoreline environment and the marine nearshore ecosystem. Relatively little is known about the direct effects of urban development and other human impacts on the migration, growth, survival, and habitat of Chinook salmon in the marine nearshore areas of Seattle. However, we do know that bulkheading, bank armoring, and other human activities within shoreline areas have affected many physical processes including sediment production and transport, and that these processes are important for forming and maintaining habitat for juvenile Chinook salmon in the marine nearshore and estuary areas.

The marine nearshore environment within the city of Seattle can be divided into four areas: Elliott Bay, Shilshole Bay, Duwamish Estuary, and other nearshore areas. These areas are discussed below except for the Duwamish Estuary, which is discussed in a separate section of this report.

Elliott Bay

Historically, Elliott Bay consisted of extensive intertidal mud and sand flats and vegetated wetlands bordered by steep banks (Blomberg, 1995). The development of the existing downtown



It is unclear whether shallow water habitat under overwater structures is used by Chinook.

business and industrial districts has resulted in extensive filling, dredging, and grading along the shoreline (Weitkamp *et al*., 2000). Currently, the shoreline along Elliott Bay is characterized by seawalls, bulkheads, and overwater structures. In Elliott Bay, overwater structures are the predominant shoreline modification, occupying over 65 percent of the bay shore. Shoreline areas having natural characteristics are very limited within Elliott Bay, and are found from the mouth of the Duwamish River to Duwamish Head. Most of the shoreline areas of Elliot Bay have been altered, with water depths dropping rapidly to 80 feet and deeper (Weitkamp *et al*., 2000). In addition, several combined sewer outfalls (CSO) operated by the city of Seattle and King County discharge to Elliott Bay. The mouth of the Duwamish/Green River is located at the southern extent of Elliott Bay.

Armoring of the shorelines of Elliott Bay has reduced shoreline and bluff erosion, reducing sediment inputs that are important to the formation and maintenance of nearshore habitats. Bank armoring along Elliott Bay has reduced the habitat areas provided by beaches and sand spits to an area from Duwamish Head to Alki Point. The shallow subtidal sandflats and other remnant sandy subtidal areas between Alki Point and Duwamish Head support productive eelgrass patches that are important to a variety of marine organisms, including juvenile Chinook salmon (KCDNR, 2001). Less armoring has occurred north of the city center and feeder bluffs along the city's Magnolia neighborhood remain active and continue to support the beaches to the north and broad sandflats near West Point.

Shilshole Bay

Salmon and Shilshole Bays are located at the westernmost portion of the Lake Washington Ship Canal system and connect the Lake Washington drainage (WRIA 8) to Puget Sound. Salmon Bay includes the Fremont Cut and Hiram Chittenden Locks, and extends east to west from Lake Union to about the railroad bridge west of the Locks. At its western end it connects to Shilshole Bay, a stretch of the Puget Sound nearshore shoreline running north to south from Golden Gardens Park to the tip of Magnolia at West Point. Historically, Salmon Bay was the estuary of a small creek draining the Lake Union watershed. It featured brackish water and a saltwater marsh at its eastern end.i After the rerouting of the Cedar River and construction of the Ship Canal and Locks, the western end of Salmon Bay, together with Shilshole Bay, became the estuary for a much larger freshwater system.

Residential development is the primary land use downstream of the Hiram M. Chittenden Locks in both bays. This area has experienced substantial bank armoring, which has reduced the quantity and quality of shallow intertidal habitat. The construction of the Shilshole Bay marina on the north of Shilshole Bay involved the construction of a large breakwater jetty, dredging, and shoreline filling that has resulted in the loss of both subtidal and intertidal habitats. Connection with bluffs and terrestrial upland development is largely limited by the construction of roads, parking area for the marina and waterfront parks, bulkheads, and the railroad that extends north from Salmon Bay to the City of Everett. The most natural shoreline areas within Shilshole Bay are found adjacent to the cliffs and bluffs in Discovery Park, and within the sand beach areas of Golden Gardens Park.

Other Shoreline Areas

The shoreline areas south of Elliott Bay are affected primarily by residential land use, except for a few water-dependent municipal, commercial, and industrial facilities, and city parks. Bank armoring is a major factor affecting the formation and maintenance of nearshore habitat within this region of the city. Approximately 87 percent of shoreline in WRIA 8 and 75 percent of shoreline in WRIA 9 have been armored (KCDNR, 2001). The majority of this armoring has occurred from the construction of bulkheads to protect residential properties, roads, and railroad right-of-ways. Bank armoring is nearly continuous along the nearshore areas north of Golden Gardens Park, as a result of a railroad right-of-way which has been constructed directly adjacent to the shoreline. The railroad bed is protected from wave action by a large riprap embankment upon which the railroad tracks have been placed. The extensive bank armoring along these nearshore areas has substantially reduced the distribution and availability of upper intertidal habitats. Unlike the situation in Elliott Bay and Shilshole Bay, the lower intertidal region of the nearshore environment has not been directly affected by extensive filling or dredging (Weitkamp *et al*., 2000). The lower intertidal and subtidal habitats within this region are affected by bank armoring and resulting reductions in sediment inputs, transport, and deposition, altered substrate composition, and loss of riparian vegetation.

Exotic Plants and Animals

The Puget Sound Expedition Rapid Assessment survey for non-native marine organisms was conducted September 8 through 16, 1998. This study found 39 non-native species in the samples collected in Puget Sound. Eleven non-native species found in the survey were new observations for Puget Sound and five species were thought to occur in the Sound, but had not been previously documented. Currently, it is unknown what, if any, impacts populations of these non-native species have on juvenile and adult Chinook salmon in the marine nearshore and estuary areas of the city.

Chinook Utilization of the Marine Nearshore

Nearshore marine and estuary environments provide important habitats to several life stages of Chinook salmon, including:

- ❏ Subadult and adult resident blackmouth, which is a population of Puget Sound Chinook that does not undergo an ocean migration, but instead matures within Puget Sound;
- ❏ Adult Chinook returning from the ocean that migrate through nearshore areas prior to entering freshwater to spawn (KCDNR 2001); and
- ❏ Juveniles that have recently outmigrated from freshwater habitats.

Moreover, the nearshore environment provides essential spawning and foraging areas for baitfish including herring, surf smelt, sand lance, and shiner perch, upon which subadult and adult Chinook feed (Fresh *et al.* 1998).

Subadults and Adults

Adult Chinook salmon return to spawn in their natal streams from mid-May through October (Myers *et al*. 1998). Chinook salmon in Puget Sound area generally form two populations, a resident population commonly referred to as "blackmouth" and an ocean rearing population. Blackmouth reside in Puget Sound for their entire life cycle. Ocean rearing Chinook migrate to the north Pacific where they mingle with other stocks before returning to Puget Sound streams to spawn. Most Chinook spend from two to four years feeding in Puget Sound and the Pacific Ocean before reaching sexual maturity (Myers *et al*. 1998). Little information is known regarding behavioral differences between the two populations in relation to their use of nearshore habitats. However, it is assumed that nearshore habitats play a more important role to resident blackmouth, which are more likely to use the nearshore environments of the Puget Sound than ocean rearing adult Chinook.

Juveniles

Puget Sound Chinook, including those from the Lake Washington and Green River drainages are "ocean type" Chinook, meaning that they spend less time rearing in fresh water and outmigrate to saltwater as smaller fry (Meyers *et al*. 1998). Based upon observations at the Hiram M. Chittenden Locks, juvenile Chinook migrate from Lake Washington to Puget Sound from mid-May into July (Goetz *et al*. 1998), with some Chinook smolts migrating through the locks at least into July (K. Fresh, pers. comm., cited in Weitkamp 2000). Similar migration timing is thought to occur for Green River Chinook, although monitoring is more difficult as there is no single point where outmigration can be easily observed.

Recent data suggest that juvenile Chinook are commonly found using nearshore habitats of King County from late January through September, and it is probable that Chinook juveniles utilize nearshore habitats, to some extent, year-round (KCDNR 2001). The period of use within estuary and marine nearshore areas of the city may be highly variable among individual juvenile fish. Shepard (1981) found that some individual Chinook may utilize estuarine and nearshore habitats for as few as four days, while other authors have documented that juvenile Chinook use estuary habitats for up to 189 days (Wallace and Collins, 1997; Levy and Northcote, 1982). There is little "hard" information on the residency time of juvenile Chinook salmon in nearshore areas (KCDNR 2001).

Habitat Requirements

Juveniles

Many factors, such as the distribution and abundance of predators, food availability, tides, river flows, and genetics may affect how and when juvenile salmonids use and migrate through the marine nearshore and estuary areas of the city of Seattle. Like the habitat use patterns observed in Lake Washington (see Lake Washington summary, this report), juvenile Chinook salmon in the marine nearshore and estuary areas of central Puget Sound tend to be closely associated with shallow habitats located close to shore (KCDNR 2001). This is consistent with observations in other regions of the Pacific northwest, where juvenile Chinook are found to be strongly associated with shoreline areas (Levings *et al*. 1983). Marine nearshore areas and estuaries may be particularly important for juvenile Chinook salmon for migration, feeding, and rearing within the central Puget Sound (KCDNR 2001). Moreover, some of these areas are used by juveniles for the physiological transition from freshwater to saltwater (especially mouths of creeks and Duwamish River). Because Puget Sound Chinook outmigrate as younger and smaller juveniles, they are more dependent on forage in the estuaries and nearshore systems to increase their body weight and condition before moving into more pelagic environments (i.e., deeper Puget Sound waters or the Pacific Ocean) (Levy and Northcote, 1982; Pearce *et al*., 1982).

The results of beach seine sampling indicate that juvenile Chinook are most abundant in shallow nearshore areas including intertidal flats, eelgrass meadows, tidal marshes, and shallow subtidal channels near estuaries (KCDNR 2001). However, sampling efforts to date have not examined juvenile Chinook use in deeper nearshore habitats very well, because most sampling has been conducted using beach seines which are restricted in use to shallow shoreline habitats (David Beauchamp, University of Washington, pers. comm.).

Direct use of nearshore habitats by maturing subadult and adult Chinook is not well understood. Subadult Chinook and adult blackmouth may forage in nearshore areas. Adult Chinook are thought to reside primarily in pelagic habitats; however, resident blackmouth may also forage in nearshore areas as well as in deep-water habitats. Both blackmouth and ocean-rearing Chinook use the nearshore environment in estuaries and river mouths as a transition zone between salt and freshwater environments during their upstream migration to freshwater spawning areas.

Predator Avoidance. Juvenile Chinook use the nearshore habitats to avoid predators including both other fish and waterfowl. Primary predators in the nearshore include staghorn sculpin, other salmonids, mergansers, grebes, pigeon guillemots, and Caspian terns (Weitkamp *et al*., 2000). Aquatic vegetation such as eelgrass beds and kelp forests, in-water structures such as large woody debris, and larger substrate provide refuge from aquatic and avian predators. Predators appear to be rare under piers in marine nearshore areas and it is questionable as to whether overwater structures result in increased predation on Chinook (Weitkamp and Farley, 1975, Weitkamp and Katz, 1976, Weitkamp 1882, Rate, 1985, Williams and Weitkamp, 1991 in Weitkamp *et al*., 2000).

Food Availability. The nearshore environment supports populations of several important prey species utilized by both juvenile, sub-adult, and adult Chinook. Young salmon are opportunistic feeders with diets that vary considerably (Healy, 1982). While in the nearshore, juvenile salmonids prey on an array of benthic, epibenthic, and pelagic organisms (Fresh *et al*., 1981). Prey species vary depending on the estuarine or nearshore habitat type and the size of the fish. Current nearshore food web analysis by the University of Washington has identified important habitats and food web connections for Chinook salmon in Puget Sound, including:

- nearshore vegetated terrestrial habitats that are the source of terrestrial insects in the diets (Brennan and Culverwell, in prep.).
- intertidal and shallow subtidal areas that produce amphipods and other epibenthic crustaceans. These areas generally possess high concentrations of organic detritus upon which benthic macroinvertebrates feed.
- eelgrass beds and kept forests that support planktonic grazers such as euphasiids, shrimp, and crab larvae, planktonic amphipods, and copepods (Cordell *et al*., unpublished).

Water Quality. Within the greater Puget Sound basin, storm water runoff, point source discharges including municipal sewage outfalls, agricultural practices, and clearing and grading practices all contribute contaminants to nearshore waters and sediments (Lynn, 1998). Adverse effects of degraded water and sediment quality include smothering of marine plants through excess sedimentation, algal blooms caused by nutrient enrichment (Lynn, 1998), and bioaccumulation of toxic materials in fish, shellfish, and mammals (Williams

Eelgrass beds in Puget Sound. Photo courtesy of King County.

et al., In Prep.).

Subadults/Adults

Food Availability. Nearshore areas also provide habitat for fish species that serve as prey for subadult and adult Chinook. Surf smelt, longfin smelt, Pacific sand lance, eulachon, and Pacific herring are major forage fish for subadult Chinook, blackmouth, and ocean-rearing adult Chinook while in Puget Sound (Fresh *et al*. 1998). While all five species commonly occur in nearshore areas as adults, eulachon and longfin smelt do not spawn in marine nearshore habitats and no spawning areas for Pacific herring are known to occur within Seattle shoreline. It is unclear what effect nearshore habitat alterations have had on eulachon, herring, and longfin smelt.

Habitat impacts on forage fish (baitfish) within Seattle may have a greater effect on sand lance and surf smelt populations than other forage fish species. Sand lance commonly spawn within the Seattle nearshore. Surf smelt also spawn along several beaches within the Seattle shoreline. Surf smelt and sand lance have specific spawning habitat requirements, which make them especially vulnerable to shoreline development activities (Lemberg *et al*., 1997; Pentilla, 1978; Pentilla, 2000). Such activities can result in change in beach elevations and substrate composition, which are critical factors for baitfish spawning. Loss of overhanging riparian vegetation along shorelines may reduce shading and result in reduced survival of these species' eggs and larvae (Pentilla, 2000).

Landscape and Habitat Forming Processes

The marine nearshore region within central Puget Sound includes several types of distinct habitat areas, including eelgrass meadows, kelp forests, tidal flats, tidal marshes, river and stream mouths and deltas, sand spits, beaches and backshores, and marine riparian zones (KCDNR 2001). These areas are defined in relation to abiotic and biotic factors including vertical position relative to the tide, slope, substrate composition, vegetative composition, and salinity. The formation, maintenance, and spatial distribution of these diverse habitat areas are determined by several key physical processes. The most important of these physical processes are those related to sediment inputs, transport, deposition, and redistribution within the marine nearshore and estuary zones.

As discussed above, land use patterns and habitat modifications within the nearshore environment in the city of Seattle have the potential to affect survival, growth, and condition of juvenile, subadult, and adult Puget Sound Chinook. Factors that have impacted the functions of the marine nearshore environment include the loss of habitat within the migratory corridor, degradation of water and sediment quality, alteration of physical processes including bank erosion and alongshore sediment transport, loss of riparian functions, and introduction of non-native species.

Rip-rap protecting the sea wall on Elliott Bay. Photo by Duncan Kelso

Human activities have resulted in disrupting the natural processes that create habitat within the nearshore environment. Bank armoring, dredging, filling, and the construction of overwater structures have resulted in direct modification to the nearshore habitat within the city of Seattle shoreline area.

The most important physical impact caused by urban development has been to sediment inputs, transport, and deposition along marine nearshore and estuary areas. Few quantitative studies of the effects of shoreline development on sediment transport have been done for habitats in Seattle, and there is limited quantitative information on the more general effects of interrupted sediment transport on biological communities. The transport of sediments from landslides is thought to be critical to the maintenance of beaches, spits, flats, eelgrass beds, and other nearshore habitats. Most of these source areas have been isolated from the nearshore environment by widespread shoreline armoring. Bank armoring, including the construction of riprap (boulder) banks and bulkheads, prevents damage to shoreline properties but also prevents erosion processes such as bank sloughing from occurring. This results in the nearshore area being "starved" of a source of small substrates (i.e., silt, sand and gravel), resulting in a shift in substrate composition from smaller substrate to larger substrate, which in turn, changes the composition of the biota in this area. Sediment inputs from streams and rivers into estuary and marine nearshore areas has generally increased as a result of land-development. However, the increased inputs of sediment from streams and rivers probably cannot compensate for the reduced sediment inputs caused by widespread bank armoring along shoreline areas. Widespread diking of the lower Green River, and channelization and dredging in the Duwamish, further reduces the availability of sediments to marine nearshore and estuary areas.

Waves and alongshore currents (drift cells) carry sediment from slides and streams to areas of deposition such as beaches, headlands, and sandspits. Bank armoring and inwater structures such as rock jetties and gabions can reduce the mobilization and transport of sediments along the shoreline. The lack of sediment recruitment, and reduced alongshore mobilization and deposition, can result in substantial changes to substrate composition in many marine nearshore and estuary areas. These substrate changes can in turn result in the reduction or elimination of intertidal and subtidal vegetation including eelgrass beds and kelp forests. Loss of vegetation may substantially reduce the availability of critical refuge, forage, and acclimation habitat areas for juvenile Chinook salmon, as well as baitfish spawning areas. Alterations in marine riparian vegetation can lead to a loss of habitat complexity, predator refuge availability, and nutrient sources and may effect the carrying capacity of the nearshore ecosystem (Brennan and Culverwell, In preparation).

In general terms, water quality is thought to affect juvenile salmonids both directly and indirectly. It is unclear to what extent each of these impacts plays a role related to the city of Seattle. Some water quality considerations, such as agricultural practices and improperly functioning septic systems are not related to activities within the city. Data indicates that water quality is generally good along the majority of the Seattle shoreline; however, water quality data is lacking for many areas (KCDNR, 2001). The impacts of nutrient and detrital (organic matter) inputs from human and natural sources on nitrogen and phosphorous cycling (i.e., nutrient dynamics) in marine nearshore areas, and the subsequent impacts of this on the productivity of marine vegetation and phytoplankton, also requires further study.

Riparian areas are the transition zones between aquatic habitats and upland areas, such as banks and bluffs. Although much is known about the importance of riparian areas in freshwater systems, relatively little research has been conducted on the functions and values of riparian vegetation in marine systems. Brennan and Culverwell (In Preparation) hypothesize that marine riparian areas provide functions similar to freshwater riparian areas and may provide additional roles unique to marine systems. Riparian corridors provide food sources in the form of insects dropping into the water and also provides shade to smelt spawning beaches (Figure 7). A loss of riparian vegetation results in a reduction in food resources for foraging in the nearshore environment. Loss of riparian vegetation along the shoreline may decrease the productivity of deeper water habitats by decreasing detrital inputs. Almost all native coniferous forests along the Seattle shoreline have been removed. Shoreline riparian areas are generally limited to landscaping in parks and residential areas and remnant deciduous forests growing on bluffs and steep slopes along the few remaining natural shoreline areas.

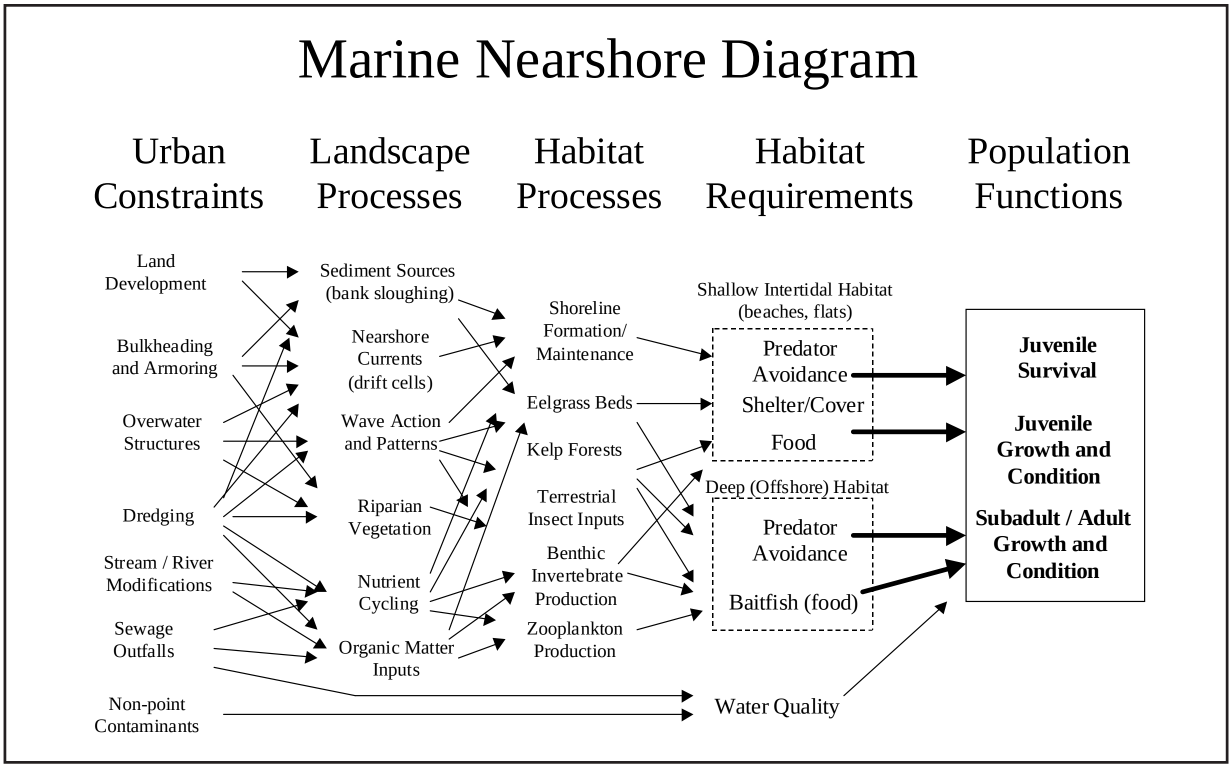


Figure 7. Hierarchical relationships between urban constraints, landscape processes, habitat requirements, and population functions for Chinook salmon in the marine nearshore.

Preliminary Focus Areas

Based on the analysis above, the following table summarizes our understanding of the most significant factors for juvenile Chinook survival and fitness in nearshore areas.

Population Function	Habitat Function	Habitat characteristic/ condition	Habitat forming processes	Constraints
Juvenile rearing and outmigration	Predator Avoidance	Shallow water (e.g., beaches, tidal flats, eelgrass beds) Marine vegetation (eelgrass beds, kelp forests) Off-channel habitats (including side channels, sloughs, and distributary channels in estuaries)	Sediment sources (bank erosion, riverine inputs) Tidal magnitude and pattern Nearshore currents (sediment transport) Wave action (bank erosion and transport) Nutrient cycling (vegetation growth)	Bank armoring and bulkheading Dredging and filling Overwater structures Loss of marine vegetation (e.g., eelgrass beds) Loss of riparian vegetation
	Food Availability	Diverse substrates in shallow shoreline areas (sand, cobbles) Eelgrass beds Kelp forests Spatial / temporal distribution	Organic matter transport from river outflows Riparian vegetation (increases terrestrial insect inputs) Aquatic macrophyte and algae growth	
	Water Quality	Generally good water quality Impacts of contaminants uncertain (sediment contaminant impacts under investigation)	Quality of source waters upstream Adsorption of contaminants by sediments.	High density human population and land uses Altered routing and magnitude of major freshwater inputs
	Access	No barriers (potential impacts of piers and other structures on migration are uncertain)		
Juvenile transition to saltwater	Brackish Water	Freshwater mixing zones in estuary and nearshore areas	Tide magnitude and timing Freshwater outflows from rivers and streams	Upstream dams and diversions (reduce freshwater outflows)
Subadult and Adult Foraging	Baitfish production	Shallow areas possessing proper spawning substrates for baitfish	Organic matter cycling Zooplankton and benthic production	Bank armoring and bulkheading (results in substrate changes) Loss of eelgrass beds

Among these factors, the protection and restoration of beach forming processes, habitat diversity, and marine vegetation emerge as a key area of focus.

Habitat Improvement Projects in the Nearshore

Project Name Project Cost or estimate Status of Project	Project Description	Habitat Requirement Predator Avoidance	Food Availability	Baitfish production
Cormorant Cove: Shoreline improvement $300,000 Completed	Riprap was moved inland to create a small beach cove. Upland edge of rip rap was planted with native shrubs and grasses.	Shallow water habitat	Habitat diversity	
Elliott Bay Near Shore Enhancement $327,000 Completed	Oyster shell, cobble and rock substrate was placed in the subtidal zone.	Shallow water habitat	Habitat diversity	Marine vegetation
Golden Gardens: Renourishment $1,000,000 Completed	Construction of the RR to the north eliminated the sediment delivered to the beach by littoral drift Gravel materials added to north and west portions of the point. A low rock groin was constructed at the north part and a feeder berm for gravel at the south part. Backshore dune and wetlands landward of beach berm were added, and stormwater mgt. was improved.	Restoration of beach forming processes	Habitat diversity	
Lincoln Park: Beach Renourishment Completed	Sea wall constructed in 1934 caused erosion along with loss of littoral drift in sea wall. In 1988, 20,000 cubic yds. of sand and gravel were placed along 1/2 mile of shoreline in front of sea wall. Extensive biological monitoring was performed pre- and post-construction, as well as pre- and post-renourishment of the beach in 1994. The renourishment involved placement of 5,000 cubic yards of beach materials. Drift logs and dune grasses have become established along the beach in recent years.	Restoration of beach forming processes		

Lowman Beach: Shoreline improvement $300,000 Completed	A faulty portion of the sea wall was replaced with a small pocket beach.	Restoration of beach forming processes	Habitat diversity	
Myrtle Edward's Park $200,000 to as much as $1,000,000 Potential	The small beach cove at the north end of the park (or between the city's park and the Port of Seattle's Elliott Bay Park) has been the subject of two previous beach restoration studies. The existing beach could be extended inland and to the south behind the existing rip-rap to expand the shallow intertidal area at the park.		Habitat diversity	
Pipers Creek to Golden Gardens: Potential Marine Protected Area Potential	Citizens group seeking special status as a marine protected area.			Marine vegetation
Schmitz Creek: Outlet Relocation Potential	Schmitz Creek enters a sediment trap and then is piped to Puget Sound with an offshore outfall. Could move outfall back to shallow water to bring terrestial nutrients to the shallow water zone for juvenile feeding.		Habitat diversity	
Seacrest Beach Renourishment Completed	Three pocket beaches were created by adding gravel to existing coves in 1989. Reconfigured rip rap used at cove edges to stabilize gravel. Beach grass was planted in backshore areas behind the pocket beaches and along top of rip rap. Renourishment in 1997.	Restoration of beach forming processes	Habitat diversity	
West Point: Beach Renourishment Completed	Eroded shoreline caused by construction of sewage lagoon in 1962 that blocked littoral drift. 58,000 cubic yds of sand and gravel were placed in a band 90 ft. wide along 3000 ft. of beach. A 40 ft. band of backshore was enhanced w/sand and planted with beach grass.	Restoration of beach forming processes	Habitat diversity	

Addressing Uncertainties

The importance of marine nearshore areas to Chinook salmon is poorly understood beyond a few studies. In the longer term, a significant body of research is needed to address how, and to what extent, specific nearshore areas within the city influence the survival, growth, and condition of Puget Sound Chinook.

Key research and assessment issues include:

1. Determine the presence, distribution, and periodicity of juvenile Chinook within marine nearshore and estuary habitats;
2. Identify preferences in nearshore areas by juveniles and sub-adults for specific types of habitat;
3. Identify potential impacts of predation on the survival and habitat use of juvenile Chinook salmon migrating and rearing in nearshore areas;
4. Evaluate the effects of overwater structures on predator abundance and efficiency, the distribution of submerged vegetation including eelgrass beds, and food availability;
5. Identify and evaluate the use of specific nearshore areas within the city by forage fish species used by subadult and adult Chinook;
6. Evaluate long-term water and sediment quality trends near Seattle and the effect of water quality issues in the marine nearshore on Chinook.

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