

# SaSI 2002

## Introduction

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Welcome to SaSI 2002. This document is a revision of the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI) prepared originally by the Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes. The departments of Fisheries and Wildlife merged in 1994 to form the Washington Department of Fish and Wildlife (WDFW).

The name of the inventory has been changed to the Salmonid Stock Inventory (SaSI) to reflect inclusion of bull trout, Dolly Varden and coastal cutthroat trout. The bull trout and Dolly Varden stock inventory was published in 1997 and revised in 1998. The coastal cutthroat stock inventory was published in 2000. Both inventories are available at the following web sites: (<http://www.wa.gov/wdfw/fish/sassi/bulldolly.htm> and <http://www.wa.gov/wdfw/fish/sassi/cutthroat.htm>).

### Part 1. Background

SaSI 2002 identifies salmon and steelhead stocks in Washington State, rates their status, and characterizes their origin and type of production. Each stock is described in a short stock report. The reports are abbreviated and updated versions of the stock reports in the 1992 SASSI regional appendix volumes.

Much of the information presented in this section of the Introduction is taken from the 1992 SASSI (WDF, WDW and WWTIT 1993) or from the joint state/tribal Summer Chum Salmon Conservation Initiative (WDFW and PNPTT 2000).

The inventory emphasizes naturally-reproducing stocks of salmonids regardless of origin (native, non-native and mixed parentage). Only those stocks that spawn within Washington State are included. Recently extinct stocks are identified when documentation of their decline and extirpation is available. Past extinctions are not included in the inventory because it is a current resource inventory, and the historic information on lost stocks is incomplete and often anecdotal.

Stocks in SaSI 2002 were identified using the same criteria used in the 1992 SASSI. These criteria are briefly described below in the Stock Definition section. Several changes to the 1992 stock list have been made (See Stock List section below.)

Most stock status rating was done using the approach in the 1992 SASSI. The exception is that the status of some Puget Sound Chinook stocks was rated using habitat-based recovery goals developed as part of the recovery efforts by NOAA Fisheries (formerly the National Marine Fisheries Service), WDFW and Puget Sound Treaty Tribes following the listing of Puget Sound Chinook as threatened under the federal Endangered Species Act in March, 1999. Both processes are described in the Stock Status section below.

Stock origin and production type were characterized in the same way as in the 1992 SASSI. Consequently, there is less description of the stock identification, stock status rating, stock origin and production type in this update than in the 1992 document. More thorough descriptions of the concepts and processes used in SaSI are found in the introduction to the 1992 SASSI (the “bluebook”) (<http://www.wa.gov/wdfw/fish/sassi/sassi.htm>).

Note the name “Chinook” is now capitalized, consistent with the change recommended by the joint American Fisheries Society and American Society of Ichthyologists and Herpetologists Committee on the Names of Fishes (Nelson et al. 2003). The name is now capitalized because the committee members believe that the name is taken from the name of the Chinook Indian Tribe.

## **Stock Reports**

SaSI 2002 includes a separate report for each stock. Each stock report is brief (one to two pages) and consists of a Stock Definition section, a Stock Status section and a Stock Origin and Production section.

## **Stock Definition**

SaSI 2002 uses the same definition of stocks, based on Ricker (1972) that was used in the 1992 SASSI:

**SaSI STOCK DEFINITION: The fish spawning in a particular lake or stream(s) at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.**

The most commonly used criteria for identifying salmonid stocks are: distinct spawning distribution, distinct run or spawning timing and distinct biological characteristics. Each of these criteria is thought to result in or reflect substantial reproductive isolation.

Distinct spawning distribution – Groups of fish that repeatedly spawn in distinct locations are likely to be reproductively isolated from one another. We do not expect spatial reproductive isolation to be complete; we recognize that some straying among stocks is a normal part of salmonid biology. Stocks are most frequently identified on the basis of the location of their spawning grounds because this information is the most readily available.

Distinct run or spawning timing -- There is often some overlap in the run timing or spawning timing between two groups of the same species spawning in the same parts of a watershed. However, differences in timing may be sufficient to result in significant reproductive isolation between the two groups, leading us to identify them as distinct stocks. An example of stocks distinguished on the basis of timing would be summer chum (which spawn in September and October, early fall chum (which spawn in November and December) and late fall chum (which spawn in December and January), often in the same streams (albeit in different reaches) in Hood Canal.

Distinct biological characteristics –Differences in genetic profiles are the biological characteristics most commonly used to identify stocks in SaSI. Genetic differences are determined by comparing allele frequencies at large numbers of gene loci or at loci with large numbers of alleles in two or more groups of fish. The loci surveyed may code for enzymes with variable forms (allozymes) or may be non-coding parts of the genome showing a high level of variation, such as variation in the numbers of repeats of specific microsatellite DNA sequences. Differences among populations at either type of locus are thought to be the result of accumulated selectively neutral mutations and are thought to reflect varying levels of reproductive isolation. The absence of significant differences between populations does not prove that only a single population exists.

Among the other biological differences that have been used for stock identification in SaSI are differences in skin color or flesh color, like those characterizing tule and bright fall Chinook in the Columbia basin, age composition at spawning, and size differences.

### **Stock List**

In the 1992 SASSI we noted that the stock lists will change over time as new genetic and other information becomes available. The 1992 SASSI had 435 stocks of salmon and steelhead. In 2002 we have identified 443 salmon and steelhead stocks. Changes in the stock list since the 1992 SASSI are:

#### Puget Sound

Run-timing designations have been dropped from the names of most Puget Sound Chinook stocks because they had been inconsistently applied. The Lower Skagit Mainstem/Tribs fall Chinook stock name is now Lower Skagit Mainstem/Tribs Chinook. White River spring and White river fall Chinook stocks retain the run timing in their names to distinguish them from one another.

The North Fork Nooksack Chinook stock is now the North Fork/Middle Fork Nooksack Chinook stock.

The name of the Stillaguamish summer Chinook stock has been changed to North Fork Stillaguamish Chinook, and the Stillaguamish fall Chinook stock is now the South Fork Stillaguamish Chinook stock.

The number of Chinook stocks in the Snohomish basin has been reduced from four (Snohomish summer, Wallace summer/fall, Snohomish fall and Bridal Veil Creek fall) to two (Skykomish and Snoqualmie)

The Duwamish/Green and Newaukum Creek summer/fall Chinook stocks have been combined as the Green (Duwamish) stock based on the outcome of genetic analysis.

The Green River/Soos Creek and Newaukum Creek coho stocks have been combined as the Green River/Soos Creek stock.

The Hood Canal summer/fall Chinook stock has been divided into the Skokomish and Mid-Hood Canal Chinook stocks.

The Hood Canal summer chum stock has been divided into the Big Beef, Anderson Creek, Dewatto, Tahuya, Skokomish, Finch Creek, Lilliwaup, Hamma Hamma, Duckabush, Dosewallips, and Big/Little Quilcene summer chum stocks.

The Elwha/Morse Creek summer/fall Chinook stock is now called Elwha Chinook.

Chimacum Creek summer chum and Dungeness summer chum stocks have been added to the stock list.

The Discovery Bay summer chum stock has been renamed Snow/Salmon creeks summer chum, and the Sequim Bay summer chum stock has been renamed JimmyComeLately summer chum.

#### Coast

The Raft, Moclips and Copalis Chinook stocks have been dropped from the stock list.

The Johns/Elk & South Bay Tribs fall Chinook stock is now called South Bay fall Chinook. Similarly, the Johns/Elk & South Bay Tribs coho stock is now called South Bay coho. The South Harbor winter steelhead stock is now called the South Bay winter steelhead stock.

The Fall River Early (North River) fall Chinook stock is now call the North River/Smith Creek fall Chinook stock. The Willapa Bay fall Chinook stock has been divided into the Willapa (River) and Naselle fall Chinook stocks.

The Willapa Bay coho stock has been subdivided into the North River/Smith Creek, Willapa (River), Palix/Niawiakum, Nemah, Naselle and Bear stocks.

#### Columbia River

In the 1992 SASSI, the Columbia basin was divided into lower and upper regions, with Bonneville Dam as the boundary between the two. In this revision the Columbia basin is divided into a lower Columbia region which now includes stocks through the White Salmon River, a mid-Columbia region which includes stocks from the Klickitat through the Yakima rivers, a Snake River region, and an upper Columbia region which includes stocks in the Wenatchee through the Okanogan rivers. These changes were made so that SaSI would be more consistent with the NOAA Fisheries Evolutionarily Significant Unit (ESU) boundaries in the Columbia basin.

A Bonneville bright fall Chinook stock has been added to the lower Columbia stock list.

The Hardy Creek fall chum and Hamilton Creek fall chum stocks have been combined into a new stock, Bonneville fall chum based on genetic analysis and inclusion of additional spawning areas.

The Mainstem Washougal summer steelhead stock and the West Fork (North Fork) Washougal summer steelhead have been combined as Washougal summer steelhead. The Mainstem

Washougal winter steelhead stock and the West Fork (North Fork) Washougal winter steelhead stocks have also been combined as Washougal winter steelhead.

Additional changes to the stock list will probably continue to appear in successive revisions as new information becomes available.

Table 1 shows the numbers of Washington salmon and steelhead stocks by region in SaSI 2002.

	<u>Chinook</u>	<u>Chum</u>	<u>Coho</u>	<u>Pink</u>	<u>Sockeye</u>	<u>Steelhead</u>
<b>PUGET SOUND</b>						
North Puget Sound	14	12	14	7	1	22
South Puget Sound	8	23	10	2	3	13
Hood Canal	2	22	9	3	0	11
Strait of Juan de Fuca	3	10	12	3	0	14
Totals	<b>27</b>	<b>67</b>	<b>45</b>	<b>15</b>	<b>4</b>	<b>60</b>
<b>COAST</b>						
North Coast	18	6	18	0	3	24
Grays Harbor	9	2	7	0	0	10
Willapa Bay	3	6	6	0	0	6
Totals	<b>30</b>	<b>14</b>	<b>31</b>	<b>0</b>	<b>3</b>	<b>40</b>
<b>COLUMBIA RIVER</b>						
Lower Columbia	23	2	17	0	0	25
Mid-Columbia	9	0	1	0	0	6
Snake River	3	0	0	0	0	3
Upper Columbia	13	0	0	0	2	3
Totals	<b>48</b>	<b>2</b>	<b>18</b>	<b>0</b>	<b>2</b>	<b>37</b>
<b>WASHINGTON STATE</b>						
<b>443 TOTAL STOCKS</b>	<b>105</b>	<b>83</b>	<b>94</b>	<b>15</b>	<b>9</b>	<b>137</b>

### **Stock Status**

In SaSI 2002 most stocks were rated using the same process that was used in the 1992 SASSI. The status of 17 Puget Sound Chinook stocks was rated using habitat-based recovery goals. Both processes are described below.

### **The 1992 Status Rating Process**

SaSI stock status rating categories are Healthy, Depressed, Critical, Unknown and Extinct. Stocks are placed into these categories using a simple screening process. A set of negative screening criteria was drawn up which, if met, would indicate that a stock is not Healthy. The criteria are:

**Long-term negative trend** – ten or more years of data showing a decline in production. The negative trend is the important factor, and several high values would not eliminate a stock

from being categorized under this criterion. The significance of the decline is not tested statistically because high variation in salmonid annual abundance and survival make statistical testing impractical.

**Short-term severe decline** – a marked drop in production in at least two of the last five years. This criterion is intended as an early warning signal that status may be declining so that the factors responsible for the decline can be identified and, if possible, corrected before more serious damage occurs.

**Chronically low** – production which may not be exhibiting a negative trend but which is consistently below a stock's potential production. The determination that stock production is chronically low may be based on observed past production levels, or on an assessment that stock performance does not meet expected levels based on available habitat. Chronically low stocks can display declining, stable, or even increasing trends.

**Decrease in fitness** – changes to stocks that result in decreased reproductive success. These changes can be subtle and include factors like changes in adult size or age structure, inbreeding associated with small numbers of spawners, changes in spawn timing, or other reduction in genetic variability. In practice, data for detecting these kinds of changes are often unavailable, and this criterion has rarely been invoked in SaSI.

**Unknown** – some stocks have not been enumerated for a sufficient number of years to identify trends in production; others are not enumerated at all. Where production data are not available or are insufficient to rate stock status with confidence, stock status is Unknown.

In some cases data sources that were used to rate status in 1992 are no longer available. For example, several steelhead stocks that were rated Healthy in 1992 based on harvest data are rated Unknown in 2002 because several fisheries have been closed and other abundance monitoring has not been conducted. Stocks whose status is unknown identify needs for future stock assessment work.

An Unknown status rating should not be understood to mean that we know nothing about a stock. There may be considerable information on stock presence and timing, but quantitative production information may be lacking or may be inadequate to rate status.

These screening criteria do not currently incorporate quantitative formulas because the available stock specific information is often too limited and too variable for statistical evaluation.

The 1992 rating process was based on the **qualitative, subjective** judgments of the state and tribal biologists most familiar with each stock, and ratings may be based on more information than is presented in the stock reports.

Quantitative production data for each stock were examined to determine whether the stock met one or more of the negative screening criteria. Stocks that met none of the criteria and whose production was judged to be within the natural range of variation and consistent with available habitat were rated Healthy. Stocks exhibiting long-term or severe short-term negative trends in

production or stocks judged to have chronically low production were rated Depressed or Critical, depending on severity. Stocks were rated as Unknown when there were no production data or data limitations did not allow assessment of current status. A rating category for recently Extinct stocks was also included. Definitions and discussions of each of these rating categories are provided below.

**Healthy** -- A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Because wild salmonid stocks experience large natural fluctuations in survival (caused by environmental variations), it is not unusual for even the most robust stock to experience occasional low abundance or fail to meet escapement goals. Such fluctuations would not necessarily warrant a change in status unless the stock experiences a consistent declining trend, or a sudden large drop in production.

The Healthy category covers a wide range of stock performance levels, from consistently robust production to those stocks that may be maintaining sustainable levels without providing any surplus production for directed harvests. **The fact that a stock may be rated as Healthy in the inventory process does not necessarily mean that managers have no current concerns about its production status.** Healthy status should **not** be considered to indicate recovered status under the federal Endangered Species Act. State and tribal fishery managers believe very strongly that habitat protection and restoration needs exist for many of the stocks classified as Healthy in SaSI as well as for Critical and Depressed stocks.

The 1992 approach to rating stock status evaluates production in terms of currently available habitat. Use of this approach does not mean that stock status will be rated Healthy if its habitat quality, quantity and availability continue to deteriorate. In addition, Healthy stock status is **not** intended to suggest that habitat is healthy or properly functioning. See the section on the 2002 Puget Sound Chinook stock status rating process below for a discussion of the use of habitat-based recovery goals to rate stock status.

**Depressed** -- A stock of fish whose production is below expected levels based on habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.

The category of Depressed stocks is used to identify those stocks that are experiencing lower than expected abundance. These stocks meet one or more of the negative screening criteria, but their production is probably above the level where permanent damage (See below in section on Critical status) has occurred to the stock. These stocks may currently be producing relatively large numbers of fish but have experienced a substantial drop in production or are producing well below their potential. Other stocks may be represented by relatively small numbers of individuals and are chronically depressed--forced to a low production level by some combination of biological, environmental, or human-caused factors. It is not unusual for a stock to stabilize at a low production level by achieving a balance with the particular set of survival pressures controlling its success. Depressed stocks are vulnerable to any additional negative impacts and can potentially change status very

rapidly. Additionally, these stocks often constrain fishery harvest opportunity because of their low abundance.

**Critical** -- A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

The Critical stock category is reserved for stocks that have declined to a level where the stock is in jeopardy of significant loss of within-stock diversity or, in the worst case, could face extinction. The loss of within-stock diversity includes such factors as a reduction of range (e.g., spawning and/or rearing distribution), shifts in age at maturity, changes in body size and fecundity, reduction in genetic variability, or lowered disease resistance. Major shifts in these or other attributes can all lead to significant reductions in a stock's ability to respond to changing environmental conditions. The usual result is reduced survival and population size. Such stressed stocks can be caught in a downward spiral of ever-increasing negative impacts that can lead to eventual extinction. Or they might reach an equilibrium with those factors controlling their performance and could display consistent population size and escapements for an extended period. While such stocks would appear to be stable, they could be delicately balanced, awaiting just one additional negative impact to push them into failure. The Critical stocks are in need of immediate restoration efforts to ensure their continued existence and to return them to a productive state.

**Unknown** -- There is insufficient information to rate stock status.

If sufficient production trend information is not available or cannot be used to assess status, stocks are rated as Unknown. They may be rated as Healthy, Depressed, Critical, or Extinct once more information is available. We do not know to what extent the Unknown stocks represent historically small populations. There is an immediate need to collect information on Unknown stocks, particularly if they are historically or currently small because they could be especially vulnerable to any negative impacts.

Several stocks that had been given a rating of Healthy, Depressed or Critical in 1992 are rated Unknown in 2002. In some cases, such as lower Columbia River coho, we believe that stocks that were rated Healthy, Depressed or Critical in 1992 should have been rated Unknown because insufficient or no production data were available at the time. Where there are still no data, status is now rated Unknown. In other cases, data that were available in 1992 are no longer collected due to fisheries closures (particularly for steelhead) or to reductions in spawner surveys, so stock status is now rated Unknown.

**Extinct** -- A stock of fish that is no longer present in its original range, or as a distinct stock elsewhere. Individuals of the same species may be observed in very low numbers, consistent with straying from other stocks.

SaSI is an inventory of the current status of wild salmonid stocks, and the inclusion of past extinctions is not emphasized. Recently extinct stocks are identified in the inventory if their decline and extirpation have been documented by WDFW and/or tribal biologists. Anecdotal accounts of stock extirpation have not been included.



## **Use of the 1992 Definitions and Processes in 2002**

In 2002, some issues have affected the use of 1992 status definitions and application of the 1992 rating process. They are discussed below. Otherwise, the 1992 definitions and rating process have not changed.

Consideration of available habitat was included in the stock rating definitions for Healthy and Depressed stocks in the 1992 SASSI. Use of this term has proved problematic, mainly because in areas where access to habitat is reduced or habitat continues to be destroyed or to deteriorate, stock status could still be rated Healthy, even though a stock may be badly depleted. In SaSI 2002, less emphasis has been placed on consideration of available habitat for rating stock status, and the definition of "available" habitat is more flexible. "Available" habitat may be habitat that is currently accessible to wild salmonids or, in some cases, may include all habitat that salmonids could reasonably be expected to utilize, even if currently inaccessible. For example, if a stock lost access to and/or was blocked from utilizing a substantial proportion of the available habitat in a stream, this may have been considered in the rating of stock status.

If meaningful salmonid recovery is to occur, currently available habitat quantity or quality may not be adequate in many cases. Some stocks, especially those listed under ESA, will not be rated Healthy, even if their production is consistent with current habitat conditions. Beginning with some Puget Sound Chinook stocks in this revision, the status of listed stocks will be related to recovery goals based on improved freshwater habitat conditions that state, tribal and federal managers believe can be achieved. Habitat-based recovery goals will be used to rate the status of other stocks as they are developed.

Endangered Species Act listings of many groups of salmon and steelhead stocks in Washington and the recovery actions associated with the listings are influencing many features of this inventory. It is important to recognize, however, that not all the stocks in a listed group are necessarily rated Depressed or Critical in SaSI. NOAA Fisheries lists Evolutionarily Significant Units (ESU's), not stocks (see Waples 1991). An ESU is a population or group of populations that is more or less reproductively isolated from other populations of the same species and which represents an important part of the evolutionary legacy of the species (Waples 1991). Pacific salmonid ESU's consist of one or more related stocks of the same species. Within an ESU such as Lower Columbia River Chinook, listed as threatened, most stocks are rated Depressed in SaSI, however, Lewis fall Chinook are rated Healthy. Similarly, in the threatened Puget Sound Chinook ESU, most stocks are rated Depressed in SaSI, a few are rated Critical and two, Upper Skagit and Suiattle, are rated Healthy. The SaSI stock status rating process uses different criteria from the federal listing process. Although as a whole, lower Columbia and Puget Sound Chinook are not thriving, there can be stocks within those ESU's whose abundance and productivity are high.

Because of a lack of ability to distinguish native fish from unmarked non-native hatchery strays on most wild spawning grounds, and a lack of information on changes in stock fitness when hatchery fish spawn naturally, some stocks may be classified as Healthy based on high spawner abundance when, in fact, many spawners may be first-generation, non-native hatchery fish with low reproductive potential. This problem has been reduced in steelhead and coho stocks because most hatchery fish have their adipose fins removed prior to release and can be distinguished from

wild fish with intact adipose fins on spawning grounds. Mass marking (by adipose fin removal and thermal marking of otoliths) is occurring in many, but not all, hatchery Chinook programs but is normally not carried out on hatchery chum and pinks because of their small size at release. In these species, hatchery-origin adults on wild spawning grounds will continue to inflate some wild escapement estimates. Future stock assessments will attempt to concentrate on natural-origin fish and to disentangle their production from that of hatchery fish.

Stocks that are composed of introduced fish with little or no potential for natural production have not been rated in SaSI 2002. There are currently two such stocks: South Sound Tribes Chinook and Deschutes winter steelhead. The stocks are still listed in the inventory because state and tribal biologists are aware that spawning occurs in streams used by the stocks, but they do not believe that the spawning is productive. See the individual stock reports for more information.

### **SaSI 2002 Puget Sound Chinook Status Rating Process**

The status of 17 of the 28 ESA-listed Puget Sound Chinook stocks was rated using habitat-based recovery goals developed by WDFW and some Puget Sound tribes during the development of recovery plans and de-listing criteria. The goals are for spawner abundance and stock productivity (adult recruits per spawner) under improved habitat conditions. NMFS (1996) compiled a matrix of properly functioning conditions (PFC) to evaluate the impacts of human activities on the freshwater habitat of ESA-listed salmon. The matrix includes water quality, habitat access, habitat features, channel conditions, flow and hydrology and watershed condition elements.

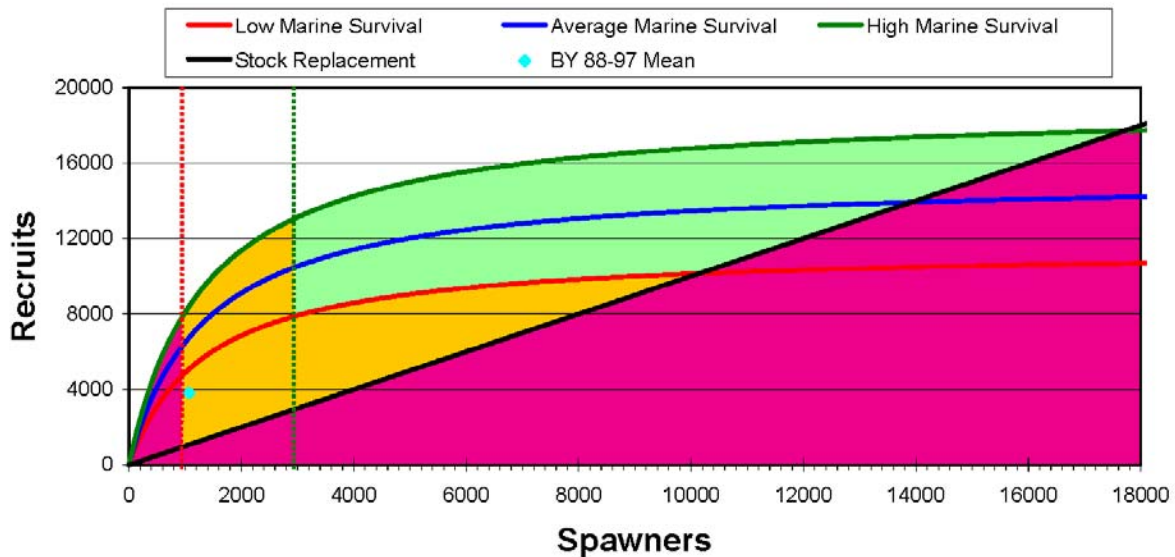
The goals were generated by an expert system method, Ecosystem Diagnosis and Treatment (EDT) (Lestelle et al. 1996, Mobrand et al. 1997, Mobrand Biometrics 2002). EDT relies on habitat input from local state, tribal and other experts. The EDT method uses up to 45 habitat and landscape attributes to predict the abundance, productivity, spatial distribution and diversity of a salmon population under particular habitat conditions. The habitat and landscape information includes a wide range of variables such as percent habitat types, stream substrate, percent fine sediment, riparian condition, large woody debris, water quality and quantity, exotic fish species present. Life history information including juvenile age at migration, time of migration (spring or summer, etc.), adult ages at return, run timing, ocean distribution, harvest rate and location, and female spawner fecundity and age distribution, is also incorporated into the model.

The EDT method starts with a conceptual framework to organize existing knowledge about a watershed ecosystem so that scientific principles can be applied to understand that system (Mobrand Biometrics 2002). The first step is to define stream reaches (“environmentally homogeneous” reaches), their habitat characteristics and to describe basin hydrography and the spatial relations among tributaries.

In the next phase, an analytical model simulates hundreds of life-history “trajectories” or different ways in which the salmonid species in question could use the habitat in space and time. A trajectory starts out in previously identified spawning stream reaches and is moved through time and space by life history stage. From these trajectories, the model estimates survival from egg incubation through adult spawning. Randomness is included in the trajectories so that the

full range of environmental conditions present in the basin is encountered. The model calculates and tracks the productivity and adult capacity of each trajectory through each stream reach. Trajectories with productivities less of than 1.0 recruit per spawner, indicating that the stock is not replacing itself, are not viable and are assumed to be unused by the fish population being modeled. The productivity and adult capacity values of all viable trajectories are combined to determine the productivity and adult capacity for the population, assuming a Beverton-Holt spawner-recruit relationship (Beverton and Holt 1957). The model is run for each of four tiers of habitat conditions: present conditions, PFC conditions, PFC+ conditions and historical conditions. Model runs for PFC+ habitat conditions were used to generate the spawner abundance and productivity goals used to rate stock status in SaSI 2002. The PFC+ analysis combines properly functioning freshwater habitat conditions (NMFS 1996) with pristine estuarine conditions, since there are no PFC guidelines available yet for estuarine or marine habitats.

Figure 1 below shows the basic approach to rating status using habitat-based recovery goals. The graph is based on the Beverton-Holt spawner-recruit relationship assuming a range of marine survivals.



**Figure 1.** Graphic illustration of stock status ratings defined by the position of mean stock abundance and productivity (centroid) relative to abundance and productivity goals. This figure is modified from one drawn by Nick Lampsakis, Point No Point Treaty Council. See text below for explanation.

Because salmon production depends upon marine survival as well as on freshwater and estuarine conditions, the final EDT production curves will differ depending on the marine conditions assumed. We present results in terms of three different marine survival regimes: “average”, “low”, and “high”. Spawner-recruit curves for high, average or low marine survival were generated from Puget Sound Chinook marine survival data compiled by NOAA Fisheries. The “average marine survival” curve is based on the actual average Puget Sound Chinook marine survival for the 1978 through 1995 brood years (the most recent years for which data are complete). This range of years should include a number of changes in marine survival including

nearly two complete cycles of the Pacific Decadal Oscillation and recent El Niño and La Niña events and any dominant or weak brood cycles. The high and low marine survival curves are based on the upper and lower, respectively, 80% confidence limits about the average marine survival. These values were chosen to cover a broad range of marine survivals but may not include unusually high or low values.

The dashed vertical green line on the right is the EDT-generated low marine survival spawner objective or “low” recovery abundance goal (the goal at maximum sustained yield (MSY)) for the stock in question. It serves as the boundary between Healthy and Depressed status based on spawner abundance. It is the number of spawners corresponding to the maximum surplus production with a given level of marine survival.

The dashed red vertical line on the left is the low abundance threshold value (also called the crisis escapement) from Table 6 of the state/tribal Comprehensive Chinook Management Plan (PSIT and WDFW 2001). It is the boundary between Depressed and Critical status based on spawner abundance. These values were set for individual stocks based on consideration of stock-specific characteristics and genetic concerns. They are escapements (or total abundances) below which additional protective measures must be taken to avoid loss of genetic integrity, long-term loss of productive potential, and potential extinction. There is no single method for determining low abundance threshold values. Some are based on the lowest recorded escapement from which subsequent escapements recovered. Some are based on the national conservation standard of the Magnuson-Stevens Act, which identified 50% of an escapement goal as the abundance level that triggers harvest management conservation actions. Others are based on stock replacement levels assuming current productivity and recent freshwater and marine survivals.

The black stock replacement line displays graphically a productivity of 1.0 in which each spawner produces a single adult recruit. Such a stock would only just be replacing itself.

The low marine survival spawner-recruit relation serves as the boundary between Healthy and Depressed status based on productivity. The stock replacement line is the boundary between Depressed and Critical status based on productivity. The status of any stock that is not replacing itself is rated Critical.

The small turquoise diamond on the graph is the average stock spawner and recruit value (the average of the number of spawners is the X-variate, and the average number of recruits is the Y-variate) for the 1988 through 1997 broods, the most recent 10 brood years for which coded-wire tag recovery data are complete. Spawner numbers are the same as the escapement estimates presented in SaSI. Recruits are adult equivalent recruits computed by NOAA Fisheries staff based on coded-wire tag recoveries and cohort analysis.

The position of this average value relative to stock status boundaries permits status rating visually in a straightforward way. For simplicity, areas of the graph representing Healthy, Depressed and Critical status have been color coded green, orange and red, respectively. The stock shown in Figure 1 above would be rated Depressed because it falls below the low marine survival curve but above the stock replacement line and below the spawner abundance goal but above the low abundance threshold.

Criteria for Healthy, Depressed and Critical ratings are summarized below.

- Healthy      Stock spawner-recruit mean is located to the right of the Healthy/Depressed spawner abundance threshold (dashed green vertical line) **and** above the low marine survival curve.
- Depressed    Stock spawner-recruit mean is located to the right of the Healthy-Depressed spawner abundance threshold **and** below the low marine survival curve **but** above the stock replacement line.
- or
- Stock spawner-recruit mean is located between the Healthy/Depressed spawner abundance threshold and the Depressed/Critical spawner abundance threshold (dashed red vertical line) **but** above the stock replacement line.
- Critical      Stock spawner-recruit mean is located to the left of the Depressed/Critical spawner abundance threshold **or** below the stock replacement line.

The hypothetical stock spawner-recruit mean (the diamond) shown in Figure 1 is positioned below the low marine survival spawner-recruit curve. It is also positioned to the left of the spawner abundance goal. The stock would be rated Depressed primarily because its productivity is low, and spawner abundance is also low.

One very important point is that the **spawner abundance goal (MSY goal) does not remain constant as marine survival changes**. The goal will increase exponentially as marine survival increases. This relationship means that **recovery goals cannot be achieved by simply waiting for ocean conditions and marine survival to increase and not taking steps to increase productivity as well**. Productivity can be increased by improving freshwater habitat and hatchery practices and by reducing stock losses associated with hydropower generation.

**NOTE:** Spawner-recruit analyses of Puget Sound Chinook stocks are on-going by NOAA Fisheries staff. The values for recruits that they provide for SaSI stock status ratings are subject to change. Changes in recruits could result in changes in status.

Summary tables of Washington salmon and steelhead stocks, their 1992 and 2002 status, origin and production type are located in Part 2 of this Introduction.

### **Problems with rating Stock Status**

There are several circumstances that complicate the rating process. When a wild stock experiences an extremely low survival, it is sometimes difficult to know if that survival is within the normal range for the stock, or if it is entering a depressed state caused by human impacts (e.g., habitat destruction or over-fishing). Naturally-produced salmonid stocks exhibit wide variations in survival, caused in part by changes in freshwater stream flows (droughts and flooding), ocean conditions and biological interactions such as competition and predation (Cooper and Johnson 1992). It is not uncommon for wild stocks to experience one or two

extremely low-survival years each decade, resulting in low adult returns. Similarly, natural variation also provides years of above-average production.

Some stocks are experiencing survivals that are so low that they are clearly below the level of natural variation. The survivals of other stocks are intermediate between obviously healthy stocks and clearly depressed stocks and are the most challenging to evaluate because they could be experiencing low survivals within the normal range for the stock. Short-term databases often exacerbate the rating problem because with only a few years of observation it is unlikely that the lowest natural survivals have been documented. The evaluation of most stocks with intermediate survivals was based on the collective judgment of technical agency and tribal staff members most familiar with each stock.

The possibility of survival rate cycles for various stocks also can create difficulty in rating stock status. These cycles may be associated with weather-related impacts on freshwater spawning and rearing success, or even genetically controlled cyclic productivity conditions. The apparent existence of cycles in survival and production data may complicate the task of identifying depleted stocks, since poor stock performance could be the result of natural cyclic variation. Wherever possible, the existence of survival cycles is considered during the stock evaluation process.

### **Stock Origin and Production**

Stock origin indicates the genetic background of a stock. An understanding of the genetic background of stocks is important for the development of any future efforts to restore and maintain them. SaSI recognizes three categories of stock origin: 1) stocks that are thought to represent native gene pools, 2) stocks that resulted from the introductions of non-native fish, and 3) mixed stocks of native and non-native fish, or substantially genetically altered native fish.

The definitions for stock origin used in SaSI are:

**Native** -- An indigenous stock of fish that has not been substantially impacted by genetic interactions with non-native stocks, or by other factors, and is still present in all or part of its original range. In limited cases, a native stock may also exist outside of its original habitat (e.g., captive brood stock programs).

**Non-native** -- A stock that has become established outside of its original range, i.e., an introduced stock.

**Mixed** -- A stock whose individuals originated from commingled native and non-native parents, and/or by mating between native and non-native fish (hybridization); or a previously native stock that has undergone substantial genetic alteration. This may include species crosses such as hybrids between cutthroat and steelhead (or rainbow trout).

**Unresolved** -- The state and tribes do not agree on the origin of a stock.

**Unknown** -- This description is applied to stocks where there is insufficient information to identify stock origin with confidence.

A great deal of uncertainty often exists about the genetic histories of many salmon and steelhead stocks, and the contributions of hatchery-origin salmonids to native Washington populations have not been rigorously evaluated. No threshold levels of hatchery introductions (numbers of fish released and/or numbers of years of releases) have been identified, which if exceeded, means that a stock can be assumed to be a mixture of native and non-native fish. Such a threshold is not readily identifiable because the genetic impact of hatchery introductions depends on the extent to which hatchery fish spawn successfully on wild spawning grounds. Spawning success is generally not known and probably depends on many factors. Consequently, in SaSI there are stocks that have been exposed to years of hatchery releases but are still considered native and stocks that have experienced fairly few hatchery releases but are considered mixed.

To understand more about the nature of an individual stock, it is also necessary to describe its production type—the type of spawning and rearing that produced the fish. For example, a stock of fish may be a genetic mixture of native and non-native fish, but in the absence of continuing hatchery releases, the stock may be self-sustaining as the result of natural spawning and rearing. The stock would be characterized as being of mixed origin with wild production. A native stock of fish in a rehabilitation program also can be sustained entirely by fish culture techniques. Such a stock would be characterized as a native stock with cultured production. Many stocks are sustained by both wild production and hatchery, often as a result of annual off-station releases of hatchery fish.

The terms defining production type are:

**Wild** -- A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (includes non-native).

**Cultured** -- A stock that depends upon spawning, incubation, hatching, or rearing in a hatchery or other artificial production facility.

**Composite** -- A stock sustained by both wild and artificial production. Composite stocks are not the best indicators of stock health trends because the relative contributions of hatchery-origin and naturally-produced fish on wild spawning grounds may not have been estimated separately in many areas.

**Unresolved** -- The state and tribes do not agree on the production type for a stock.

**Unknown** -- This description is applied to stocks where there is insufficient information to identify production type with confidence.

## **SaSI 2002 Stock Reports**

Stock reports in SaSI 2002 begin with the Stock Status section. The 1992 and 2002 status ratings are followed by the data that were used to generate the 2002 status rating. In SaSI 2002, status rating is intended to reflect current status. Data used to rate status are presented from 1986 to 2000 or 2001, depending on availability. Data prior to 1986 are available for many stocks. This range of years overlaps the data string used to rate status in 1992 and extends it to

the present. Data are primarily spawner abundance (escapement) estimates. Less frequently there are juvenile abundance data from smolt trapping and some run size estimates (escapement plus catch). These data are presented in both graphic and tabular form. The graph allows readers to see data trends easily, while the table provides numerical values. The origin of the data is described so that readers will know what parameter was actually counted in field—redds, live spawners, carcasses, smolts, etc. and how complete the survey coverage is. The usefulness of each data set for rating stock status is assessed (see below in Changes to SaSI 2002). The data description is followed by a justification of the 2002 stock status rating, including identification of any negative screening criteria that resulted in Depressed or Critical ratings. For Puget Sound Chinook stocks with recovery goals, status is justified in terms of the goals.

The next section is Stock Definition, which presents the reasons for identifying a group of salmon or steelhead as a discrete stock.

The spawning distribution for the stock is described briefly. Spawning ground maps (1:250,000 scale) are available for most stocks. These maps are intended only to support stock definition. For example, the maps reinforce the identification of North Fork Stillaguamish Chinook as the population of Chinook that spawns in the North Fork of the Stillaguamish River rather than in the South Fork. These maps are **not** intended to show all spawning areas or the exact location of spawning areas. More detailed maps of spawning areas, juvenile rearing areas and stock presence can be found in the Washington Conservation Commission's Limiting Factors Analysis Water Resource Inventory Area (WRIA)-based reports located at <http://www.scc.wa.gov> or at the StreamNet web site (<http://www.streamnet.org>). In 2003, the SalmonScape site, which will be accessed through the WDFW web site (<http://www.wa.gov/wdfw>), will also contain geographic information on stocks. In some cases, the watershed maps in SaSI show no spawning areas. We are aware that a stock spawns in a watershed but have not conducted enough spawner surveys to comprehensively determine spawning locations.

Spawning timing is described briefly. This description is a general description of timing and may vary from year to year, depending on stream flow.

Results of available genetic analyses are presented briefly reviewed. Dendrograms are not shown in these short reports.

Stock reports end with the Stock Origin section, which briefly: (1) summarizes the history of hatchery fish introductions that may have affected stock composition; (2) summarizes hatchery programs designed to increase the numbers of fish in a depleted stock; (3) characterizes the stock as native, non-native, mixed or unknown; and (4) characterizes the production type of a stock as wild, cultured, or a composite of the two.

## **Changes to SaSI 2002 Stock Reports**

The production data for each stock have been evaluated based on their usefulness for rating stock status. This evaluation replaces the “Data Quality” rating, which was not defined in the 1992 SASSI. The usefulness of a data set for rating stock status depends on a combination of two attributes, accuracy and adequacy. Accuracy depends on factors such as visibility of redds or fish at the time that spawner surveys are done. The better the viewing conditions, the more



accurate the counts. In addition, adequacy of spawner survey coverage, for example, is necessary if spawner survey index areas are to represent spawner distribution or spawner density for the stock as a whole. In this example, both accurate counts and adequate surveys are necessary to assess stock status.

Run timing designations have been dropped from most Puget Sound Chinook stock names. For example, the Lower Skagit Mainstem/Tribs fall Chinook stock is now called Lower Skagit Mainstem/Tribs Chinook. The Puget Sound Technical Review Team, convened by NOAA Fisheries to develop recovery guidelines for ESA-listed stocks in Puget Sound, has recommended that run timing designations be dropped because they have been applied inconsistently to Chinook stocks in Puget Sound. Run-timing designations have been retained for other species in Puget Sound and for Chinook and other species on the Washington Coast and Columbia River basin.

## **Future Revisions**

SaSI is very much a work in progress. SaSI 2002 is important in that it is the first comprehensive revision since 1992, but it is just a first step in updating SaSI. SaSI stock status ratings will become increasingly more quantitative and recovery-oriented as recovery goals for more listed stocks are developed. SaSI will increasingly focus on the natural-origin component of stocks, as increased marking of hatchery fish makes distinguishing hatchery and natural-origin fish on wild spawning grounds possible for some species. The stock list will continue to evolve as a result of new information and new analyses, particularly genetic analyses. Finally, SaSI will become more of an information clearing-house for recovery-oriented stock information.