Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead

West Coast Salmon Biological Review Team

Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112

Southwest Fisheries Science Center
Santa Cruz Laboratory
110 Shaffer Road
Santa Cruz, CA 95060

July 2003

This is a scientific report. It does not represent or set policy for NMFS or NOAA, regardless of whether any statements contained herein may appear to do so.

TABLE OF CONTENTS

Executive Summary **5**

Introduction **7**

Methods **24**

References **30**

A. CHINOOK

A. 1 Background and History of Listings **1**
A.2.1 Snake River Fall-Run Chinook **3**
A.2.2 Snake River Spring/Summer-Run Chinook **11**
A.2.3 Upper Columbia River Spring-Run Chinook **28**
A.2.4 Puget Sound Chinook **41**
A.2.5 Lower Columbia River Chinook **78**
A.2.6 Upper Willamette River Chinook **104**
A.2.7 California Coastal Chinook **113**
A.2.8 Sacramento River Winter-Run Chinook **124**
A.2.9 Central Valley Spring-Run Chinook **131**
A.3 Chinook BRT Conclusions **143**
A.4 References **149**
A.5 Appendices **160**

B. STEELHEAD

B.1 Background and History of Listings **1**
B.2.1 Snake River Basin Steelhead **7**
B.2.2 Upper Columbia River Steelhead **24**
B.2.3 Middle Columbia River Steelhead **34**
B.2.4 Lower Columbia River Steelhead **50**
B.2.5 Upper Willamette River Steelhead **73**
B.2.6 Northern California Steelhead **84**
B.2.7 Central California Coast Steelhead **97**
B.2.8 South-Central California Coast Steelhead **106**
B.2.9 Southern California Steelhead **114**
B.2.10 California Central Valley Steelhead **123**
B.2.11 Steelhead BRT Conclusions **134**
B.3 References **142**
B.4 Appendices **157**

C. COHO
C.1 Background and History of Listings **1**
C.2.1 Oregon Coast Coho **3**
C.2.2 Southern Oregon/Northern California Coasts Coho **30**
C.2.3 Central California Coho **54**
C.2.4 Lower Columbia River Coho **71**
C.2.5 Coho BRT Conclusions **90**
C.3 References **94**
C.4 Appendices **107**

D. SOCKEYE
D.1 Background and History of Listings **1**
D.2.1 Snake River Sockeye **4**
D.2.2 Ozette Lake Sockeye **9**
D.3 Sockeye BRT Conclusions **15**
D.4 References **17**
D.5 Appendices **20**

E. CHUM
E.1 Background and History of Listings **1**
E.2.1 Hood Canal Summer-Run Chum **3**
E.2.2 Lower Columbia River Chum **20**
E.3 Chum BRT Conclusions **32**
E.4 References **34**
E.5 Appendices **36**

ACKNOWLEDGMENTS

We are grateful to the large number of regional biologists who provided raw data and information used in this report. This report was improved as a result of comments provided by state, tribal, and federal comanagers on an earlier draft. The effort to update the status of all listed ESUs of west coast salmon and steelhead would not have been possible without the help of many, including Andrew Albaugh, Charlene Bergeron, Ronda Carbary, Henry Carson, Kurt Davis, Christopher Donohoe, Tamara Harms, Christine Holt, Andrea Jarvela, Laura Johnston, Jenny Moslemi, Jessica Piasecke, Cory Ruedebusch, Brycen Swart, JJ Westfall, and Thomas Williams.

EXECUTIVE SUMMARY

During the 1990s, the National Marine Fisheries Service (NMFS; NOAA Fisheries) conducted a series of reviews of the status of West Coast populations of Pacific salmon and steelhead (*Oncorhynchus* spp.) with respect to the U.S. Endangered Species Act (ESA). This report summarizes scientific conclusions of the NMFS Biological Review Team (BRT) regarding the updated status of 26 ESA-listed ESUs of salmon and steelhead (and one candidate species ESU) from Washington, Oregon, Idaho, and California. These ESUs were listed following a series of status reviews conducted during the 1990s. The status review updates were undertaken to allow consideration of new data that accumulated over the various time periods since the last updates and to address issues raised in recent court cases regarding the ESA status of hatchery fish and resident (nonanadromous) populations.

This report represents the first major step in the agency's efforts to review and update the listing determinations for all listed ESUs of salmon and steelhead. By statute, ESA listing determinations must take into consideration not only the best scientific information available, but also those efforts being made to protect the species. After receiving the BRT report and considering the conservation benefits of protective efforts, NMFS will determine what changes, if any, to propose to the listing status of the affected ESUs.

As in the past, the BRT used a risk-matrix method to quantify risks in different categories within each ESU. In the current report, the method was modified to reflect the four major criteria identified in the NMFS viable salmonid populations (VSP) document (McElhany et al. 2000): abundance, growth rate/productivity, spatial structure, and diversity. These criteria are being used as a framework for approaching formal ESA recovery planning for salmon and steelhead. Tabulating mean risk scores for each element allowed the BRT to identify the most important concerns for each ESU and to compare relative risk across ESUs and species. The BRT considered these data and other information in making their overall risk assessments. Based on provisions in the draft revised NMFS policy on consideration of artificial propagation in salmon listing determinations, the BRT's risk analyses focused on the viability of populations sustained by natural production.

Based on the criterion of self-sustainability, for the following ESUs the majority BRT conclusion was "in danger of extinction:" Upper Columbia River spring-run chinook, Sacramento River winter-run chinook, Upper Columbia River steelhead, Southern California steelhead, California Central Valley steelhead, Central California Coast coho, Lower Columbia River coho, Snake River sockeye. For the following ESUs, the majority BRT conclusion was "likely to become endangered in the foreseeable future:" Snake River fall-run chinook, Snake River spring/summer-run chinook, Puget Sound chinook, Lower Columbia River chinook, Upper Willamette River chinook, California Coastal chinook, Central Valley spring-run chinook, Snake River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Northern California steelhead, Central California Coast steelhead, South-Central California Coast steelhead, Oregon Coast coho, Southern Oregon/Northern California Coasts coho, Ozette Lake sockeye, Hood Canal summer-run chum, and Lower Columbia River chum. In one case (Middle Columbia River steelhead), the BRT was nearly evenly split on the question of whether the ESU

was or was not likely to become endangered in the foreseeable future (a slight majority concluded that the ESU was likely to become endangered) (Table 1).

Table 1. BRT conclusions regarding updated status of salmon and steelhead ESUs; X indicates the majority vote; (X) indicates a substantial minority (>40% of the vote).

Species	ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Chinook	Snake River fall-run		X	
	Snake River spring/summer-run		X	
	Upper Columbia River spring-run	X	(X)	
	Puget Sound		X	
	Lower Columbia		X	
	Upper Willamette		X	
	California Coastal		X	
	Sacramento River winter-run	X		
	Central Valley spring-run		X	
Steelhead	Snake River Basin		X	
	Upper Columbia River	X	(X)	
	Middle Columbia River		X	(X)
	Lower Columbia River		X	
	Upper Willamette River		X	
	Northern California		X	
	Central California Coast		X	
	South Central California Coast		X	
	Southern California	X		
	California Central Valley	X		
Coho	Oregon Coast		X	(X)
	Southern Oregon / Northern California Coasts		X	
	Central California	X		
	Lower Columbia	X		
Sockeye	Snake River	X		
	Ozette Lake		X	
Chum	Hood Canal summer-run		X	
	Lower Columbia River		X	

INTRODUCTION

PRIMARY CONTRIBUTORS: ROBIN S. WAPLES AND THOMAS C. WAINWRIGHT (NORTHWEST FISHERIES SCIENCE CENTER)

During the 1990s, the National Marine Fisheries Service (NMFS; NOAA Fisheries) conducted a series of reviews of the status of West Coast populations of Pacific salmon and steelhead (*Oncorhynchus* spp.) with respect to the U.S. Endangered Species Act (ESA). Initially, these reviews were in response to petitions for populations of a particular species within a particular geographic area, but in 1994, the agency began a series of proactive, comprehensive ESA status reviews of all populations of anadromous Pacific salmonids from Washington, Idaho, Oregon, and California (Federal Register, Vol. 59, No. 175, September 12, 1994, p. 46808).

The first step in these reviews is to determine the units that can be considered "species" under the ESA and, hence, listed as threatened or endangered, if warranted, based on their status. The ESA allows listing not only of full species, but also named subspecies and "distinct population segments" (DPSs) of vertebrates (including fish). The ESA petitions and status reviews for Pacific salmonids have focused primarily on the DPS level. To guide DPS evaluations of Pacific salmon, NMFS has used the policy developed in 1991 (NMFS 1991, Waples 1991, 1995), which is described in the next section. As a result of these status reviews, NMFS has identified over 50 evolutionary significant units (ESUs) of salmon and steelhead from California and the Pacific Northwest, of which 26 are listed as threatened or endangered species under the ESA. A complete list of these evaluations can be found at (http://www.nwr.noaa.gov/1salmon/salmesa/fractlist.htm), and the technical documents representing results of the status reviews can be accessed online at web sites of the Northwest Fisheries Science Center (http://www.nwfsc.noaa.gov/pubs/), the Southwest Regional Office (http://swr.nmfs.noaa.gov/salmon.htm), the Santa Cruz Laboratory (http://www.pfeg.noaa.gov/tib/esa/salmonids/esa_docs/index.html), and the Northwest Regional Office (http://www.nwr.noaa.gov/1habcon/habweb/listnwr.htm).

In 2000, NMFS initiated formal ESA recovery planning for listed salmon and steelhead ESUs. Recovery efforts are organized into a series of geographic areas or domains. Within each domain, a technical recovery team (TRT) has been (or is in the process of being) formed to develop a sound scientific basis for recovery planning. Regional planners will use the information provided by the TRTs to craft comprehensive recovery plans for all listed ESUs within each domain. For more information about the ESA recovery planning process for salmon and steelhead and the TRTs, see the NMFS Northwest Salmon Recovery Planning web site (http://www.nwfsc.noaa.gov/cbd/trt/).

Recently, several factors led NMFS to conclude that the ESA status of listed salmon and steelhead ESUs should be reviewed at this time. First, a September 2001 court ruling called into question the NMFS decision to not list several hatchery populations considered to be part of the Oregon Coast coho salmon ESU (Alsea Valley Alliance v. Evans [161 F. Supp. 2d 1154, D. Oreg. 2001]; Alsea decision). The ruling held that the ESA does not allow listing of any unit smaller than a DPS (or ESU), and that NMFS had violated that provision of the act by listing

only part of an ESU. Although this legal case applied directly only to the Oregon Coast coho salmon ESU, the same factual situation (hatchery populations considered part of listed ESUs, but not listed) also applied to most other listed ESUs of salmon and steelhead. Second, two additional lawsuits currently pending that involve California ESUs of steelhead (EDC v. Evans, SACV-00-1212-AHS (EEA); MID v. Evans, CIV-F-02-6553 OWW DLB (E.D. Cal)) raised a similar issue—NMFS concluded that resident fish were part of the ESU, but only the anadromous steelhead were listed. Again, this same factual situation is found in most, if not all, listed steelhead ESUs. Finally, at least several years of new data are available for most ESUs, and up to a decade has passed since the first populations were listed in the Sacramento and Snake Rivers. Furthermore, in some (but not all) areas, adult returns in the last few years have been considerably higher than have been seen for several decades.

As a result of these factors, NMFS committed to a systematic updating of the ESA status of all listed ESUs of Pacific salmon and steelhead (Federal Register Vol. 67, No. 28, February 11, 2002). This report summarizes updated biological information for the 26 listed salmon and steelhead ESUs and one candidate ESU (Lower Columbia coho salmon), and presents the Biological Review Team's (BRT's) conclusions regarding these ESUs' current risk status. The BRT consisted of a core group of scientists from the NMFS Northwest and Southwest Fisheries Science Centers, supplemented by experts on particular species from NMFS and other federal agencies. BRT membership is indicated in the sections for each species. The BRT met in January, March, and April 2003 to review information related to the updated status reviews.

ESU Determinations

As amended in 1978, the ESA allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. However, the ESA provided no specific guidance for determining what constitutes a distinct population segment, and the resulting ambiguity led to the use of a variety of criteria in listing decisions over the past decade. To clarify the issue for Pacific salmon, NMFS published a policy describing how the agency will apply the definition of "species" in the ESA to anadromous salmonid species, including sea-run cutthroat trout and steelhead (NMFS 1991). A more detailed description of this topic appeared in the NMFS "Definition of Species" paper (Waples 1991). The NMFS policy stipulates that a salmon population (or group of populations) will be considered "distinct" for purposes of the ESA if it represents an ESU of the biological species. An ESU is defined as a population that: 1) is substantially reproductively isolated from conspecific population, and 2) represents an important component in the evolutionary legacy of the species. Information that can be useful in determining the degree of reproductive isolation includes incidence of straying, rates of recolonization, degree of genetic differentiation, and the existence of barriers to migration. Insight into evolutionary significance can be provided by data on genetic and life-history characteristics, habitat differences, and the effects of stock transfers or supplementation efforts. The NMFS BRTs have used a comprehensive approach that utilized all available scientific information to define ESUs. A discussion of how the NMFS policy was applied in a number of ESA status reviews can be found in Waples (1995).

Geographic Boundaries

The status review updates focused primarily on risk assessments, and (apart from the discussion of resident fish in steelhead ESUs) the BRT did not consider issues associated with the geographic boundaries of ESUs. If significant new information arises to indicate that specific ESU boundaries should be reconsidered, that would be done at a later time.

Artificial Propagation

Most salmon and steelhead ESUs have hatchery populations associated with them, and it is important for administrative, management, and conservation reasons to determine the biological relationship between these hatchery fish and natural populations within the ESU. The ESA status reviews conducted since 1993 have been guided by the NMFS ESA policy for artificial propagation of Pacific salmon and steelhead (NMFS 1993). That policy recognizes that "genetic resources important to the species' evolutionary legacy may reside in hatchery fish as well as in natural fish, in which case, the hatchery fish can be considered part of the "biological ESU in question." As part of the coastwide status reviews, the NMFS BRTs applied this principle in evaluating the ESU status of hatchery populations associated with all listed salmon and steelhead ESUs, with the result being that many hatchery populations are currently considered to be part of the ESUs. However, only a small fraction of these hatchery populations have been listed—generally, those associated with natural populations or ESUs considered at high risk of extinction. NMFS felt that listing other hatchery populations in the ESUs would provide little or no additional conservation benefit beyond that conferred by the listing of natural fish, but would greatly increase the regulatory burden on stakeholders, researchers, and the general public.

As discussed above, a recent court decision has determined that this approach is inconsistent with the act—an ESU must be listed or not listed in its entirety. At the same time that NMFS announced the status review updates, the agency committed to revising the ESA artificial propagation policy for Pacific salmon and using the revised policy to guide the hatchery ESU determinations and consideration of artificial propagation in the risk analyses (Federal Register Vol. 67, No. 28, February 11, 2002). Although a revised policy has not yet been proposed through formal rulemaking, a draft has been publicly available on the agency's web site since August 2002 (http://www.nwr.noaa.gov/HatcheryListingPolicy/DraftPolicy.pdf). That draft indicates that hatchery populations that have "diverged substantially from the evolutionary lineage represented by the ESU" will not be considered part of the ESU. The draft policy is currently under revision, and one issue that remains to be resolved is how "substantial" the divergence must be before a hatchery population should no longer be considered part of a salmon or steelhead ESU, even if it was originally derived from populations within the ESU. Due to the lack of resolution of this issue, the BRT has not attempted to revisit the ESU determinations for hatchery populations in this report. However, a separate working group has updated the stock histories and biological information for every hatchery population associated with each listed ESU (SSHAG 2003) and has also assigned each hatchery population to one of four categories, as described below. How these categories relate to ESU membership remains to be determined. A table showing the SSHAG categories appears in the Appendix to the section of the report for

each species. The BRT reviewed the information in these appendices, along with other hatchery information, to obtain a better understanding of the nature and role of hatcheries associated with each listed ESU.

In the SSHAG document, each hatchery stock was assigned to a category based on variation across three axes (Figure 1): 1) the degree of genetic divergence between the hatchery stock and the natural population(s) that occupy the watershed into which the hatchery stock is released; 2) the origin of the hatchery stock; and 3) the status of the natural population(s) in the watershed. There are four categories of divergence: minimal, moderate, substantial, and extreme. Minimal divergence means that based on the best information available, there is no appreciable genetic divergence between the hatchery stock and the natural population(s) in the watershed (e.g., because the hatchery and wild populations are well mixed each generation). Moderate divergence means the level of divergence between the hatchery stocks and the local natural populations is no more than what would be expected between closely related populations within the ESU. Substantial divergence is roughly the level of divergence expected between more distantly related populations within the ESU. Extreme divergence is divergence greater than what would be expected among natural populations in the ESU, such as that caused by deliberate artificial selection or inbreeding. The second axis describes the origin of the hatchery stock, and can either be local, nonlocal but predominantly from within the ESU, or predominantly from outside of the ESU. The third axis describes the status of the natural population(s) in the watershed of the same species as the hatchery stock, which can either be native or nonnative.

Category 1 stocks are characterized by no more than minimal divergence between the hatchery stock and the local natural population(s) and regular, substantial incorporation of natural-origin fish into the hatchery broodstock. Within Category 1, Category 1a stocks are characterized by the existence of a native natural population of the same species in the watershed, while Category 1b stocks are characterized by the lack of such a population (i.e., the local naturally spawning population was introduced from elsewhere). Note that a Category 1a designation can describe a range of biological scenarios, and does not necessarily imply that the hatchery stock and the associated natural population are close to a "pristine" state. For example, a hatchery program that started many years ago with local broodstock and regularly incorporated local natural-origin fish in substantial proportions thereafter would likely be a Category 1a, even if both the hatchery stock and the local natural population have diverged from what the natural population was like historically.

Category 2 stocks are no more than moderately diverged from the local, natural population(s) in the watershed. Category 2a stocks were founded from a local, native population in the watershed in which they are released. Category 2b stocks were founded nonlocally but from within the ESU, and are released in a watershed that does not contain a native natural population. Category 2c stocks were founded nonlocally but from within the ESU, and are released in a watershed that contains a native natural population.

Category 3 stocks are substantially diverged from the natural population(s) in the watershed in which they are released. The "a", "b," and "c" designations are the same as described for Category 2 above.

Category 4 stocks characterized either by being founded predominantly from sources that are not considered part of the ESU in question, or by extreme divergence from the natural population(s) in the watershed in which they are released, regardless of founding source.

Source of hatchery stock and status of local population

relationship to natural population	source from local, native natural population	source non-local but within ESU, no native local natural population	source non-local but within ESU, native local natural population exists	source non-local and predominantly from outside of ESU
Substantial natural origin fish in broodstock and minimal divergence	1a	1b	NA	4
Moderate to few natural origin fish in broodstock and no more than moderate divergence *	2a	2b	2c	
substantial divergence **	3a	3b	3c	
extreme divergence ***	4	4	4	4

* moderate divergence = no more than observed between similar populations within ESU
** substantial divergence = comparable to divergence observed within entire ESU
*** extreme divergence = greater than divergence observed within ESU or substantial artificial selection or manipulation

Figure 1. Summary of hatchery categorization system (SSHAG 2003).

Resident Fish

In addition to the anadromous life history, sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*) have nonanadromous or resident forms, generally referred to as kokanee and rainbow trout, respectively. (At least one resident population of chinook salmon also occurs, in Lake Cushman, Washington.) As is the case with hatchery fish, it is important to determine the relationships of these resident fish to anadromous populations in listed ESUs. This issue is complicated by the complexity of jurisdictional responsibilities—NMFS has ESA responsibility for anadromous Pacific salmonids, but the U.S. Fish and Wildlife Service (USFWS) has ESA jurisdiction for resident fish. At the time this report was prepared, the two agencies had not

developed a general policy on how to determine the ESU/DPS status of resident fish or how to make the listing determinations for the overall ESU/DPSs.

Resident (kokanee) populations in the two ESA-listed sockeye salmon ESUs (Redfish Lake and Lake Ozette) have been genetically characterized and determined not to be part of the sockeye salmon ESUs. However, the ESU status of many resident populations of *O. mykiss* remains in doubt. For the purposes of this status review update, therefore, the BRT adopted a working framework for determining the ESU/DPS status of *O. mykiss* that are geographically associated with listed steelhead ESUs. These evaluations were guided by the same biological principles used to define ESUs of natural fish and determine ESU membership of hatchery fish: the extent of reproductive isolation from, and evidence of biological divergence from, other populations within the ESU. These principles are comparable to the "discreteness" and "significance" criteria of the joint DPS policy of the two listing agencies (61 FR 4722, 7 February 1996). Ideally, each resident population would be evaluated individually on a case-by-case basis using all available biological information. In practice, little or no information is available for most resident salmonid populations.

To facilitate conclusions about the ESU/DPS status of resident fish, NMFS and USFWS have identified three different cases, reflecting the range of geographic relationships between resident and anadromous forms within different watersheds:

> Case 1: No obvious physical barriers to interbreeding exist between resident and anadromous forms.
>
> Case 2: Long-standing natural barriers (e.g., a waterfall) separate resident forms upstream from anadromous forms downstream.
>
> Case 3: Relatively recent (e.g., within last 100 years) human actions or man-made barriers (e.g., construction of a dam without provision for upstream fish passage) separate resident and anadromous forms.

The BRT reviewed available information about individual resident populations of *O. mykiss* to determine which case each population fits into. The BRT also adopted, for the purpose of the updated status reviews and extinction risk assessments, the following working assumptions about ESU membership of resident *O. mykiss* falling in each of these categories:

> Case 1: Resident fish were assumed provisionally to be part of the ESU. Rationale: Empirical studies show that resident and anadromous *O. mykiss* are typically very similar genetically when they co-occur in sympatry, with no physical barriers to migration or interbreeding (Chilcote 1976, Currens et al. 1987, Leider et al. 1995, Pearsons et al. 1998). (Note: This assumption is not necessarily applicable to *O. nerka*, because sockeye and kokanee can show substantial divergence, even in sympatry.)
>
> Case 2: Resident fish were assumed provisionally not to be part of the ESU. Rationale: Many populations in this category have been isolated from contact with anadromous populations for thousands of years. Empirical studies (Chilcote 1976, Currens et al. 1990) show that, in these cases, the resident fish typically show substantial genetic and life-history divergence from the nearest downstream anadromous populations.

Case 3: No default assumption was made about ESU status of resident fish.

The default assumptions about ESU membership for Case 1 and Case 2 populations can be overridden by specific information for individual populations. For example, as noted above, anadromous and resident *O. nerka* can diverge substantially in sympatry, and it is possible the same may be true for some *O. mykiss* populations.

The BRT discussed Case 3 populations at some length. Case 3 populations were, most likely, Case 1 populations (and hence presumably part of the ESU) prior to construction of the artificial barrier. Some BRT members felt that, in the absence of information to the contrary, it is reasonable to assume that Case 3 populations of *O. mykiss* are still in the ESU, given that the time since erection of the artificial barriers has been relatively short for substantial evolutionary divergence. However, the majority of the BRT members preferred to make no particular assumption regarding Case 3 populations. They reached this conclusion for two major reasons. First, Case 3 populations that historically were part of the ESU may no longer represent the ESU biologically because of (a) bottlenecks and/or local adaptation and rapid evolutionary divergence in a novel environment; or (b) displacement or introgression from nonnative, hatchery-origin rainbow trout. Notably, releases of hatchery rainbow trout have been widespread in the Pacific Northwest and California, including areas impounded by dams that block access to anadromous fish (Ludwig 1995, Van Vooren 1995). Empirical studies (Wishard et al. 1984, Williams et al. 1997, Utter 2001) have shown that the results of such releases can be quite variable, ranging from replacement of the native gene pool to hybridization to no detectable genetic effect. Therefore, the current relationship between Case 3 populations and anadromous populations in the ESU is difficult to evaluate without empirical data and historical stocking records for the population in question. Second, identifying a default assumption for Case 3 populations in the face of considerable biological uncertainty requires consideration of other factors that are not entirely scientific (such as, What is the appropriate burden of proof? and What are the biological, economic, and political consequences of making a wrong assumption?). Therefore, in this report the BRT did not suggest a default assumption regarding the ESU status of Case 3 populations. Instead, this report summarizes empirical information that does exist for specific Case 3 populations and discusses its relevance to ESU determinations. As new biological information relevant to the ESU status of individual Case 3 populations is developed as part of the overall recovery planning process for West Coast salmon and steelhead described in the Background and Introduction section, that information will be passed on to NMFS Regional Office Staff for consideration.

Genetic data can provide a powerful means for determining the evolutionary origin of a sampled population, and such data can therefore be very useful in evaluating the extent to which native resident *O. mykiss* populations have been affected by releases of nonnative hatchery rainbow trout. The steelhead ESU reports in Section B of this report summarize this information as it applies to specific Case 3 populations. As discussed above, rapid genetic changes associated with human impacts can also occur within populations in the absence of stock transfers, and these changes are unlikely to be detected with standard molecular genetic techniques. Evaluating the importance of such effects is very difficult. Phenotypic and life-history traits can serve as proxies for genetically based, adaptive differences among populations; however, such traits can also be affected by environmental conditions, which confounds their interpretation. These confounding effects can generally be teased apart only with very detailed

experiments. It is therefore likely that the evolutionary relationships of many Case 3 populations will remain uncertain for the foreseeable future.

In response to a request for additional information about listed ESUs of steelhead (67 FR 79898-79900; 31 December 2002), NMFS received two comments relevant to the ESU status of resident *O. mykiss*. The Center for Biological Diversity (CBD 2003) argued that NMFS erred in referring to *O. mykiss* trapped above dams as "resident" fish and excluding them from the steelhead listings. According to CBD, the distinction between anadromous and resident populations should be based not on circumstances of geography (i.e., whether the fish are currently above or below a recent man-made barrier), but rather on biological attributes of the populations—specifically, the "genetic trait expressed in smoltification." They argued that resident populations that are genetically (i.e., historically) anadromous, but which are currently trapped above human barriers with no opportunity to express anadromy, should be considered part of the listed steelhead ESUs. The BRT's conclusions regarding the ESU status of Case 3 resident populations (above human barriers) is described above.

Trout Unlimited (2003) argued that, based on substantial ecological and life history differences, anadromous and resident *O. mykiss* should be in separate ESUs, even in cases where there are no appreciable molecular genetic differences between the two forms. They cited studies showing a) little evidence that transplanted rainbow trout can give rise to anadromous populations, and b) one study in the Deschutes River, in which all anadromous fish examined were found to have an anadromous female parent and all resident fish examined were found to have a resident female parent, as evidence for a genetic basis for the differences between the two forms. This argument is similar to the arguments the BRT has considered in previous status reviews, that summer and winter steelhead, or spring and fall chinook in coastal basins, should be in different ESUs (Busby et al. 1996; Myers et al. 1998). As in those status reviews, the BRT does not dispute that the two forms of *O. mykiss* can exhibit some degree of reproductive isolation, even in areas where they co-occur. However, the strong genetic similarity of the two forms in sympatry in every case where they have been examined indicates that, in general, the two forms are genetically linked on evolutionary time frames. Furthermore, the Deschutes River study (Zimmerman and Reeves 2000) also examined a population in British Columbia, where the authors found that anadromous fish can give rise to resident offspring, and vice versa—a result that has been found in other areas as well. In general, genetic data show that resident and anadromous *O. mykiss* below barriers in the same basin are genetically more similar to each other than either is to the same form in another basin. Therefore, lumping steelhead and resident populations into separate ESUs would create artificial units in which each population had its nearest relative in a different ESU. This problem could be resolved only by considering every population (anadromous or resident) its own ESU—a result that would lead to hundreds of ESUs of *O. mykiss* and would be inconsistent with the approach NMFS has taken in all other status reviews for Pacific salmon. Therefore, the BRT continued to consider the evolutionary relationships between resident and anadromous populations in a way that was consistent with the approach used in evaluating alternative life history forms in previous status reviews.

Although resident *O. mykiss* may occasionally produce anadromous offspring, and vice versa, there is (as noted by Trout Unlimited 2003) little empirical evidence to indicate that a population of resident *O. mykiss* can give rise to a self-sustaining anadromous *population*. This

issue is relevant to extinction risk analysis for ESUs containing both forms and is discussed in Section B of this report.

Risk Assessments

ESA Definitions

After the composition of an ESA species is determined, the next question to address is, "Is the species threatened or endangered?" Section 3 of the ESA defines endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range." The term threatened species is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Neither NMFS nor the USFWS have developed formal policy guidance about how to interpret the ESA definitions of threatened or endangered species.

The BRT considers a variety of information in evaluating the level of risk faced by an ESU. According to Section 4 of the ESA, the determination of whether a species is threatened or endangered should be made "solely on the basis of the best scientific and commercial data available" regarding the species' current status, after taking into account efforts being made to protect the species. In its biological status reviews, the BRT does not evaluate possible future effects of protective efforts, except to the extent the effects are already reflected in metrics of population or ESU viability. Protective efforts are taken into account in a separate process by the NMFS regional offices prior to making listing determinations. Therefore, the BRT does not make recommendations as to whether identified ESUs should be listed as threatened or endangered species because that determination requires evaluation of factors not considered by the team. Rather, the BRT draws scientific conclusions about the current risk of extinction faced by ESUs, under the assumption that present conditions will continue into the future (recognizing, of course, that natural demographic and environmental variability are inherent features of "present conditions").

Factors for Decline

According to Section 4 of the ESA, the Secretary (of Commerce or the Interior) shall determine whether a species is threatened or endangered as a result of any (or a combination) of the following factors: destruction or modification of habitat; overutilization; disease or predation; inadequacy of existing regulatory mechanisms; or other natural or man-made factors. Collectively, these are often referred to as "factors for decline." In the Federal Register notices announcing the ESA listing decisions for West Coast salmon and steelhead, NMFS included sections identifying what have come to be known as the 4H factors for decline—habitat degradation and loss, hydropower development, overharvest, and hatchery propagation—as well as other factors. However, in the status reviews, the BRT did not attempt a rigorous analysis of this subject, and the same is true for this report. There are several reasons for this.

- First, the BRT chose to focus primarily on the question of whether an ESU is at risk rather than how it came to be at risk. Although the latter question is important, a

population or ESU that has been reduced to low abundance will continue to be at risk for demographic and genetic reasons until it reaches a larger size, regardless of the reasons for its initial decline. Furthermore, in some cases, a factor that was important in causing the original declines may no longer be an impediment to recovery.

- Second, unlike many other ESA-listed species that face a single primary threat, salmon face a bewildering array of potential threats throughout every stage of their complex life cycle. It is relatively easy to simply enumerate current and past threats to salmon populations, but it is much more difficult to evaluate the relative importance of a wide range of interacting factors.
- Third, evaluating the degree to which historic factors for decline will continue to pose a threat in the future generally requires consideration of issues that are more in the realm of social science than biological science—such as whether proposed changes will be funded, and, if funded, will be implemented effectively.

In it's listing determination for the updated status reviews, NMFS will consider factors for decline and the extent to which they have been alleviated by protective efforts. It is expected that these issues will be addressed in detail in formal ESA recovery planning for ESUs that remain listed. The agency has outlined a two-step process for recovery planning; the first step is identifying biologically based delisting criteria, and the second step is developing a suite of actions (the Recovery Plan) that has a high probability of achieving the recovery goals. (For more information about ESA recovery planning for West Coast salmon and steelhead, visit http://www.nwfsc.noaa.gov/cbd/trt/about.htm.) Delisting would occur only after the ESU satisfied both the biological delisting criteria and associated administrative delisting criteria, which typically involve assurances that the threats to the continued existence of the ESU have been satisfactorily resolved.

Although this report does not consider factors for decline in a comprehensive way, the BRT did consider major risk factors that were identified in previous status reviews. The sections in this report focusing on specific ESUs summarize the previous BRT conclusions and identify any major changes in risk factors that have occurred since the time of listing.

Artificial Propagation

The 1993 NMFS ESA policy for artificial propagation of Pacific salmon and steelhead recognizes that artificial propagation can be one of the conservation tools used to help achieve recovery of ESA-listed species, but it does not consider hatcheries to be a substitute for conservation of the species in its natural habitat. Therefore, ESA risk analyses for salmon and steelhead ESUs were conducted for "natural" fish (which are defined as the progeny of naturally spawning fish), based on whether or not the natural populations can be considered self-sustaining without regular infusion of hatchery fish. This is the same provision articulated in the joint USFWS-NMFS policy on artificial propagation of all species under the ESA (Federal Register, Volume 65, Number 114, June 13, 2000, p. 37102) and is consistent with the approach the USFWS has used to evaluate captive propagation programs for other species, such as the condor (USFWS 1996) and the Bonytail chub (USFWS 2002).

The draft revised salmon hatchery policy outlines a three-step approach for considering artificial propagation in listing determinations:

1. Identify which hatchery populations are part of the ESU (see previous section).
2. Review the status of the ESU.
3. Evaluate existing protective efforts and make a listing determination.
4. This document is concerned with step 2—the risk analysis for listed salmon and steelhead ESUs.

The draft revised hatchery policy interprets the purpose of the ESA is to conserve threatened and endangered species in their natural habitats. In its risk evaluations, the BRT therefore used the approach it has in the past—focusing on whether populations and ESUs are self-sustaining in their natural habitat. In this report, therefore, when we refer to evaluations or conclusions of the BRT regarding the status of ESUs, we are referring to analyses conducted using the criterion of self-sustainability of natural populations.

Artificial propagation can be used as a conservation tool. Potential benefits of artificial propagation for natural populations include reducing the short-term risk of extinction, helping to maintain a population until the factors limiting recovery can be addressed, reseeding vacant habitat, and helping to speed recovery. Whether these potential benefits will be realized in any particular case is difficult to predict. To the extent that such benefits have already occurred, they will be reflected in the population abundance and trend data considered by the BRT. The draft revised hatchery policy also indicates that the potential future conservation benefits of artificial propagation should be considered before a listing determination is made. The potential conservation benefits of artificial propagation, together with other protective efforts, will be considered by NMFS regional office and headquarters staff in determining whether to propose any changes to the current ESA listing for West Coast salmon and steelhead.

Artificial propagation is important to consider in ESA evaluations of anadromous Pacific salmonids for several other reasons. First, although natural fish are the subject of risk assessments, possible positive or negative effects of artificial propagation on natural populations must also be evaluated. For example, artificial propagation can alter life-history characteristics such as smolt age and migration and spawn timing. Second, in addition to the potential to increase abundance of fish, artificial propagation poses a number of risks to natural populations that may affect their risk of extinction or endangerment. In contrast to most other types of risk for salmon populations, those arising from artificial propagation are often not reflected in traditional indices of population abundance. For example, to the extent that habitat degradation, overharvest, or hydropower development have contributed to a population's decline, these factors will already be reflected in population abundance data and accounted for in the risk analysis. The same is not necessarily true of artificial propagation. Hatchery production may mask declines in natural populations that will be missed if only raw population abundance data are considered. Therefore, a true assessment of the viability of natural populations cannot be attained without information about the genetic and demographic contribution of naturally spawning hatchery fish. Furthermore, even if such data are available, they will not in themselves provide direct information about possible deleterious effects of fish culture. Such an evaluation

requires consideration of the genetic and demographic risks of artificial propagation for natural populations.

Resident Fish

As indicated above, the BRT concluded in previous status reviews that at least some resident *O. mykiss* populations belonged to steelhead ESUs, and these resident fish were considered in the overall risk analyses for those ESUs. However, in most cases, little or no information was available about the numbers and distribution of resident fish, as well as about the extent and nature of their interactions with anadromous populations. Given this situation, the previous risk analyses for steelhead ESUs focused primarily on the status of anadromous populations.

In these updated status reviews, increased efforts have been made to gather biological information for resident *O. mykiss* populations to assist in the risk analyses. (Although the two listed sockeye salmon ESUs considered in this report [Redfish Lake and Lake Ozette] have associated kokanee populations, in neither case are the kokanee considered to be part of the sockeye salmon ESU, so the kokanee were not formally considered in the risk analyses.) Information on resident fish is summarized below in the report for steelhead (Section B), where ESU-specific information is discussed in more detail. The steelhead report also contains a more general discussion of how resident fish were considered in the risk analyses for steelhead ESUs.

Factors Considered in Status Assessments

Salmonid ESUs are typically metapopulations; that is, they are usually composed of multiple populations with some degree of interconnection, at least over evolutionary time periods. This makes the assessment of extinction risk difficult. The approach to this problem that NMFS adopted for recovery planning is outlined in the viable salmonid populations (VSP) report (McElhany et al. 2000). In this approach, risk assessment is addressed at two levels: first, the population level, then at the overall ESU level. We have modified previous BRT approaches to ESU risk assessments to incorporate VSP considerations.

Individual populations are assessed according to the four VSP criteria: abundance, growth rate/productivity, spatial structure, and diversity. The condition of individual populations is then summarized on the ESU level, and larger-scale issues are considered in evaluating the status of the ESU as a whole. These larger-scale issues include total number of viable populations, geographic distribution of these populations (to ensure inclusion of major life-history types and to buffer the effects of regional catastrophes), and connectivity among these populations (to ensure appropriate levels of gene flow and recolonization potential in case of local extirpations). These considerations are detailed in McElhany et al. (2000).

In previous status reviews, the BRTs have used a simple "risk matrix" for quantifying ESU-scale risks according to major risk factors. The revised matrix (Table 1) integrates the four major VSP criteria (abundance, productivity, spatial structure, and diversity) directly into the risk assessment process. After reviewing all relevant biological information for a particular ESU, each BRT member assigns a risk score (see below) to each of the four VSP criteria. Use of the

risk matrix makes it easier to compare risk factors within and across ESUs. The scores are tallied and reviewed by the BRT before making its overall risk assessment (see FEMAT method, below). Although this process helps to integrate and quantify a large amount of diverse information, there is no simple way to translate the risk matrix scores directly into an assessment of overall risk. For example, simply averaging the values of the various risk factors would not be appropriate; an ESU at high risk for low abundance would be at high risk even if there were no other risk factors.

Scoring VSP criteria. Risks for each VSP factor are ranked on a scale of 1 (very low risk) to 5 (very high risk):

1. *Very Low Risk.* Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.
2. *Low Risk.* Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may, in combination with other factors.
3. *Moderate Risk.* This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.
4. *High Risk.* This factor contributes significantly to long-term risk of extinction and is likely to contribute to short-term risk of extinction in the foreseeable future.
5. *Very High Risk.* This factor by itself indicates danger of extinction in the near future.

Recent events. The "recent events" category considers events that have predictable consequences for ESU status in the future but have occurred too recently to be reflected in the population data. Examples include a flood that decimated most eggs or juveniles in a recent broodyear, or large jack returns that generally anticipate strong adult returns in subsequent year(s). This category is scored as follows:

++ — expect a strong improvement in status of the ESU;

+ — expect some improvement in status;

0 — neutral effect on status;

- — expect some decline in status;

-- — expect strong decline in status.

Table 1. Template for the risk matrix used in BRT deliberations. The matrix is divided into five sections that correspond to the four VSP "parameters" (McElhany et al. 2000) plus a "recent events" category.

[ESU Name]

Risk Category	**Score***
Abundance Comments:	
Growth Rate/Productivity Comments:	
Spatial Structure and Connectivity Comments:	
Diversity Comments:	
Recent Events	

* Rate overall risk of ESU on 5-point scale (1–very low risk; 2–low risk; 3–moderate risk; 4–increasing risk; 5–high risk), except recent events double plus (++, strong benefit) to double minus (--, strong detriment)

Historical distribution and abundance. The ESA has no provision that requires a species to occupy its entire historic habitat or reach historic levels of abundance before it can be considered no longer threatened or endangered. Using the VSP criteria described above, it is only necessary that an ESU contain enough viable populations and satisfy concerns for spatial structure and diversity. However, developing strictly quantitative viability criteria is extremely challenging, even at the population level (see "Methods"). Therefore, other approaches that provide insight into viability are also important to consider. If our definitions of ESUs (groups of populations on independent evolutionary trajectories) and populations (demographically independent units over at least a 100-year time frame) are correct, then by definition they were sustainable at historic levels. Therefore, we can be confident that a population or ESU that approximates its historic distribution and abundance will be viable into the future. This *a priori* presumption of viability diminishes the further the current status departs from the historical template. For a population or ESU that is greatly reduced from its historic distribution and/or abundance, there is little *a priori* reason to assume the current status is viable. The viability of such a population or ESU is in considerable doubt unless independent data can be developed to assess viability.

Marine productivity. In the last decade, evidence has accumulated to demonstrate (1) recurring, decadal-scale patterns of ocean-atmosphere climate variability in the North Pacific Ocean (Zang et al. 1997, Mantua et al. 1997), and (2) correlations between these oceanic productivity "regimes" and salmon population abundance in the Pacific Northwest and Alaska (Hare et al. 1999, Mueter et al. 2002). There seems to be little doubt that survival rates in the marine environment can be strong determinants of population abundance for Pacific salmon and steelhead. It is also generally accepted that for at least two decades, beginning about 1977, marine productivity conditions were unfavorable for the majority of salmon and steelhead populations in the Pacific Northwest (in contrast, many populations in Alaska attained record abundances during this period). Finally, there is evidence that an important shift in ocean-atmosphere condition occurred around 1998. One indicator of the ocean-atmosphere variation for the North Pacific is the Pacific Decadal Oscillation index (PDO); Figure 2 shows that the PDO has taken mostly negative values since 1999 (time period C on the graph), whereas the values were positive in most of the previous two decades (time period B) and generally negative again for a long period before that (period A). Negative PDO values are associated with relatively cool ocean temperatures (and generally high salmon productivity) off the Pacific Northwest, and positive values are associated with warmer, less productive conditions. As discussed in this report, increases in many salmon populations in recent years may be largely a result of more favorable ocean conditions.

Although these facts are relatively well established, much less certainty can be attached to any predictions about what this means for the viability of listed salmon and steelhead. For several reasons, considerable caution is needed to project into the future. First, empirical evidence for "cycles" in PDO, marine productivity, and salmon abundance extends back only about a century, or about three periods of two- to four-decades' duration. This is a very short data record for inferring future behavior of a complex system. Thus, as with the stock market, the past record is no guarantee of future performance. Second, the past decade has seen particularly wide fluctuations not only in climatic indices (e.g., the 1997–1998 El Niño was in many ways the most extreme ever recorded, and the 2000 drought was one of the most severe on

record), but also in abundance of salmon populations. In general, as the magnitude of fluctuations increases, the population extinction rate also increases. Third, if there is anthropogenically caused climate change in the future, it could affect ocean productivity. The range of future climate change scenarios consistent with existing data is so wide that future consequences cannot be predicted with any certainty; however, many models suggest that northern latitudes are likely to experience significant temperature increases (IPCC 2001). Finally, changes in the pattern of ocean-atmosphere interactions do not affect all species (or even all populations of a given species) in the same way (Peterman et al. 1998).

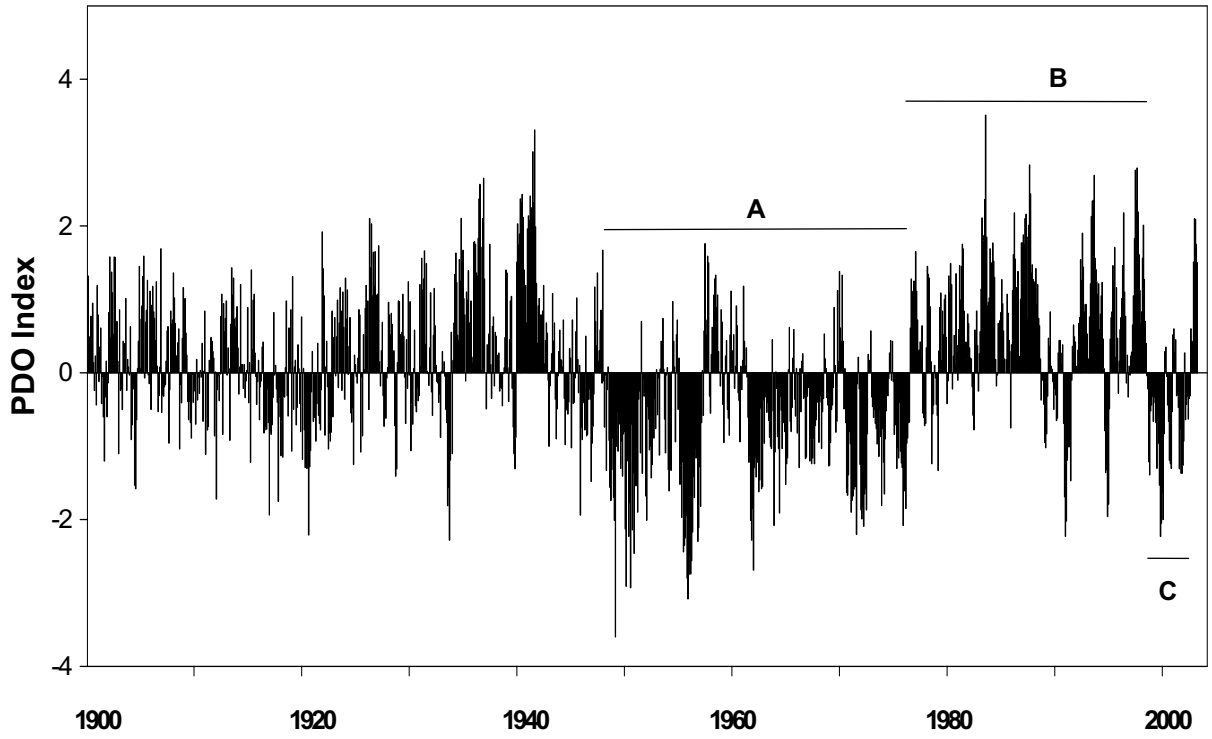


Figure 2. Monthly values for the Pacific Decadal Oscillation Index, which is based on sea surface temperatures in the North Pacific. Values shown are deviations from the long-term (1900–1993) mean. See text for discussion of time periods A, B, and C. (From http://tao.atmos.washington.edu/pdo/)

Based on these considerations, the BRT identified a number of possible future scenarios for impacts of ocean productivity on listed salmon and steelhead populations:

1. The PDO index could remain primarily negative for another decade or two (a typical duration for "regimes" observed in the past), leading to marine productivity conditions that are generally more favorable to Pacific Northwest salmon and steelhead than occurred from the mid-1970s to the late 1990s.
2. The last several years might be an anomaly, and the PDO index might revert back to the positive regime it has largely been in since the mid 1970s. It is worth noting in this regard that the PDO index has been positive in every month from August 2002 through March 2003 (Figure 2).

3. Marine and freshwater systems may continue to see wide fluctuations in environmental conditions.
4. Anthropogenically caused climate change might be a significant factor in the future, with consequences that are difficult to predict.

Given all these uncertainties, the BRT was reluctant to make any specific assumptions about the future behavior of the ocean-atmospheric systems or their effects on the distribution and abundance of salmon and steelhead. The BRT was concerned that even under the most optimistic scenario (a), increases in abundance might be only temporary and could mask a failure to address underlying factors for decline. The real conservation concern for West Coast salmon and steelhead is not how they perform during periods of high marine survival, but how prolonged periods of poor marine survival affect the VSP parameters of abundance, growth rate, spatial structure, and diversity. It is reasonable to assume that salmon populations have persisted over time, under pristine conditions through many such cycles in the past. Less certain is how the populations will fare in periods of poor ocean survival when their freshwater, estuary, and nearshore marine habitats are degraded.

Overall Risk Assessment

The BRT analysis of overall risk to the ESU uses categories that correspond to definitions in the ESA: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (As discussed above, these evaluations do not consider protective efforts and therefore are not recommendations regarding listing status.) The overall risk assessment reflects professional judgment by each BRT member. This assessment is guided by the results of the risk matrix analysis as well as expectations about likely interactions among factors. For example, a single factor with a "high risk" score might be sufficient to result in an overall score of "in danger of extinction," but a combination of several factors with more moderate risk scores could also lead to the same conclusion.

To allow for uncertainty in judging the actual risk facing an ESU, the BRT has adopted a "likelihood point" method, often referred to as the "FEMAT" method because it is a variation of a method used by scientific teams evaluating options under President Clinton's Forest Plan (Forest Ecosystem Management: An Ecological, Economic, and Social Assessment Report of the Forest Ecosystem Management Assessment Team [FEMAT; http://www.or.blm.gov/ForestPlan/NWFPTitl.htm]). In this approach, each BRT member distributes ten likelihood points among the three ESU risk categories, reflecting their opinion of how likely that category correctly reflects the true ESU status. Thus, if a reviewer were certain that the ESU was in the "not at risk" category, he or she could assign all ten points to that category. A reviewer with less certainty about ESU status could split the points among two or even three categories. This method has been used in all status review updates for anadromous Pacific salmonids since 1999.

METHODS

Primary contributors: Thomas P. Good and Sarah Sydor
(Northwest Fisheries Science Center)

Data on abundance, the fraction of hatchery-origin spawners, harvest, age structure, and hatchery releases were requested from state, federal and tribal sources [Federal Register, Vol. 67, No. 28, February 11, 2002, p. 6215] and were compiled with previous data to conduct updated risk analyses for each ESU. Data on adult returns were obtained from a variety of sources, including time series of freshwater spawner surveys, redd counts, and counts of adults migrating past dams/weirs. Time series were assembled and analyzed at the scale of VSP populations where these have been identified by Technical Recovery Teams (TRTs) or "quasi-populations" where populations are in the process of being identified by TRTs.

Preliminary data and analyses were reviewed by state, federal, and tribal comanagers for accuracy and completeness. Where possible, population or ESU-level estimates of the fraction of hatchery-origin spawners were obtained or calculated using information from scale analyses, fin clips, etc. Estimates of harvest were obtained for some stocks directly; for others, harvest rates on nearby indicator stocks were used to estimate the number of fish in the target population that would have returned to spawn in the absence of harvest. See appendices at the end of each species section for detailed information and references for data sources.

Recent abundance

Recent abundance of natural spawners is reported as the geometric mean (and range) of the most recent data to be consistent with previous coast-wide status reviews of these species (Weitkamp et al. 1995, Busby et al. 1996, Gustafson et al. 1997, Johnson et al. 1997, Myers et al. 1998). Geometric means were calculated to represent the recent abundance of natural spawners for each population or quasi-population within an ESU. Geometric means were calculated for the most recent five years (chinook, steelhead), four years (chum, sockeye), or three years (coho); these time frames were selected to correspond with modal age at maturity for each species. Zero values in the data set were replaced with a value of one, and missing data values within a multiple-year range were excluded from geometric mean calculations. The geometric mean is the *n*th root of the product of the *n* data:

$$\overline{X}_G = \sqrt[n]{N_1 N_2 N_3 ... N_n}\ , \qquad \text{(Eq. 1)}$$

where N_t is the abundance of natural spawners in year *t*.

Arithmetic means (and ranges) were also calculated for the most recent abundance data:

$$\overline{X}_A = \frac{\sum N_i}{n}\ , \qquad \text{(Eq. 2)}$$

where N_t is the abundance of natural spawners in year *t*.

Trends in abundance

Short-term and long-term trends were calculated from time series of the total number of adult spawners. Short-term trends were calculated using data from 1990 to the most recent year, with a minimum of 10 data points in the 13-year span. Long-term trends were calculated using all data in a time series.

Trend was calculated as the slope of the regression of the number of natural spawners (log-transformed) over the time series; to mediate for zero values, one was added to natural spawners before transforming the data. Trend was reported in the original units as exponentiated slope, such that a value > 1 indicates a population trending upward, and a value < 1 indicates a population trending downward. The regression was calculated as

$$\ln(N+1) = \beta_0 + \beta_1 X + \varepsilon\,, \qquad \text{(Eq. 3)}$$

where N is the natural spawner abundance, β_0 is the intercept, β_1 is the slope of the equation, and ε is the random error term.

Confidence intervals (95%) for the slope, in their original units of abundance, were calculated as

$$\exp(\ln(b_1) - t_{0.05(2),df}\, s_{b_1}) \le \beta_1 \le \exp(\ln(b_1) + t_{0.05(2),df}\, s_{b_1})\,, \qquad \text{(Eq. 4)}$$

where b_1 is the estimate of the true slope β_1, $t_{0.05(2),\,df}$ is the two-sided t-value for a confidence level of 0.95, df is equal to n-2, n is the number of data points in the time series, and s_{b1} is the standard error of the estimate of the slope, b_1. The probability that the trend value was declining [P(trend < 1)] was also calculated.

Population growth rate

In addition to analyses of trends in natural spawners, we calculated the median short-term population growth rate (λ) of natural-origin spawners as a measure for comparative risk analysis. Lambda more accurately reflects the biology of salmon and steelhead, as it incorporates overlapping generations and calculates running sums of cohorts. It is an essential parameter in viability assessment, as most population extinctions are the result of steady declines, $\lambda < 1$. It has been developed for data sets with high sampling error and age-structure cycles (Holmes 2001). These methods have been extensively tested using simulations for both threatened and endangered populations as well as for stocks widely believed to be at low risk (Holmes, in press), and cross-validated with time series data (Holmes and Fagan 2002).

The λ of natural-origin spawners was calculated in two ways for each population over the short-term time frame (1990-most recent year). The first (λ) assumed that hatchery-origin spawners had zero reproductive success, while the second (λ_h) assumed that hatchery-origin spawners had reproductive success equivalent to that of natural-origin spawners. These extreme assumptions bracket the range likely to occur in nature. Empirical studies indicate that hatchery-

origin spawning fish generally have lower (and perhaps much lower) reproductive success than natural-origin spawners (reviewed by Reisenbichler and Rubin 1999). However, this difference can vary considerably across species and populations, and it is very rare that data are available for a particular population of interest. Therefore, to be conservative, we bracketed the scenarios that are likely to be occurring in nature.

A multi-step process based on methods developed by Holmes (2001), Holmes and Fagan (2002) and described in McClure et al. (in press) was used to calculate estimates for λ, its 95% confidence intervals, and its probability of decline [P(λ < 1)]. The first step was calculating 4-year running sums for natural-origin spawners as

$$R_t = \sum_{i=1}^{4} N_{t-i+1} \ . \qquad \text{(Eq. 5)}$$

where N_t is the number of natural-origin spawners in year *t.* A 4-year running sum window was used for all species, as analysis by McClure et al. (in press) indicates this is an appropriate window for a diverse range of species life histories.

Next, an estimate of μ, the rate at which the median of *R* increases through time (Holmes 2001), was calculated as

$$\hat{\mu} = mean\left(\ln\left(\frac{R_{t+1}}{R_t} \right) \right) \qquad \text{(Eq. 6)}$$

—the mean of the natural log-transformed running sums of natural-origin spawners. The point estimate for λ was then calculated as the median annual population growth rate,

$$\hat{\lambda} = e^{\hat{\mu}} \ . \qquad \text{(Eq. 7)}$$

Confidence intervals (95%) were calculated for $\hat{\lambda}$ to provide a measure of the uncertainty associated with the growth rate point estimate. First, an estimate of variability for each population was determined by calculating an estimate for σ^2_{pop} using the slope method (Holmes 2001). The slope method formula is

$$\hat{\sigma}^2_{pop} = \text{slope of var}\left(\ln\left(\frac{R_{t+\tau}}{R_t} \right) \right) \text{vs.}\, \tau., \qquad \text{(Eq. 8)}$$

where τ is a temporal lag in the time series of running sums.

Individual population variance estimates were highly uncertain, so a more robust variance estimate, σ^2_{avg}, was obtained by averaging the σ^2_{pop} estimates from all the populations in an ESU. This average variance estimate was then applied as the variance for every population in an ESU. The degrees of freedom associated with the average variance estimate are obtained by summing the degrees of freedom for each of the individual population variance estimates. The degrees of freedom for the individual population estimates were determined using the method of Holmes

and Fagan (2002), which identifies the adjusted degrees of freedom associated with slope method variance estimates. The calculation for the adjusted degrees of freedom is

$$df = 0.212n - 1.215, \qquad \text{(Eq. 9)}$$

where n is the length of the time series. Using the average variance estimate and the summed degrees of freedom, the 95% confidence intervals for λ were calculated as

$$\exp\left(\hat{\mu} \pm t_{.05(2),df}\sqrt{\hat{\sigma}_{slp}^{\ 2}/(n-4)}\right). \qquad \text{(Eq. 10)}$$

In addition, the probability that the population growth rate was declining [P(λ < 1)] was calculated utilizing the fact that ln(λ) follows a *t*-distribution. This probability is calculated by finding the probability that the natural log of the calculated lambda divided by its standard error is less than zero.

The preceding treatment ignores contributions of hatchery-origin spawners to the next generation, in effect assuming that they had zero reproductive success. This assumption produces the most optimistic view of viability of the natural population. The other extreme assumption (that hatchery-origin spawners have reproductive success equivalent to that of natural-origin spawners), produces the most pessimistic view of viability of the natural population, given any particular time series of data. To calculate the median growth rate under this assumption (λ_h), a modified approach to the method developed by Holmes (2001) was used to calculate estimates for λ_h, 95% confidence intervals for λ_h, and to determine $P(\lambda_h < 1)$. The first step was calculating 4-year running sums (*RN*) for natural-origin spawners as

$$(RN)_t = \sum_{i=1}^{4} N_{t-i+1}\ . \qquad \text{(Eq. 11)}$$

Next, the 4-year running sum of hatchery-origin spawners was calculated as

$$(RH)_t = \sum_{i=1}^{4} H_{t-i+1}\ , \qquad \text{(Eq. 12)}$$

where H_t is the number of hatchery spawners in year *t*.

The ratio of total spawners to natural origin spawners was calculated as

$$\psi_t = \frac{(RN)_t + (RH)_t}{(RN)_t}. \qquad \text{(Eq. 13)}$$

The average age at reproduction, *T*, was calculated in three steps:

1. Determine the total number of spawners for each age (*A*) by calculating

$$A_j = \sum_{j=1}^{\max age} \sum_{all\ t} a_j (N+H)_t . \qquad \text{(Eq. 14)}$$

2. Calculate the total number of spawners (G)

$$G = \sum_{j=1}^{\max age} A_j . \qquad \text{(Eq. 15)}$$

3. Determine the average age at reproduction (T) by calculating

$$T = \sum_{j=1}^{\max age} \frac{j \times A_j}{G} . \qquad \text{(Eq. 16)}$$

Next, an estimate of μ, the rate at which the median increases through time (Holmes 2001), was calculated as

$$\hat{\mu} = mean\left(\ln\left(\frac{(RN)_{t+1}}{(RN)_t} \right) - \frac{1}{T} \ln(\psi_t) \right). \qquad \text{(Eq. 17)}$$

The point estimate for λ_h was then calculated as the median annual population growth rate (Eq. 7).

Confidence intervals (95%) for λ_h and its probability of decline [$P(\lambda_h < 1)$] were calculated as for λ, with modification to the slope method for calculating the variance:

$$\hat{\sigma}^2 = \text{slope of var}\left(\ln\left(\frac{(RN)_{t+\tau}}{(RN)_t} \right) - \frac{1}{T} \ln\left(\prod_{i=0}^{\tau-1} \psi_{t+i} \right) \right) \text{vs.}\, \tau. \qquad \text{(Eq. 18)}$$

Calculating recruits

Recruits, or spawners in the next generation, from a give brood year were calculated as

$$C_t = \sum_{i=1}^{MaxAge} N_{t+i} A(i)_{t+i} , \qquad \text{(Eq. 19)}$$

where C_t is the number of recruits from brood year t, N_t is the number of natural origin spawners in year t, and $A(i)_t$ is the fraction of age i spawners in year t. The estimate of preharvest recruits is similarly

$$C(preHarvest)_t = \sum_{i=1}^{MaxAge} P_{t+i} A(i)_{t+i} , \qquad \text{(Eq. 20)}$$

where $C(preHarvest)_t$ is the number of preharvest recruits in year t, P_t is the number of natural origin spawners that would have returned in year t if there had not been a harvest, and $A(i)_t$ is the fraction of age i spawners in year t had there not been a harvest. [Because P_t is in terms of the number of fish that would have appeared on the spawning grounds had there not been a harvest, it can be quite difficult to estimate and simplifying assumptions are often made].

Population Viability Analysis

A variety of quantitative approaches to Population Viability Analysis (PVA) have been used with Pacific salmonids. Because no consensus has emerged on how best to model population viability in salmon, we did not employ a standardized PVA model in this report. However, we considered results of PVA analyses that had been conducted for specific populations.

REFERENCES

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261 p.

CBD (Center for Biological Diversity). 2003. Letter from David Hogan to Rodney McInnis re: Status review updates for Snake River sockeye salmon and southern California steelhead: and additional information request for nine ESUs of west coast steelhead. February 14, 2003. 4 p.

Chilcote, M. W. 1976. Genetic comparison of Deschutes River steelhead and rainbow trout at selected enzyme loci. M. S. Thesis, Oregon State Univ., Corvallis, OR.

Currens, K. P., S. L. Stone, and C. B. Schreck. 1987. A genetic comparison of rainbow trout (*Salmo gairdneri*) above and below Izee Falls in the John Day River, Oregon. Oregon Coop. Fish. Res. Unit Genet. Lab. Rep. 87(2), 34 p. (Available from Oregon Cooperative Fishery Research Unit, Oregon State University, Corvallis, OR 97331.)

Currens, K. P., C. B. Schreck, and H. W. Li. 1990. Allozyme and morphological divergence of rainbow trout (*Oncorhynchus mykiss*) above and below waterfalls in the Deschutes River, Oregon. Copeia 1990:730-746.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-33, 282 p.

Holmes, E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Sciences: 98(9): 5072-5077.

Holmes, E. E. and W. F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83: 2379-2386.

IPPC (Intergovernmental Panel on Climate Change). 2001. Climate change 2001: impacts, adaptation, and vulnerability. Cambridge University Press, New York, NY.

Johnson, O.W., W. S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-32, 280 p.

Kostow, K. 2003. The biological implications of non-anadromous *Oncorhynchus mykiss* in Columbia River Basin steelhead ESUs. Draft report to the National Marine Fisheries Service. January 13, 2003. 90 pp.

Leider, S. A., S. R. Phelps, and P. L. Hulett. 1995. Genetic analysis of Washington steelhead: Implications for revision of genetic conservation management units. Wash. Dep. Fish Wildl. Prog. Rep., 21 p. (Available from Washington Department of Fish and Wildlife, Fish Management Program, 600 Capitol Way N, Olympia, WA 98501-1091).

Ludwig, B. 1995. British Columbia's trout hatchery program and the stocking policies that guide it. Amer. Fish. Soc. Symposium 15:139-143.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78: 1069-1079.

McClure, M. M., E. E. Holmes, B. L. Sanderson, and C. E. Jordan. 2003. A large-scale, multi-species status assessment: anadromous salmonids in the Columbia River Basin. Ecological Applications (in press).

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

Mueter, F. J., R. M. Peterman, and B. J. Pyper. 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (*Oncorhynchus* spp.) in northern and southern areas. Can. J. Fish. Aquat. Sci. 59:456-463.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

NMFS (National Marine Fisheries Service). 1991. Notice of policy: Policy on applying the definition of species under the Endangered Species Act to Pacific salmon. Federal Register [Docket 910248-1255, 20 November 1991] 56(224): 58612-58618.

NMFS (National Marine Fisheries Service). 1993. Interim policy on artificial propagation of Pacific salmon under the Endangered Species Act. Federal Register [Docket 921186-2286, 5 April 1993] 58(63): 17573-17576.

Peterman, R. M., B. J. Pyper, M. F. Lapointe, M. D. Adkison, and C. J. Walters. 1998. Patterns of covariation in survival rates of British Columbian and Alaskan sockeye salmon (*Oncorhynchus nerka*) stocks. Can. J. Fish. Aquat. Sci. 55:2503-2517.

Pearsons, T. N., S. R. Phelps, S. W. Martin, E. L. Bartrand and G. A. McMichael. 1998. Gene flow between resident and anadromous rainbow trout in the Yakima Basin: ecological and genetic evidence. Project No. 89-105. Bonneville Power Administration, Portland, OR.

Reisenbichler, R. R. and S. P. Rubin. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations. ICES Journal of Marine Science 56:459-466.

SSHAG (Salmon and Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum, Coho, and Chinook Salmon and Steelhead stocks within Evolutionarily Significant Units listed under the Endangered Species Act. May 12, 2003. NMFS Northwest and Southwest Fisheries Science Centers.

Trout Unlimited. 2003. Letter from Kaitlin Lovell to James Lecky and Donna Darm re: Comments on information request for nine ESUs of west coast steelhead. February 15, 2003. 6 p.

USFWS (United States Fish and Wildlife Service). 1996. California Condor Recovery Plan, Third Revision. Portland, Oregon, 62 p.

USFWS (United States Fish and Wildlife Service). 2002. Bonytail *(Gila elegan*s) Recovery Goals: amendment and supplement to the Bonytail Chub Recovery Plan. U.S.F.W.S., Mountain-Prairie Region (6), Denver, Colorado.)

Utter, F. M. 2001. Patterns of subspecific anthropogenic introgression in two salmonid genera. Rev. Fish Biol. Fish. 10:265-279.

Van Vooren, A.R. 1995. The roles of hatcheries, habitat, and regulations in wild trout management in Idaho. Amer. Fish. Soc. Symposium 15:512-517.

Waples, R. S. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of "species" under the Endangered Species Act. Mar. Fish. Rev. 53(3):11-22.

Waples, R. S. 1995. Evolutionarily significant units and the conservation of biological diversity under the Endangered Species Act. pp 8-27 in: J. L. Nielsen, ed. Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society, Bethesda, MD.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. 258 p.

Williams, R. N., R. F. Leary and K. P. Currens. 1997. Localized genetic effects of a long-term hatchery stocking program on resident rainbow trout in the Metolius River, Oregon. N. Amer J. Fish. Man. 17: 1079-1093.

Wishard, L. N., J. E. Seeb, F. M. Utter and D. Stefan. 1984. A genetic investigation of suspected redband trout populations. Copeia 1984:120-132.

Zhang, Y., J.M. Wallace, and D.S. Battisti. 1997. ENSO-like interdecadal variability: 1900-93. J. Climate 10: 1004-1020.

Zimmerman, C. E. and G. H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Can. J. Fish. Aquat. Sci. 57: 2152-2162.

A. CHINOOK SALMON

A.1 BACKGROUND AND HISTORY OF LISTINGS

Primary contributor: James M. Myers
(Northwest Fisheries Science Center)

Chinook salmon (*Oncorhynchus tshawytscha* Walbaum), also commonly referred to as king, spring, quinnat, Sacramento, California, or tyee salmon, is the largest of the Pacific salmon (Myers et al. 1998). The species historically ranged from the Ventura River in California to Point Hope, AK in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). Additionally, chinook salmon have been reported in the Mackenzie River area of Northern Canada (McPhail and Lindsey 1970). Chinook salmon exhibit very diverse and complex life-history strategies. Healey (1986) described 16 age categories for chinook salmon, seven total ages with three possible freshwater ages. This level of complexity is roughly comparable to sockeye salmon (*O. nerka*), although sockeye salmon have a more extended freshwater residence period and utilize different freshwater habitats (Miller and Brannon 1982, Burgner 1991). Two generalized freshwater life-history types were initially described by Gilbert (1912): "stream-type" chinook salmon reside in freshwater for a year or more following emergence, whereas "ocean-type" chinook salmon migrate to the ocean predominately within their first year. Healey (1983, 1991) has promoted the use of broader definitions for "ocean-type" and "stream-type" to describe two distinct races of chinook salmon. This racial approach incorporates life-history traits, geographic distribution, and genetic differentiation and provides a valuable frame of reference for comparisons of chinook salmon populations. For this reason, the BRT has adopted the broader "racial" definitions of ocean- and stream-type for this review.

Of the two life-history types, ocean-type chinook salmon exhibit the most varied and plastic life-history trajectories. Ocean-type chinook salmon juveniles emigrate to the ocean as fry, subyearling juveniles (during their first spring or fall), or as yearling juveniles (during their second spring), depending on environmental conditions. Ocean-type chinook salmon also undertake distinct, coastally oriented, ocean migrations. The timing of the return to freshwater and spawning is closely related to the ecological characteristics of a population's spawning habitat. Five different run times are expressed by different ocean-type chinook salmon populations: spring, summer, fall, late-fall, and winter. In general, early run times (spring and summer) are exhibited by populations that use high spring flows to access headwater or interior regions. Ocean-type populations within a basin that express different runs times appear to have evolved from a common source population. Stream-type populations appear to be nearly obligate yearling outmigrants (some 2-year-old smolts have been identified), they undertake extensive off-shore ocean migrations, and generally return to freshwater as spring-run- or summer-run fish. Stream-type populations are found in northern British Columbia and Alaska, and in the headwater regions of the Fraser River and Columbia River interior tributaries.

Prior to development of the ESU policy (Waples 1991), the NMFS recognized Sacramento River winter-run chinook salmon as a "distinct population segment" under the ESA (NMFS 1987). Subsequently, in reviewing the biological and ecological information concerning

West Coast chinook salmon, Biological Review Teams (BRTs) have identified additional ESUs for chinook salmon from Washington, Oregon, and California: Snake River fall-run (Waples et al. 1991), Snake River spring- and summer-run (Matthews and Waples 1991), and Upper Columbia River summer-run- and fall-run chinook salmon (originally designated as the mid-Columbia River summer-run- and fall-run chinook salmon, Waknitz et al. 1995), Puget Sound chinook salmon, Washington Coast chinook salmon, Lower Columbia River chinook salmon, Upper Willamette River chinook salmon, Middle Columbia River spring-run chinook salmon, Upper Columbia River spring-run chinook salmon, Oregon Coast chinook salmon, Upper Klamath and Trinity rivers chinook salmon, Central Valley fall-run and late-fall-run chinook salmon, and Central Valley spring-run chinook salmon (Myers et al. 1998), the Southern Oregon and Northern California chinook salmon, California Coastal chinook salmon, and Deschutes River (NMFS 1999).

Of the 17 chinook salmon ESUs identified by the NMFS, eight are not listed under the United States ESA, seven are listed as threatened (Snake River spring- and summer-run chinook salmon, and Snake River fall-run chinook salmon [Federal Register, Vol. 57, No. 78, April 22, 1992, p. 14653]; Puget Sound chinook salmon, Lower Columbia River chinook salmon, and Upper Willamette River chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]; Central Valley fall-run, and California Coastal chinook salmon [Federal Register, Vol. 64, No. 179, September 16, 1999, p. 5039]), and two are listed as endangered (Sacramento River winter-run chinook salmon [Federal Register, Vol. 59, No. 2, January 4, 1994, p. 440], and Upper Columbia River spring-run chinook salmon [Federal Register, Vol. 64, No. 56, March 24, 1999, p. 14308]).

The NMFS convened a BRT to update the status of listed chinook salmon ESUs in Washington, Oregon, California, and Idaho. The chinook salmon BRT[1] met in January, March and April of 2003 in Seattle, Washington, to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chinook salmon status review included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhaney, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

A.2.1 SNAKE RIVER FALL-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

Snake River fall-run chinook salmon enter the Columbia River in July and August. The Snake River component of the fall chinook salmon run migrates past the Lower Snake River mainstem dams from August through November. Spawning occurs from October through early December. Juveniles emerge from the gravels in March and April of the following year. Snake River fall-run chinook salmon are subyearling migrants, moving downstream from natal spawning and early rearing areas from June through early fall.

Fall-run chinook salmon returns to the Snake River generally declined through the first half of this century (Irving and Bjornn 1981). In spite of the declines, the Snake River basin remained the largest single natural production area for fall-run chinook salmon in the Columbia River drainage into the early 1960s (Fulton 1968). Spawning and rearing habitat for Snake River fall-run chinook salmon was significantly reduced by the construction of a series of Snake River mainstem dams. Historically, the primary spawning fall-run chinook salmon spawning areas were located on the upper mainstem Snake River. Currently, natural spawning is limited to the area from the upper end of Lower Granite Reservoir to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater and Tucannon Rivers, and small mainstem sections in the tailraces of the Lower Snake hydroelectric dams.

Adult counts at Snake River dams are an index of the annual return of Snake River fall-run chinook salmon to spawning grounds. Lower Granite Dam is the uppermost of the mainstem Snake River dams that allow for passage of anadromous salmonids. Adult traps at Lower Granite Dam have allowed for sampling of the adult run as well as for removal of a portion of non-local hatchery fish passing above the dam. The dam count at Lower Granite covers a majority of fall-run chinook salmon returning to the Snake basin. However, Snake River fall-run chinook salmon do return to locations downstream of Lower Granite Dam and are therefore not included in the ladder count. Lyons Ferry Hatchery is located on the mainstem Snake River below both Little Goose and Lower Monumental Dams. Although a fairly large proportion of adult returns from the Lyons Ferry Hatchery program do stray to Lower Granite Dam, a substantial proportion of the run returns directly to the facility. In addition, mainstem surveying efforts have identified relatively small numbers of fall-run chinook salmon spawning in the tailraces of lower Snake River mainstem hydroelectric dams (Dauble et al. 1999).

Lyons Ferry Hatchery was established as one of the hatchery programs under the Lower Snake Compensation Plan administered through the Unites States Fish and Wildlife Service. Snake River fall chinook. Snake River fall-run chinook salmon production is a major program for Lyons Ferry Hatchery, which is operated by the Washington Department of Fish and Wildlife and is located along the Snake River main stem between Little Goose Dam and Lower Monumental Dam. WDFW began developing a Snake River fall-run chinook salmon broodstock in the early 1970s through a trapping program at Ice Harbor Dam and Lower Granite Dam. The Lyons Ferry facility became operational in the mid-1980s and took over incubation and rearing for the Snake River fall chinook mitigation/compensation program.

A.2.1.1 Summary of Previous BRT Conclusions

Previous chinook salmon status reviews (Waples et al. 1991, Myers et al. 1998) identified several concerns regarding Snake River fall-run chinook salmon: steady and severe decline in abundance since the early 1970s; loss of primary spawning and rearing areas upstream of the Hells Canyon Dam complex; increase in non-local hatchery contribution to adult escapement over Lower Granite Dam, and relatively high aggregate harvest impacts by ocean and in-river fisheries.

A.2.1.2 New Data and Updated Analyses

A major Snake River fall-run chinook salmon supplementation effort based upon the Lyons Ferry Snake River fall-run chinook salmon broodstock has been implemented in recent years (Bugert and Hopley, 1989; Bugert et al. 1995). Facilities adjacent to major natural spawning areas have been used to acclimate release groups of yearling smolts. Additional releases of sub-yearlings have been made in the vicinity of the acclimation sites. The level of subyearling releases depends upon the availability of sufficient broodstock to maintain the on-station program and the off-station yearling releases (Table A.2.1.1). Returns in 2000 and 2001 reflect increases in the level of off-station plants and relatively high marine survival rates.

Abundance

The 1999 NMFS status review update noted increases in the Lower Granite Dam counts in the mid-1990s (Figure A.2.1.1), and the upward trend in returns has continued; the 2001 count over Lower Granite Dam exceeded 8,700 adult fall-run chinook salmon. The 1997 through 2001 escapements were the highest on record since the count of 1,000 in 1975. Returns of naturally produced chinook salmon and increased hatchery returns from the Lyons Ferry Hatchery (on-station releases and supplementation program) account for the increase in escapements over Lower Granite Dam (Table A.2.1.2).

Returns classified as natural origin exceeded 2,600 in 2001. The 1997-2001 geometric mean natural-origin count over Lower Granite Dam was 871 fish, approximately 35% of the delisting abundance criteria proposed for this run (2,500 natural-origin spawners averaged over an 8 year period). The largest increase in fall-run chinook salmon returns to the Snake River spawning area was from the Lyons Ferry Snake River stock component. Returns increased from under 200/year prior to 1998 to over 1,200 and 5,300 adults in 2000 and 2001, respectively. The increase includes returns from the on-station release program as well as returns from large supplementation releases above Lower Granite Dam. Smolt releases from the acclimation sites above Lower Granite Dam have been marked. In recent years, large numbers of unmarked subyearling Lyons Ferry fall chinook have been released from the acclimation sites. These fish will contribute to adult returns over Lower Granite Dam, complicating the estimation of natural production rates (WDFW 2003). Escapement over Lower Granite Dam represents the majority of Snake River fall-run chinook salmon returns. In addition, Snake River fall-run chinook salmon returns to the Tucannon River (less than 100 spawners per year based on redd counts) system and to Lyons Ferry Hatchery (recent average returns to the facility have been

approximately 1100 fish/year). Small numbers of fall-run chinook salmon redds have also been reported in tailrace areas below the mainstem Snake River dams (Dauble et al. 1999).

Table A.2.1.1. Escapement and stock composition of fall-run chinook salmon at Lower Granite Dam, 1975-2001; stock composition based on mark recoveries from Lower Granite Dam adult trapping (from Henry Yuen (USFWS Vancouver, WA) U.S. v. Oregon Technical Advisory Committee data base). Returning adults produced from naturally spawning parents (regardless of the origin of the parents) are classified as natural origin.

				Stock Composition of Lower Granite Dam Escapement		
Run Year	**Lower Granite Dam Count**	**Marked Fish to Lyons Ferry Hatchery**	**Lower Granite Dam Escapement**	**Natural-Origin**	**Hatchery-Origin (Snake River)**	**Hatchery-Origin (Non-Snake River)**
1975	1000		1000	1000		
1976	470		470	470		
1977	600		600	600		
1978	640		640	640		
1979	500		500	500		
1980	450		450	450		
1981	340		340	340		
1982	720		720	720		
1983	540		540	428	112	
1984	640		640	324	310	6
1985	691		691	438	241	12
1986	784		784	449	325	10
1987	951		951	253	644	54
1988	627		627	368	201	58
1989	706		706	295	206	205
1990	385	50	335	78	174	83
1991	630	40	590	318	202	70
1992	855	187	668	549	100	19
1993	1170	218	952	742	43	167
1994	791	185	606	406	20	180
1995	1067	430	637	350	1	286
1996	1308	389	919	639	74	206
1997	1451	444	1007	797	20	190
1998	1909	947	962	306	479	177
1999	3381	1519	1862	905	879	78
2000	3830	1372	2458	857	1278	323
2001	10782	2064	8718	2652	5330	736

Table A.2.1.2. Fall chinook hatchery releases into the Snake River basin. All releases are from Lyons Ferry Hatchery-origin broodstock. On station releases and acclimation site "Yearling" releases are marked or tagged; acclimation site "Sub-yearling" releases are generally unmarked (1994-2001 data are from Milks et al. (2003); 1985-1993 release data are from the Fish Passage Center Hatchery database.

			Acclimation Sites							
	Lyons Ferry (Direct)		Pittsburg Landing		Capt. John		Big Canyon (Clearwater R.)		Hells Canyon Dam[1]	
Release Year	Yearling	Sub-yearling	Yearling	Sub-yearling	Yearling	Sub-yearling	Yearling	Sub-yearling	Yearling	Sub-yearling
1985	650,300	539,392	-	-	-	-	-	-	-	-
1986	481,950	1,789,566	-	-	-	-	-	-	-	-
1987	386,600	1,012,500	-	-	-	-	-	-	-	-
1988	407,500	4,563,500	-	-	-	-	-	-	-	-
1989	413,017	1,710,865	-	-	-	-	-	-	-	-
1990	436,354	3,043,756	-	-	-	-	-	-	-	-
1991	224,439	-	-	-	-	-	-	-	-	-
1992	689,601	-	-	-	-	-	-	-	-	-
1993	206,775	-	-	-	-	-	-	-	-	-
1994	603,661	-	-	-	-	-	-	-	-	-
1995	349,124	-	-	-	-	-	-	-	-	-
1996	407,503	-	114,299	-	-	-	-	-	-	-
1997	456,872	-	147,316	-	-	-	199,399	252,705	-	-
1998	419,002	-	141,814	-	133,205	-	61,172	-	-	-
1999	432,166	204,194	142,885	-	157,010	-	229,608	347,105	-	-
2000	456,401	196,643	134,709	400,156	131,186	892,847	131,306	890,474	-	-
2001	338,757	199,976	103,741	374,070	101,976	501,129	113,215	856,968	-	115,251

[1] Hells Canyon Dam releases increased to 500,000 in 2002

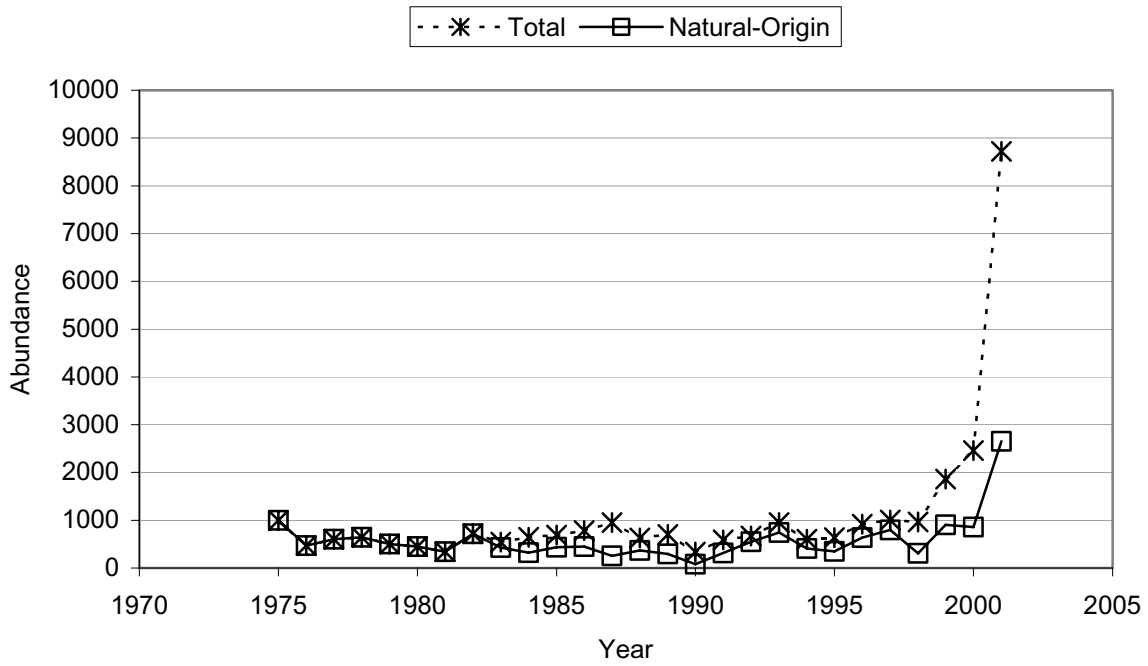


Figure A.2.1.1. Estimated spawning escapement of fall-run chinook salmon at Lower Granite Dam.

Productivity

Both the long-term and short-term trends in total returns are positive (1.05, 1.22). The short-term (1990-2001) estimates of the median population growth rate λ are 0.98 assuming a hatchery spawning effectiveness of 1.0 (equivalent to that of wild spawners) and 1.137 with an assumed hatchery spawning effectiveness of 0. The estimated long-term growth rate for the Snake River fall-run chinook salmon population is strongly influenced by the hatchery effectiveness assumption. If hatchery spawners have been equally as effective as natural-origin spawners in contributing to broodyear returns, the long-term λ estimate is 0.899 and the associated probability that λ is less than 1.0 is estimated as 99%. If hatchery returns over Lower Granite Dam are not contributing at all to natural production (hatchery effectiveness of 0.0), the long-term estimate of λ is 1.024. The associated probability that λ is less than 1.0 is 0.26.

Broodyear return-per-spawner (r/s) estimates were low for three or more consecutive years in the mid-1980s and the early 1990s (Figure A.2.1.2). The large increase in natural abundance in 2000 and 2001 is reflected in the 1996 and 1997 return-per-spawner estimates (1997 r/s is based on 4-year-old component only).

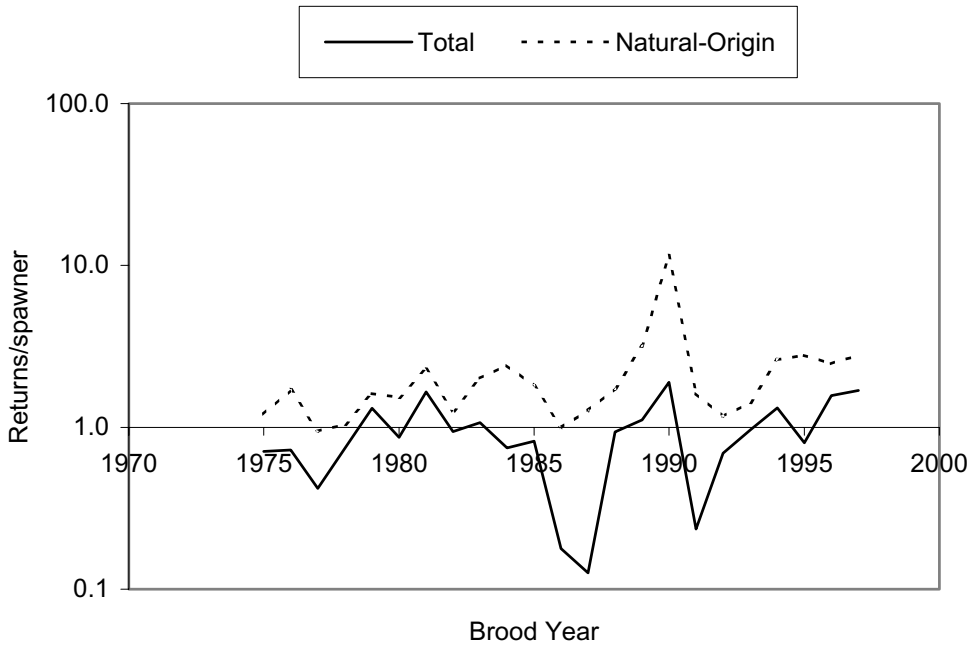


Figure A.2.1.2. Return/spawner plotted against brood year escapements for Snake River fall-run chinook (escapement estimates from Lower Granite Dam counts assuming a 10% pre-spawning mortality; brood year returns estimated by applying sample age at return estimate to annual dam counts.

Harvest impacts

Snake River fall-run chinook salmon are subject to harvest in a wide range of fisheries due to their patterns of ocean distribution and the timing of their spawning run up the Columbia River. Coded-wire tag studies using Lyons Ferry Hatchery fish of Snake River origin indicate that Snake River fall-run chinook salmon have a broad distribution. Recoveries of tagged fish from the Snake River have been reported from coastal fisheries from California, Oregon, Washington, British Columbia and Southeast Alaska. The timing of the return and upriver spawning migration of Snake River fall-run chinook salmon overlaps with the Hanford Reach up-river bright chinook salmon returns as well as with several large hatchery runs returning to lower river release areas or to the major hatcheries adjacent to the lower mainstem Columbia River.

Harvest impacts on Snake River fall-run chinook salmon declined after listing and have remained relatively constant at approximately 35-40% in recent years (Figure A.2.1.3). The decline and subsequent listing of Snake River fall-run chinook salmon prompted major restrictions on U. S. fisheries impacting this stock. In-river gillnet and sport fisheries are 'shaped' in time and space to maximize the catch of harvestable hatchery and natural (Hanford Reach) stocks while minimizing impacts on the intermingled Snake River fall-run chinook salmon. Reductions in ocean fishery impacts on Snake River fall-run chinook salmon resulted from management measures designed to protect weakened or declining stocks specific to each set of fisheries.

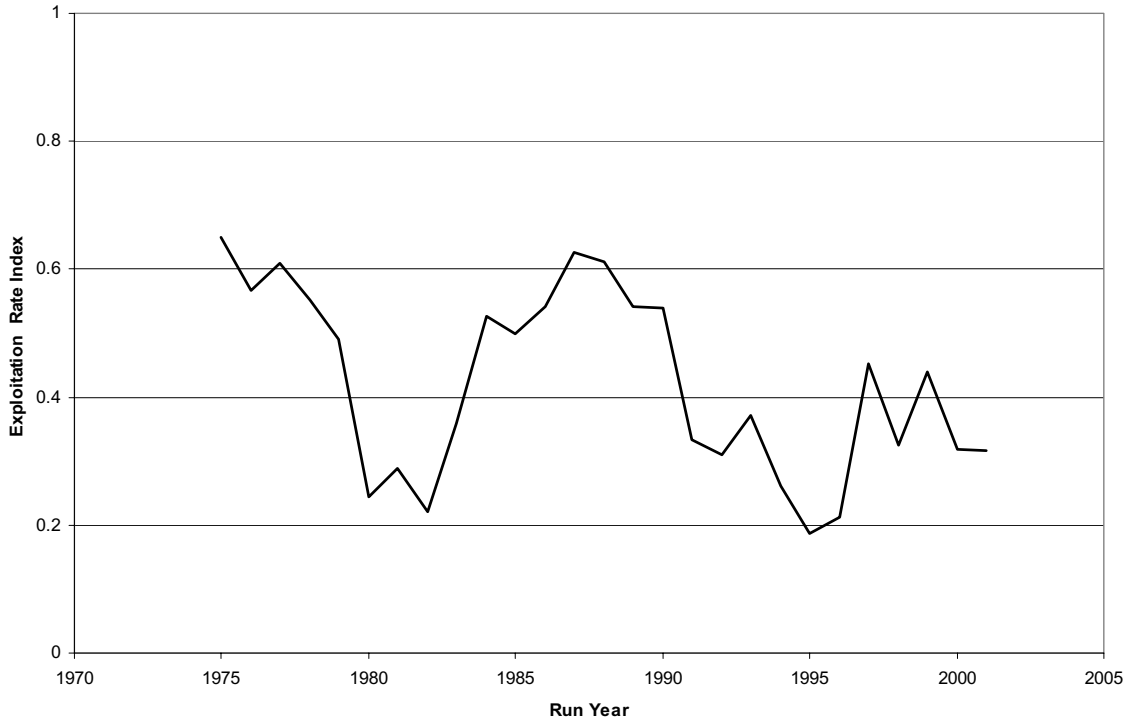


Figure A.2.1.3. Aggregate (ocean and in-river fisheries) exploitation rate index for Snake River fall chinook. Data from Marmorek et al. 1998; 1998-2001 data from Columbia River TAC data base (Henry Yuen, pers. comm..).

Mainstem hydropower impacts

Migration conditions for subyearling chinook salmon from the Snake River have generally improved since the early 1990s (FCRPS 2000 Biological Opinion). The lack of baseline data prior to the mid-1990s precludes quantifying the changes.

Habitat

There have been no major changes in available habitat for Snake River fall-run chinook salmon since the previous status review.

A.2.1.5 New Hatchery Information

Hatchery/Natural composition

The composition of the fall chinook run at Lower Granite Dam is determined by sampling marked returns. Since the early 1980s, the run has consisted of three major components: unmarked returns of natural origin, marked returns from the Lyons Ferry Hatchery program, and strays from hatchery programs outside of the mainstem Snake River (Table A.2.2). While all

three components of the fall run have increased in recent years, returns of Snake River origin chinook salmon have increased disproportionately to outside hatchery strays. Prior to the 1998/99 status reviews, the five-year average contribution of outside stocks to the escapement over Lower Granite Dam exceeded 26.2%. The most recent five-year average (1997-2001) was 12.4%, with the contribution in 2001 being just over 8%. The drop in relative contribution by outside stocks reflects the disproportionate increase in returns of the Lyons Ferry component, the systematic removal of marked hatchery fish at the Lower Granite Dam trap, and modifications to the Umatilla program to increase homing of fall-run chinook salmon release groups intended to return to the Umatilla River.

The primary contributor of non-ESU strays to Lower Granite Dam continues to be releases from the Umatilla fall-run chinook salmon program (Priest Rapids stock). In addition, returns from the Klickitat fall-run chinook salmon releases have been consistently detected at the Lower Granite Dam adult trap. In 2000-2002, two or three adult chinook salmon with Klickitat coded wire tags were detected in each sampling year (Milks et al. 2003). Recoveries of Umatilla origin adult tags at the Lower Granite trap ranged from 43 to 166 for the same three-year period (Milks et al. 2003).

One of the concerns leading to the listing of Snake River fall-run chinook salmon under the ESA was the possibility of significant introgression due to increased straying by outside stocks into the natural spawning areas above Lower Granite Dam. Removal of all outside origin stock at Lower Granite Dam is not feasible--the trapping operation does not handle 100% of the run at the dam and outside stocks are generally not 100% marked. A genetic analysis of outmigrant smolts produced from spawning above Lower Granite Dam was conducted to evaluate the potential for introgression of outside stocks. Marshall et al. (2000) concluded that distinctive patterns of allelic diversity persisted in the stock, indicating that the natural Snake River fall-run chinook salmon run remains a distinct resource.

Categorizations of Snake River fall-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.2 SNAKE RIVER SPRING/SUMMER-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

Spring and summer chinook salmon runs returning to the major tributaries of the Snake River were classified as an evolutionarily significant unit (ESU) by NMFS (Matthews and Waples 1991). This ESU includes production areas that are characterized by spring-timed returns, summer-timed returns, and combinations from the two adult timing patterns. Runs classified as spring chinook salmon are counted at Bonneville Dam beginning in early March and ending the first week of June; runs classified as summer-run chinook salmon return to the Columbia River from June through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they emigrate up into tributary areas and spawn. In general, spring-run type chinook salmon tend to spawn in higher elevation reaches of major Snake River tributaries in mid- through late August, and summer-run Snake River chinook salmon spawn approximately 1 month later than spring-run fish.

Many of the Snake River tributaries used by spring and summer chinook salmon runs exhibit two major features: extensive meanders through high elevation meadowlands and relatively steep lower sections joining the drainages to the mainstem Salmon (Matthews and Waples 1991). The combination of relatively high summer temperatures and the upland meadow habitat creates the potential for high juvenile salmonid productivity. Historically, the Salmon River system may have supported more than 40% of the total return of spring-run and summer-run chinook salmon to the Columbia River system (e.g., Fulton 1968).

The Snake River spring/summer-run chinook salmon ESU includes current runs to the Tucannon River, the Grand Ronde River system, the Imnaha River and the Salmon River (Matthews and Waples 1991). The Salmon River system contains a range of habitats used by spring/summer-run chinook salmon. The South Fork and Middle Fork tributaries to the Salmon currently support the bulk of natural production in the drainage. Two large tributaries entering above the confluence of the Middle Fork, the Lemhi and Pahsimeroi Rivers, drain broad alluvial valleys and are believed to have historically supported substantial, relatively productive anadromous fish runs. Returns into the upper Salmon River tributaries have re-established following the opening of passage around Sunbeam Dam on the mainstem Salmon River downstream of Stanley, ID. Sunbeam Dam in the Upper Salmon River was a serious impediment to migration of anadromous fish and may have been a complete block in at least some years before its partial removal in 1934 (Waples, et al. 1991).

Current runs returning to the Clearwater River drainages were not included in the Snake River spring/summer-run chinook salmon ESU. Lewiston Dam in the lower main stem of the Clearwater River was constructed in 1927 and functioned as an anadromous block until the early 1940s (Matthews and Waples 1991). Spring and summer chinook salmon runs into the Clearwater system were reintroduced via hatchery outplants beginning in the late 1940s. As a result, Matthews and Waples (1991) concluded that even if a few native salmon survived the

hydropower dams, "...the massive outplantings of non-indigenous stocks presumably substantially altered, if not eliminated, the original gene pool."

Spring-run and summer-run chinook salmon from the Snake River basin exhibit stream type life-history characteristics (Healey 1983). Eggs are deposited in late summer and early fall, incubate over the following winter and hatch in late winter/early spring of the following year. Juveniles rear through the summer, overwinter and migrate to sea in the spring of their second year of life. Depending on the tributary and the specific habitat conditions, juveniles may migrate extensively from natal reaches into alternative summer rearing and/or overwintering areas. Snake River spring/summer-run chinook salmon return from the ocean to spawn primarily as 4 and 5 year old fish, after 2 to 3 years in the ocean. A small fraction of the fish return as 3-year-old 'jacks', heavily predominated by males.

A.2.2.1 Summary of Previous BRT Conclusions

The 1991 ESA status review (Mathews and Waples, 1991) of the Snake River spring/summer-run chinook salmon ESU concluded that the ESU was at risk based on a set of key factors. Aggregate abundance of naturally produced Snake River spring/summer-run chinook salmon runs had dropped to a small fraction of historical levels. Short-term projections (including jack counts, habitat/flow conditions in the broodyears producing the next generation of returns) were for a continued downward trend in abundance. Risk modeling indicated that if the historical trend in abundance continued, the ESU as a whole was at risk of extinction within 100 years. The review identified related concerns at the population level within the ESU. Given the large number of potential production areas in the Snake basin and the low levels of annual abundance, risks to individual subpopulations may be greater than the extinction risk for the ESU as a whole. The 1998 chinook salmon status review (Myers et al. 1998) summarized and updated these concerns. Both short and long-term abundance trends had continued downward. The report identified continuing disruption due to the impact of mainstem hydroelectric development including altered flow regimes and impacts on estuarine habitats. The 1998 review also identified regional habitat degradation and risks associated with the use of outside hatchery stocks in particular areas—specifically including major sections of the Grande Ronde River basin.

Direct estimates of annual runs of historical spring/summer-run chinook salmon to the Snake River are not available. Chapman (1986) estimated that the Columbia River produced 2.5 million to 3.0 million spring-run and summer-run chinook salmon per year in the late 1800s. Total spring-run and summer-run chinook salmon production from the Snake River basin contributed a substantial proportion of those returns; the total annual production of Snake River spring-run and summer-run chinook salmon may have been in excess of 1.5 million adult returns per year (Matthews and Waples 1991). Returns to Snake River tributaries had dropped to roughly 100,000 adults per year by the late 1960s (Fulton 1968). Increasing hatchery production contributed to subsequent years' returns, masking a continued decline in natural production.

A.2.2.2 New Data and Updated Analyses

Abundance

Aggregate returns of spring-run chinook salmon (as measured at Lower Granite Dam) showed a large increase over recent year abundances (Figure A.2.2.1). The 1997-2001 geometric mean return of natural-origin chinook salmon exceeded 3,700. The increase was largely driven by the 2001 return—estimated to have exceeded 17,000 naturally produced spring chinook salmon—however, a large proportion of the run in 2001 was estimated to be of hatchery origin (88%). The summer run over Lower Granite Dam has increased as well (Figure A.2.2.2). The 1997-2001 geometric mean total return was slightly more than 6,000. The geometric mean return for the broodyears for the recent returns (1987-96) was 3,076 (Note: does not address hatchery/wild breakdowns of the aggregate run).

Returns in other production areas are shown in Figures A.2.2.3-A.2.2.16 and summarized in Table A.2.2.1. The lowest five-year geometric mean returns for almost all of the individual Snake River spring/summer-run chinook salmon production areas were in the 1990s. Sulphur Creek and Poverty Flats production areas had low five-year geometric mean returns in the early 1980s. Many, but not all, production areas had large increases in return year 2001.

Recent return levels are also compared against interim delisting criteria (abundance) for those production areas with designated levels. (Table A.2.2.1). The interim abundance criteria were suggested by the Snake River Salmon Recovery Team (Bevan et al., 1995) or, in some cases, were developed for use in analyses supporting the Federal Columbia River hydropower system Biological Opinions.

Productivity

Long-term trend and long-term λ estimates were below 1 for all natural production data sets, reflecting the large declines since the 1960s. Short-term trends and λ estimates were generally positive with relatively large confidence intervals (Table A.2.2.1 & Figure A.2.2.17). Grande Ronde and Imnaha data sets had the highest short-term growth rate estimates. Tucannon River, Poverty Flat (did not have 2000 and 2001 included) and Sulphur Creek index areas had the lowest short-term λ estimates in the series. Patterns in returns per spawners for stocks with complete age information (e.g. Minam River) show a series of extremely low return rates in the 1990s followed by increases in the 1995-97 broodyears (Figure A.2.2.18).

Hydropower impacts

Snake River spring/summer-run chinook salmon must migrate past a series of mainstem Snake and Columbia River hydroelectric dams on their migrations to and from the ocean. The Tucannon River population must migrate through six dams; all other major Snake River drainages supporting spring/summer-run chinook salmon production are above eight dams. Earlier status reviews concluded that mainstem Columbia and Snake River hydroelectric projects have resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat.

Table A.2.2.1. Summary of abundance and trend information for Snake River spring/summer-run chinook salmon relative to previous analyses. Five-year geometric means calculated using years 1997 to 2001 unless otherwise noted. Previous natural geomean for 1987-96 period. Interim targets from B. Lohn Apr. 2002 letter to NWPPC. Comparison of current (recent 5 year geometric mean) to interim target only for those production areas with estimated spawners and corresponding interim target (rpm = redds/mile).

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target (#'s)	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Tucannon R.	24	303 (128 – 1012)	80	190	-4.1	-11.0		
Wenaha R. *	36	225 (67 – 586)	82		-9.4	-23.6		
Wallowa R.	95	0.57 redds (0.0 – 29.0)			+11.5			
Lostine R.	95	34 redds (9 – 131)			+12.7			
Minam R.	95	180 (96 – 573)	172	69	+3.3	-14.5		
Catherine Cr.*	44	50 (13 – 262)	22	45	-25.1	-22.5		
Upper Grande Ronde R.*	42	46 (3 – 336)	20		-9.4			
South Fork Salmon R.	91	496 redds (277 – 679)			+1.1	-13.6		
Secesh R.	96	144 redds (38 – 444)			+9.8			
Johnson Cr.	100	131 redds (49 – 444)[1]			-1.5			
Big Creek Springs	100	53 (21 – 296)	53		+5.4	-34.2		
Big Creek Summers	?	5 redds (2 – 58)			+1.7	-27.9		
Loon Cr.	100	27 redds (6 – 255)			+12.2			
Marsh Cr.	100	53 (0 – 164)	53		-4.0			
Bear Valley / Elk Cr.	100	266 (72 – 712)	266		+6.2			
North Fork Salmon **	?	5.6 redds (2.0 – 19.0)						

Table A.2.2.1 (continued).

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Lemhi R.	100	72 redds (35 – 216)			+12.8	-27.4		
Pahsimeroi R.	?	161 (72 – 1097)			+12.8			
E. Fork Springs***	?	0.27 rpm (0.2 – 1.41)			-5.7			
E. Fork Salmon Summers	100	1.22 rpm (0.35 – 5.32)			+0.9	-32.9		
Yankee Fork Springs***	?	0.0 rpm (0.0 – 0.0)			-6.3			
Yankee Fork Summers	100	2.9 redds (1.0 – 18.0)			+4.1			
Valley Cr. Springs	100	7.4 redds (2.0 – 28.0)			+14.9	-25.9		
Valley Cr. Summers****	?	2.14 rpm (0.71 – 9.29)			+5.8	-29.3		
Upper Salmon Springs	?	69 redds (25 – 357)			+5.3			
Upper Salmon Summers***	?	0.24 rpm (0.07 – 0.58)			-3.3			
Alturas Lake Cr.	?	2.7 redds (0 – 18)			+10.2			
Imnaha R.	38	564 redds (194 – 3,041)[1]		216	+12.8	-24.1		
Big Sheep Cr.	3	0.25 redds (0.0 – 1.0)			+0.8			
Lick Cr.	41	1.4 redds (0.0 – 29.0)			+11.7			

* 5 year geometric mean calculated using years 1992 – 1996
** 5 year geometric mean calculated using years 1996 – 2000
*** 5 year geometric mean calculated using years 1993 – 1997
**** 5 year geometric mean calculated using years 1997, 2000 and 2001 only
[1] Expanded redds

Harvest

Harvest impacts on Snake River spring-run chinook salmon are generally low. Ocean harvest rates are also low. Historical harvest estimates reflect the impact of mainstem and tributary in-river fisheries. In response to initial declines in returns, in-river harvests of both chinook spring-run and summer-run chinook salmon were restricted beginning in the early 1970s (Matthews and Waples 1991).

Fishery impacts were further reduced following listing in 1991, with lower harvest rates from 1991-1999. In response to the large increase in returns of spring chinook salmon runs, additional impacts were allowed beginning in 2000. The management agreement providing for increased impacts as a function of abundance also calls for additional reductions if and when runs drop back down below prescribed thresholds[2].

Habitat

Tributary habitat conditions vary widely among the various drainages of the Snake River basin. There is habitat degradation in many areas of the basin reflecting the impacts of forest, grazing and mining practices. Impacts relative to anadromous fish include lack of pools, increased water temperatures, low flows, poor overwintering conditions, and high sediment loads. Substantial portions of the Salmon River drainage, particularly in the Middle Fork, are protected in wilderness areas.

A.2.2.5 New Hatchery Information

Hatchery production

Spring-run and summer-run chinook salmon are produced from a number of artificial production facilities in the Snake River basin (Table A.2.2.2). Much of the production was initiated under the Lower Snake River Compensation Plan. Lyons Ferry Hatchery serves as a rearing station for Tucannon spring-run chinook salmon broodstock. Rapid River Hatchery and McCall Hatchery provide rearing support for a regionally derived summer-run chinook salmon broodstock released into lower Salmon River areas. Two major hatchery programs have operated in the upper Salmon basin—the Pahsimeroi and Sawtooth facilities. Since the mid-1990s, small-scale natural stock supplementation studies and captive breeding efforts have been initiated in the Snake River basin.

Historically, releases from broodstock originating outside of the basin have constituted a relatively small fraction of the total release into the basin. The 1998 chinook salmon status review (Myers et al. 1998) identified concerns regarding the use of the Rapid River Hatchery stock reared at Lookingglass Hatchery in the Grande Ronde River basin. The Rapid River stock was originally developed from broodstock collected from the spring-run chinook salmon returns to historical production areas above the Hells Canyon complex.

---

[2] Order Approving Interim Management Agreement for Upriver Spring chinook, Summer Chinook and Sockeye. Approved April 5, 2001. U.S. v Oregon. Civil -68-513.

Use of the Rapid River stock in Grande Ronde drainage hatchery programs has been actively phased out since the late 1990s. In addition, a substantial proportion of marked returns of Rapid River stock released in the Grande Ronde have been intercepted and removed at the Lower Granite Dam ladder and at some tributary level weirs. Carcass survey data indicate significant declines in hatchery contributions to natural spawning in areas previously subject to Rapid River stock strays.

Concerns for the high incidence of BKD disease in Snake River basin hatchery facilities were also identified (Myers et al. 1998).

Categorization of Snake River spring/summer-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

Table A.2.2.2. Total hatchery releases of spring and summer chinook into the Snake River Basin. Summarized by stock and release site. Information from Fish Passage Center smolt release data base.

Basin	Stock	Average releases per year		
		1985 - 1989	1990 - 1994	1995 - 2001
Mainstem Snake	Rapid River	405,192	445,411	146,728
	Leavenworth	32,857	-	-
	Lookingglass	-	-	20,622
	Mixed	-	-	29,369
	Mainstem Total	**438,049**	**445,411**	**196,719**
Tucannon	Tucannon River	63,733	108,957	93,742
Mainstem Grande Ronde	Carson	784,785	100,934	-
	Imnaha River	24,700	-	-
	Lookingglass	396,934	-	-
	Rapid River	452,786	642,605	239,756
	Grande Ronde River	-	-	581
Catherine Creek	Carson	60,893	-	-
	Rapid River	-	14,000	-
	Catherine Creek	7,552	-	24,973
	Lookingglass	153,420	-	-
Wallowa	Carson	70,529	-	-
	Lookingglass	55,120	-	-
	Lostine River	-	-	25,847
	Rapid River	-	28,863	-
	Grande Ronde Total	**2,006,718**	**786,401**	**291,158**
Little Salmon	Rapid River	2,374,325	2,631,741	1,552,835
South Fork Salmon	South Fork Salmon River	929,351	1,020,393	888,469
Pahsimeroi	Pahsimeroi River	418,160	479,382	74,934
	Salmon River	55,809	-	40,444
East Fork Salmon	Salmon River	182,598	147,614	6,222
Upper Salmon	Pahsimeroi River	145,100	-	-
	Rapid River	10,020	20,000	-
	Salmon River	1,220,188	1,091,576	96,877
	Salmon River Total	**5,335,551**	**5,390,706**	**2,659,782**
Imnaha	Imnaha River	**98,425**	**339,928**	**269,886**
ESU Total	**All Stocks**	**7,942,476**	**7,071,402**	**3,511,286**

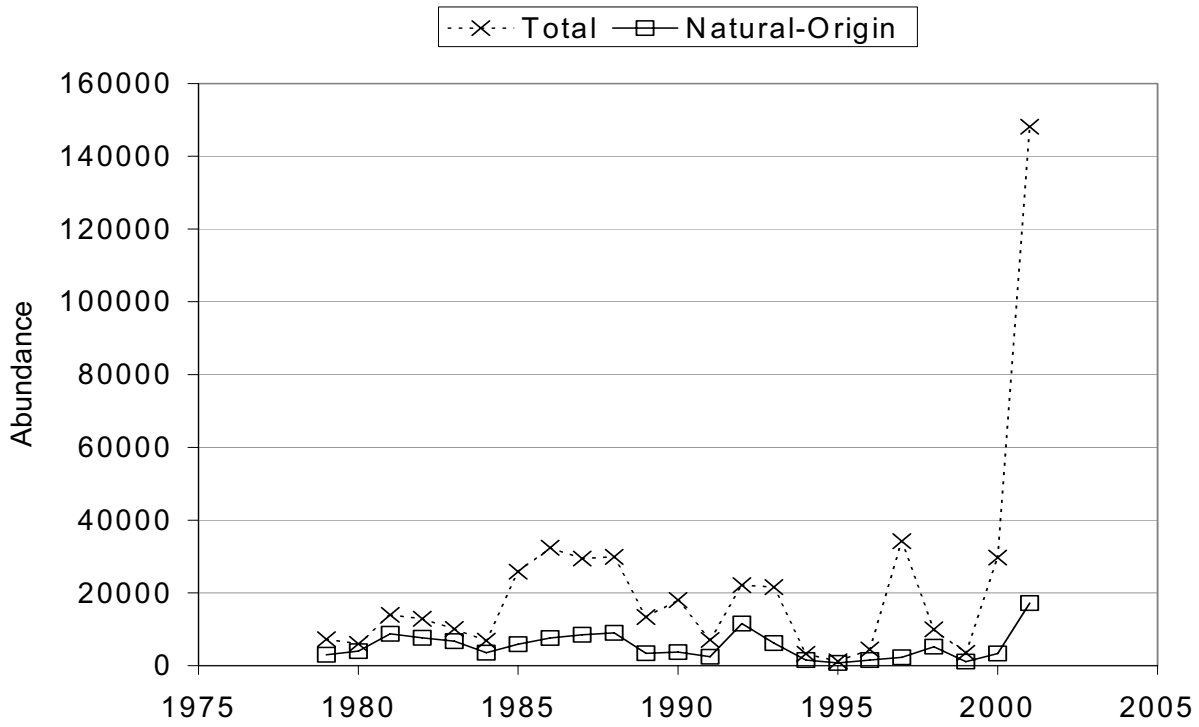


Figure A.2.2.1. Snake River spring-run chinook salmon escapement over Lower Granite Dam.

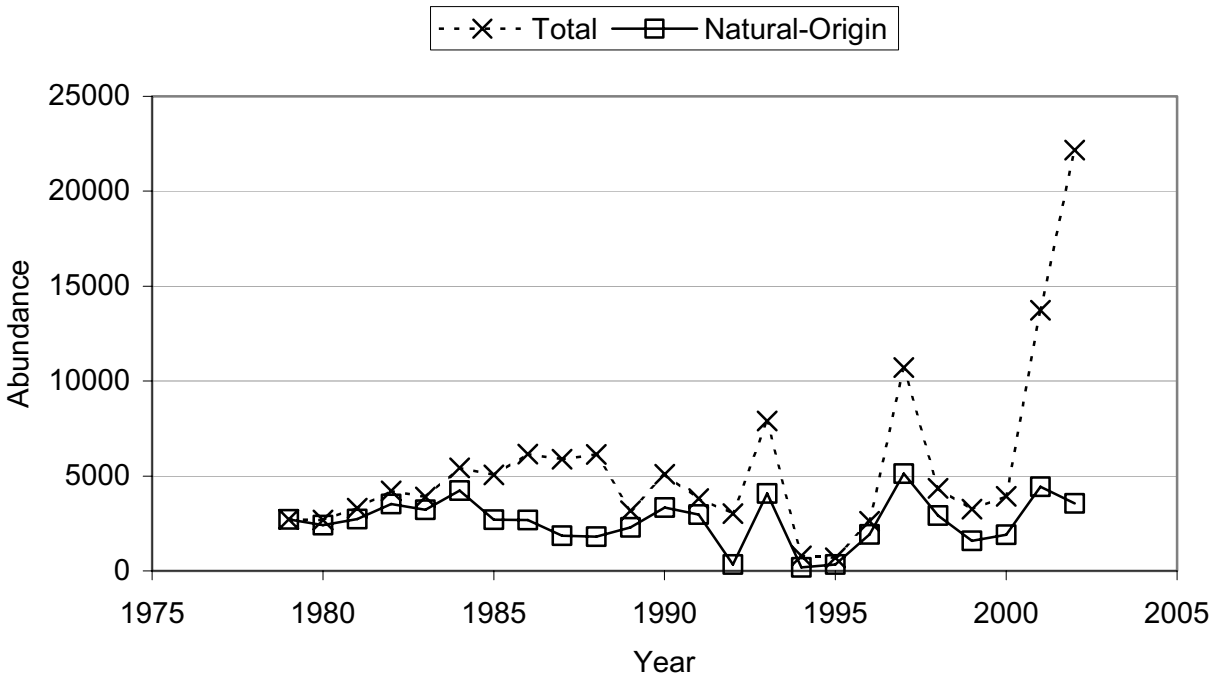


Figure A.2.2.2. Snake River summer-run chinook salmon escapement.

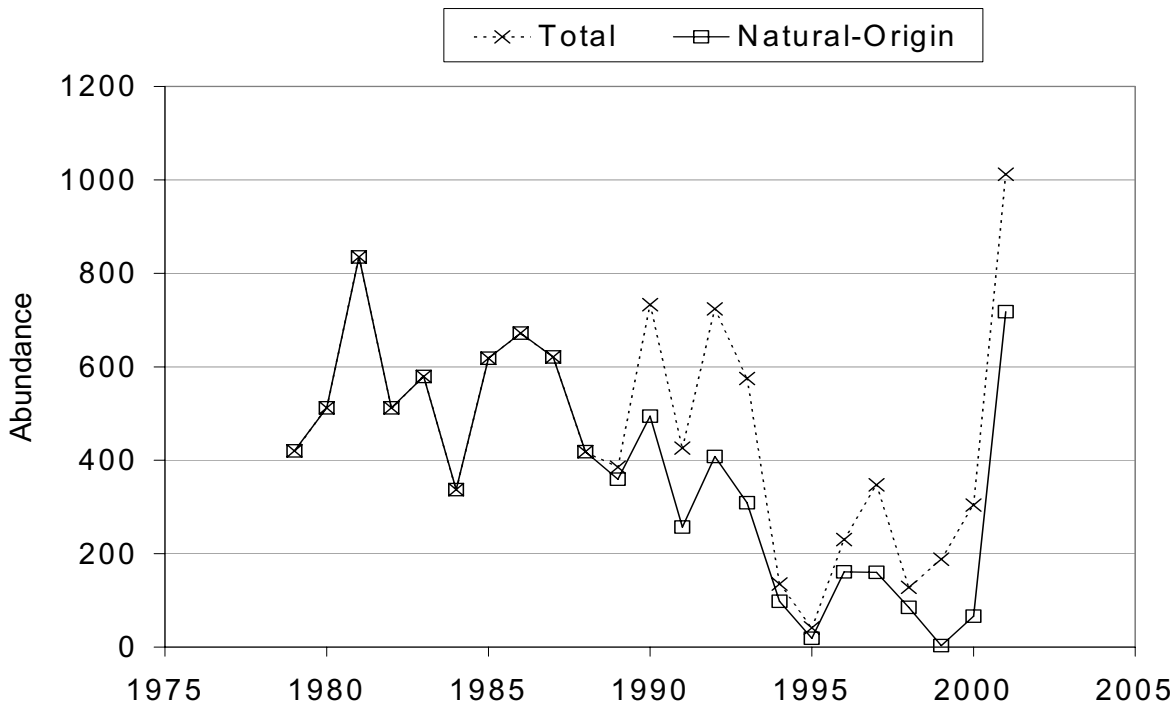


Figure A.2.2.3. Tucannon River spring-run chinook salmon spawning escapement; estimates based on trap counts and expanded redd estimates (WDFW).

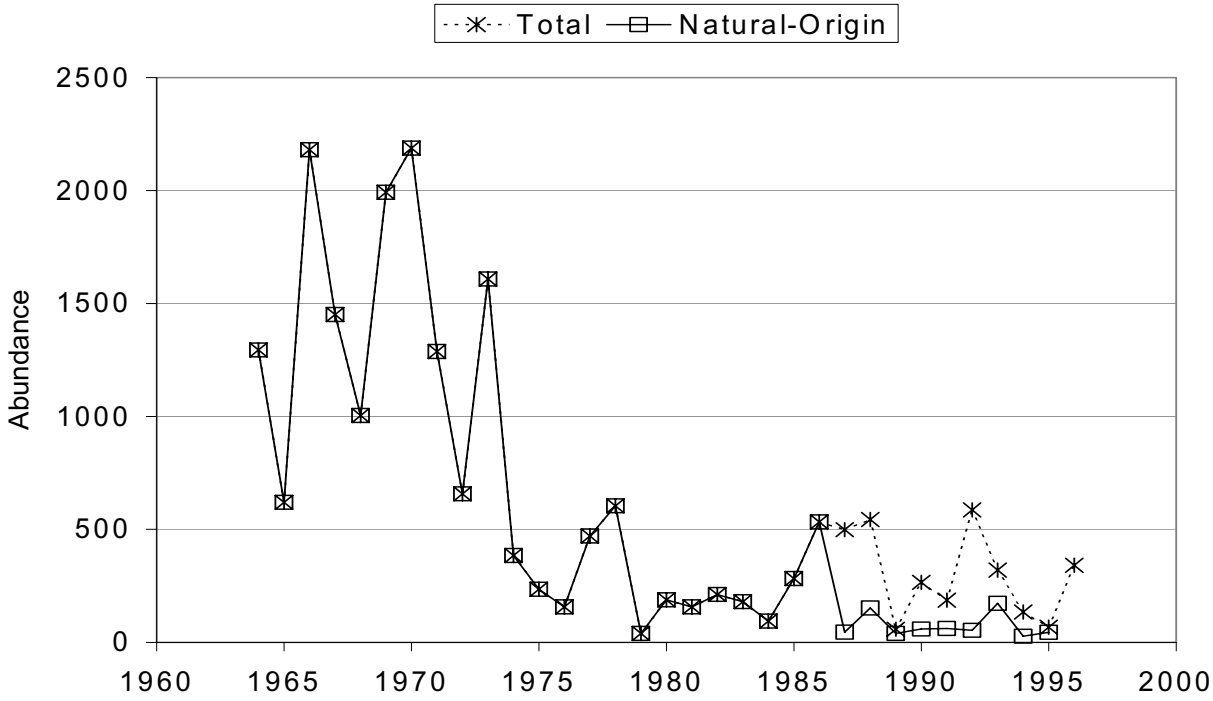


Figure A.2.2.4. Wenaha River spring-run chinook spawning escapement; estimates expanded from redd counts.

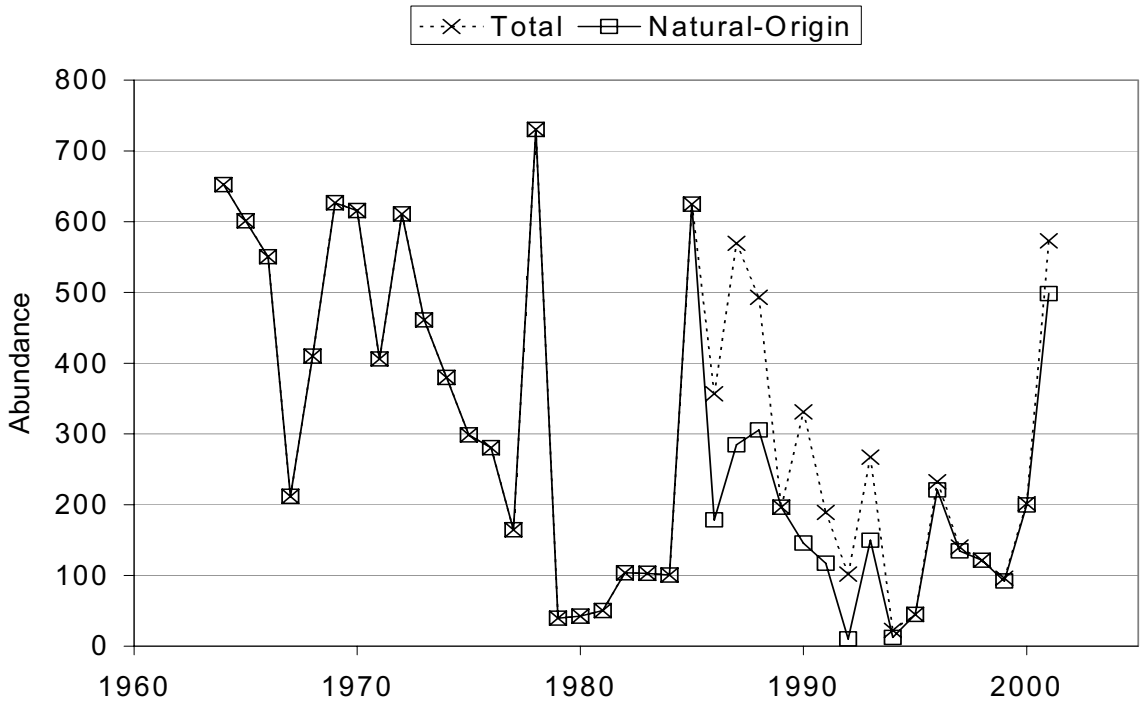


Figure A.2.2.5. Minam River chinook salmon spawning escapements; estimates based on expanded redd counts and carcass sampling (ODFW).

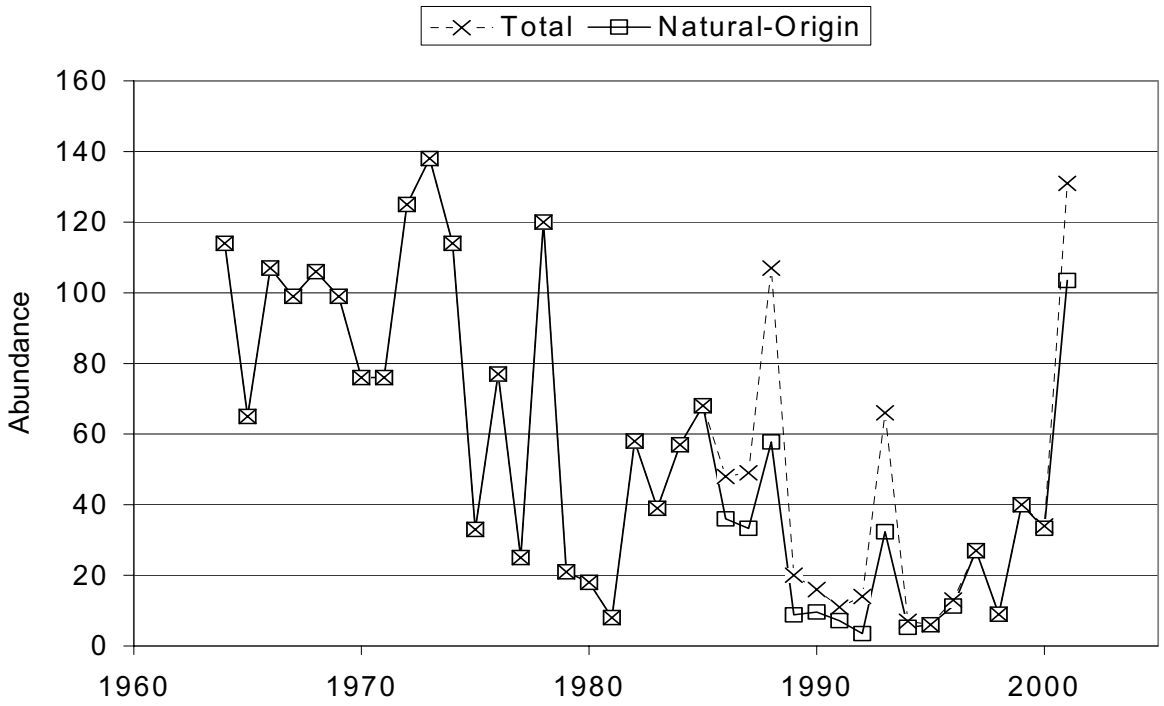


Figure A.2.2.6. Lostine River spring-run chinook salmon total counts; estimates based on redd count expansions and carcass sampling (ODFW).

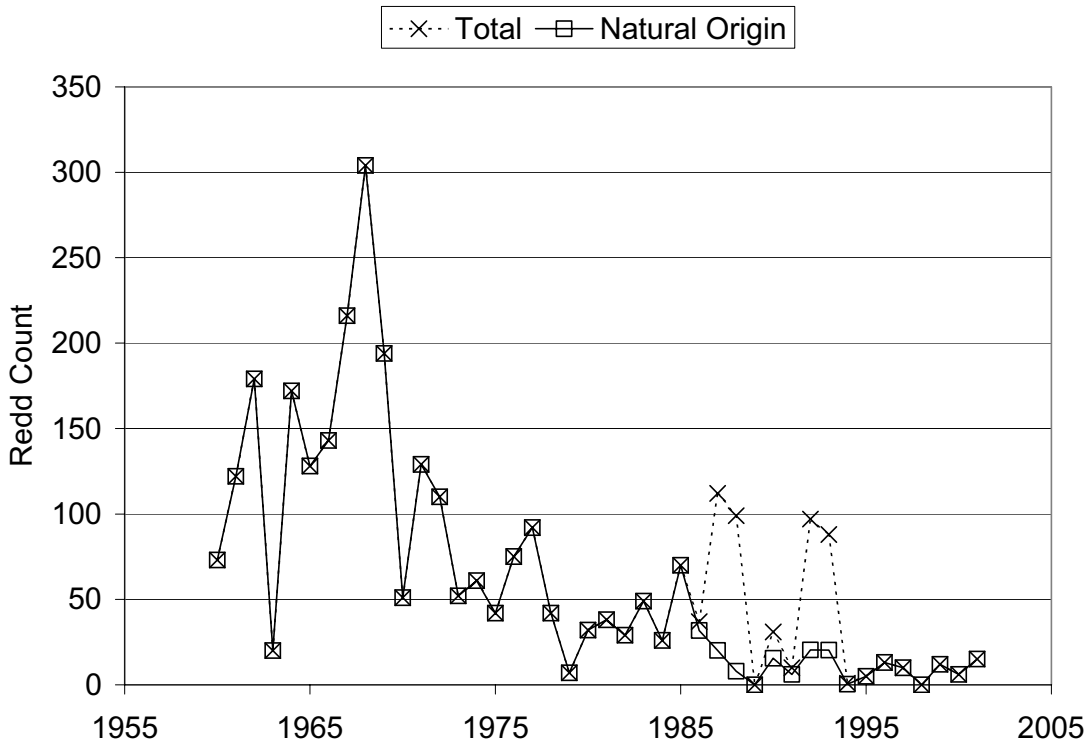


Figure A.2.2.7. Upper Grande Ronde River spring-run chinook redd counts; hatchery contributions based on carcass sampling (ODFW).

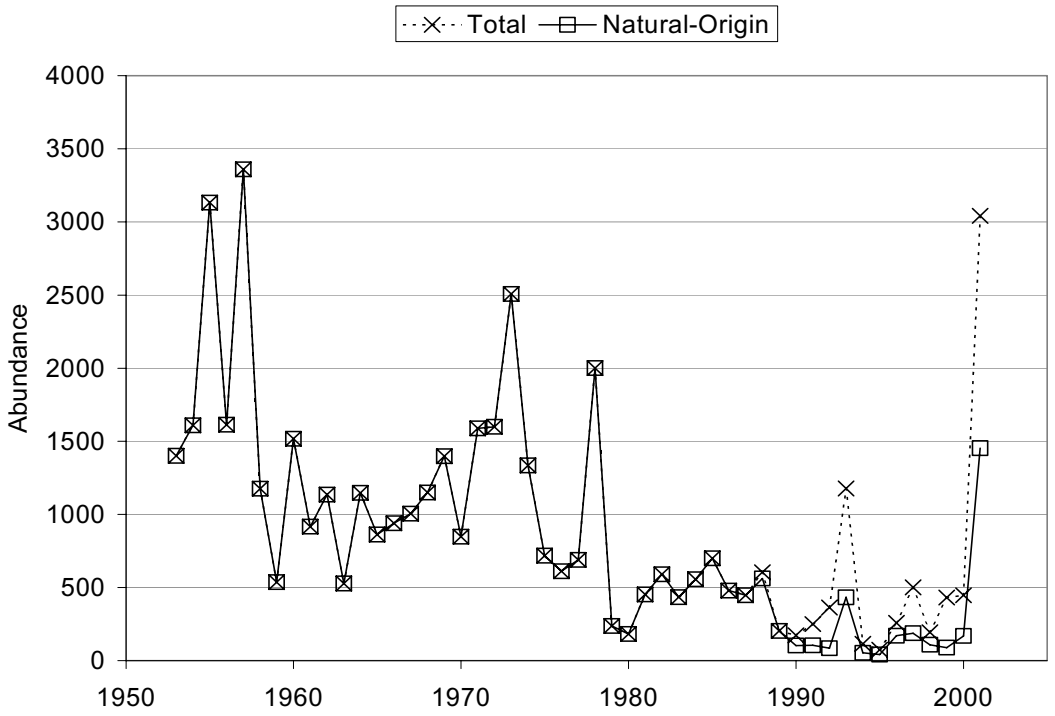


Figure A.2.2.8. Imnaha River spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass sampling (ODFW).

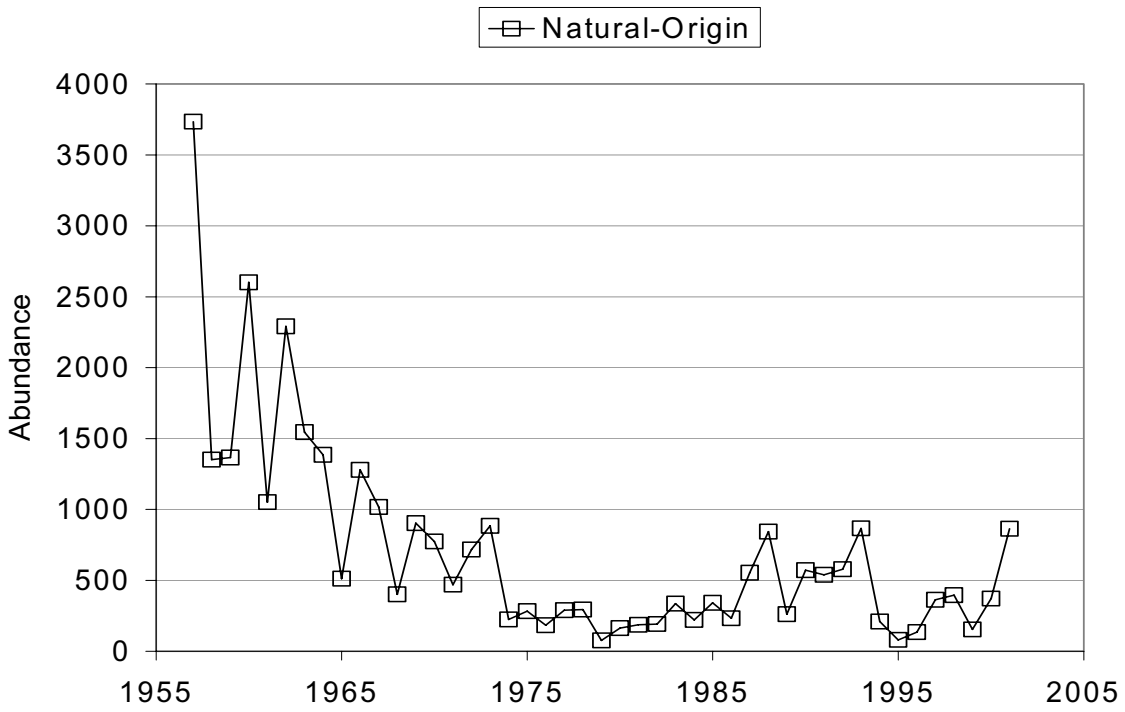


Figure A.2.2.9. Poverty Flat summer-run chinook salmon spawning escapement; estimates based on Idaho Department of Fish and Game (IDFG) redd count expansions.

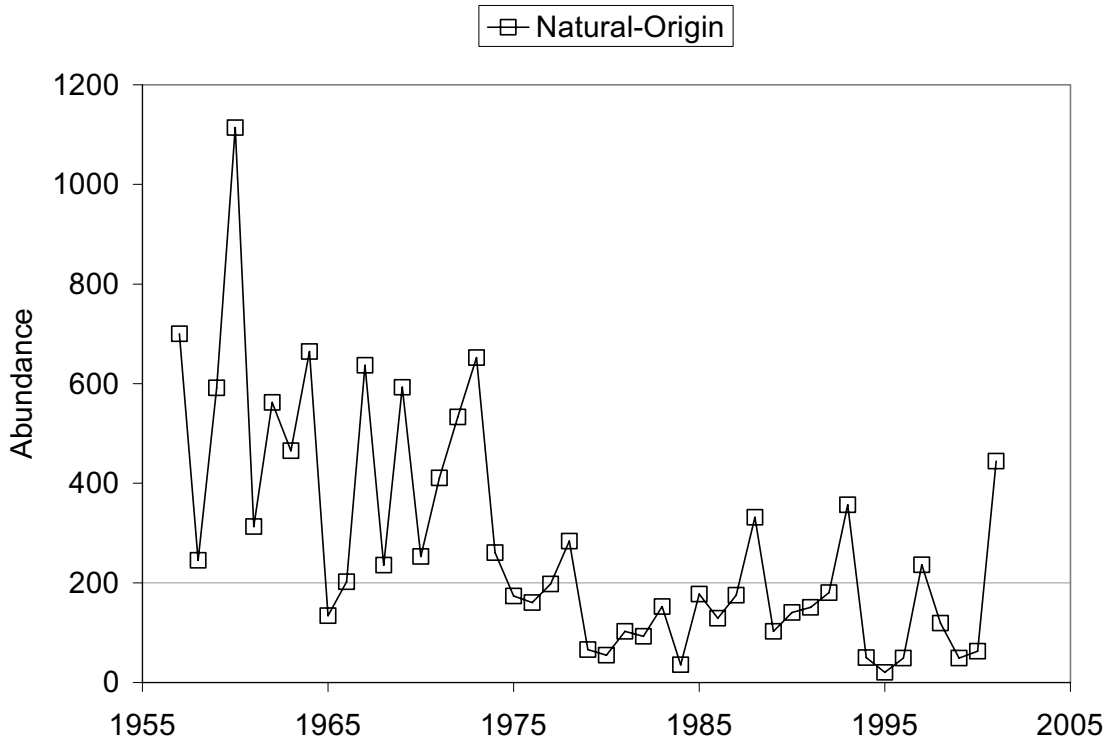


Figure A.2.2.10. Johnson Creek summer-run chinook salmon spawning escapement; estimates based on expanded redd counts (IDFG).

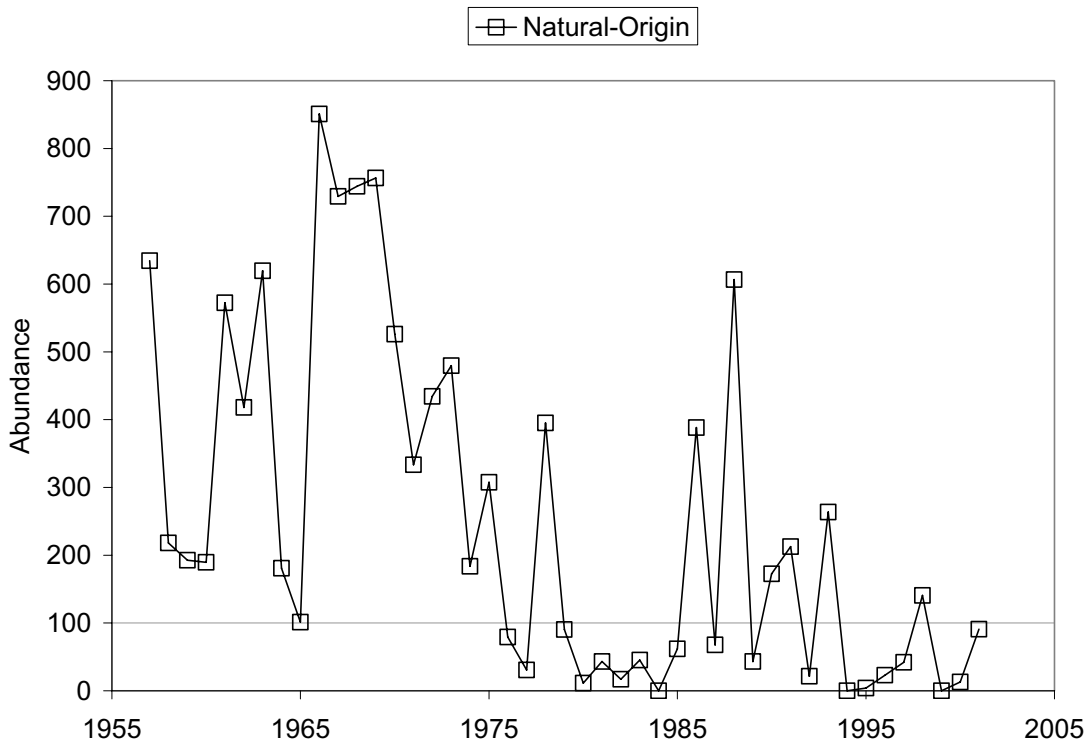


Figure A.2.2.11. Sulphur Creek spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass surveys (IDFG).

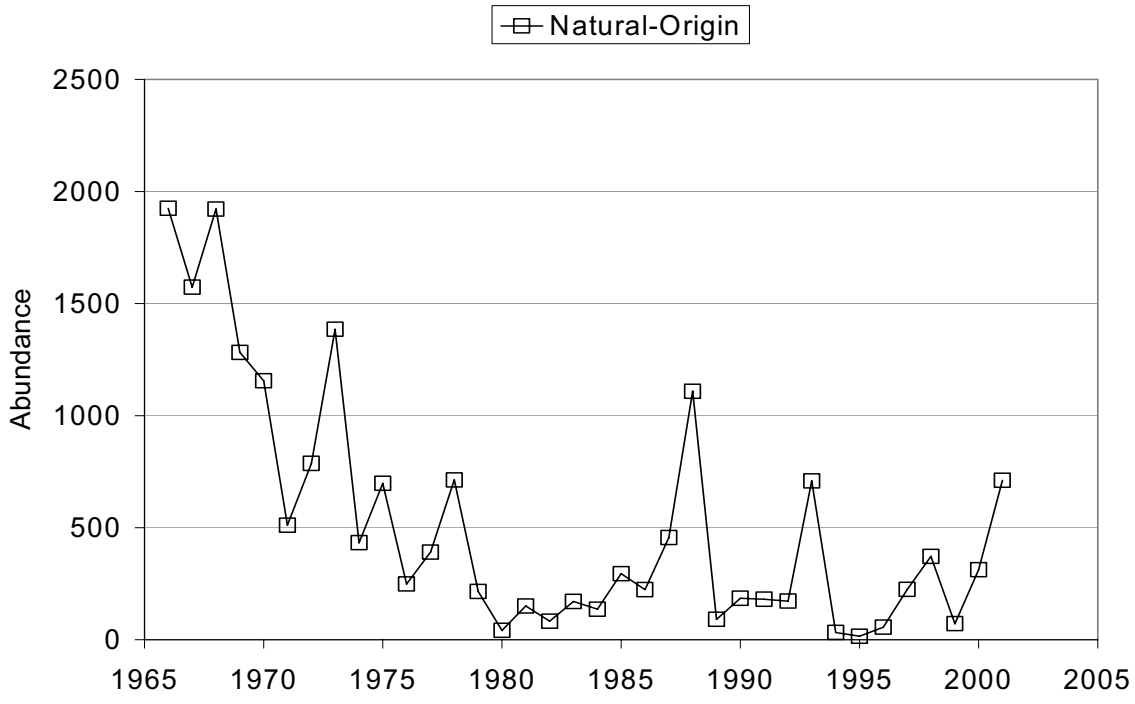


Figure A.2.2.12. Bear Valley/Elk Creek spring chinook spawning escapement; estimates based on expanded redd counts and carcass surveys (IDFG).

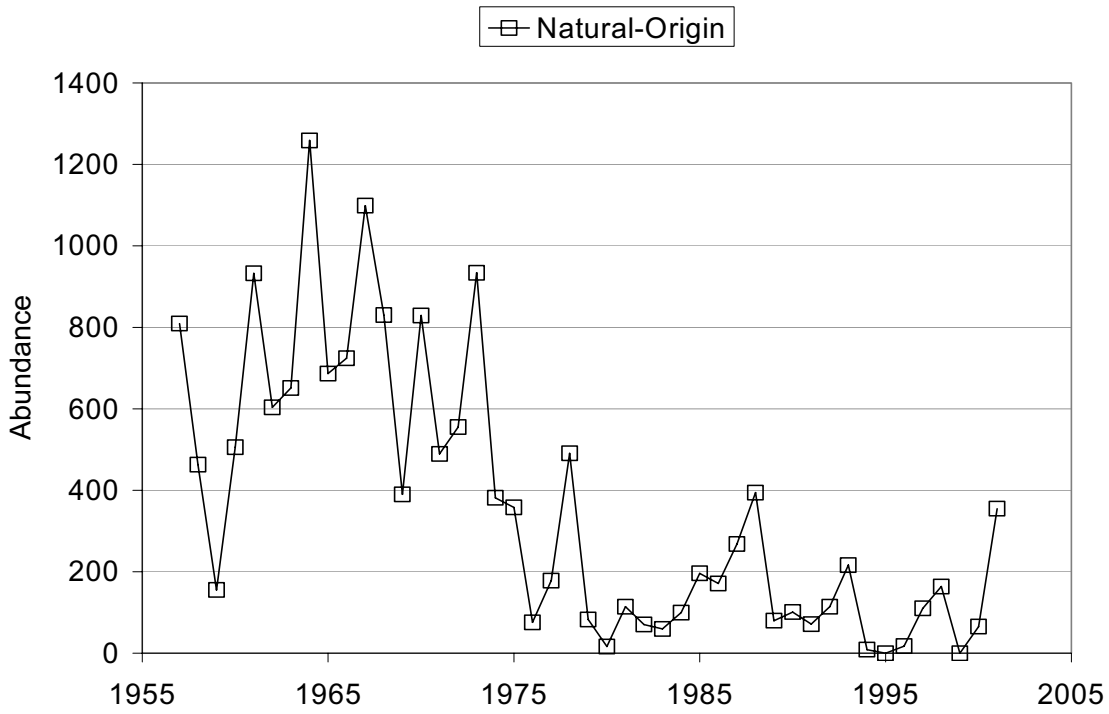


Figure A.2.2.13. Marsh Creek spring-run chinook salmon spawning escapement; estimates based on expanded redd counts and carcass sampling.

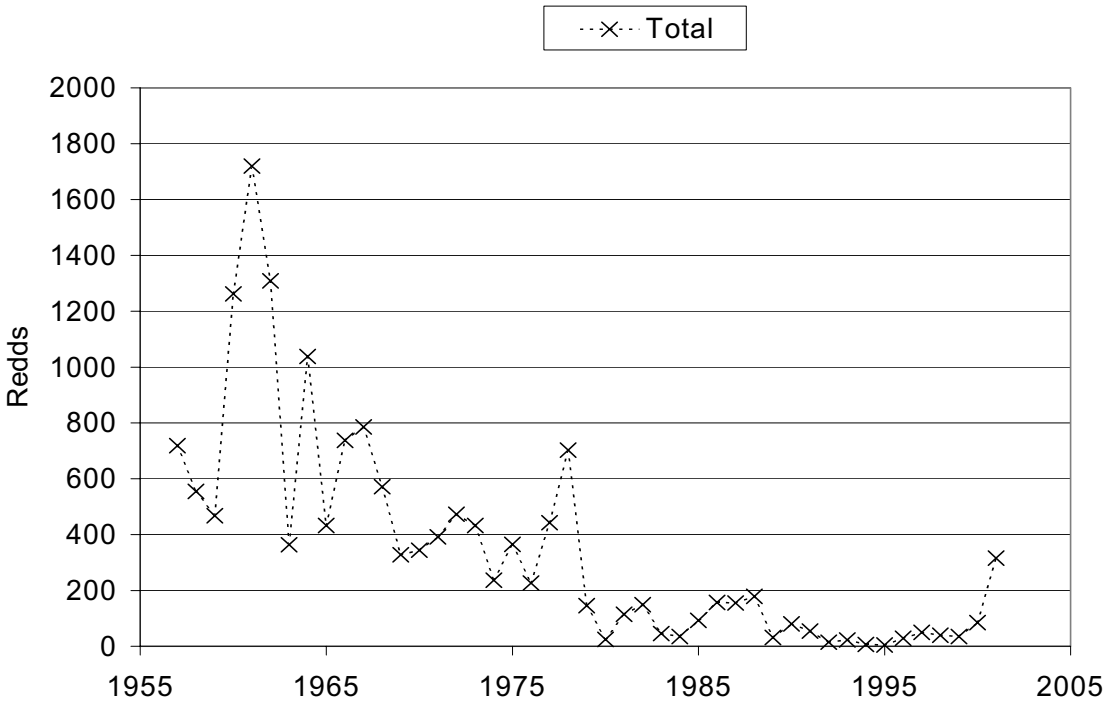


Figure A.2.2.14. Total redd count in the Lemhi River (includes hatchery and natural returns).

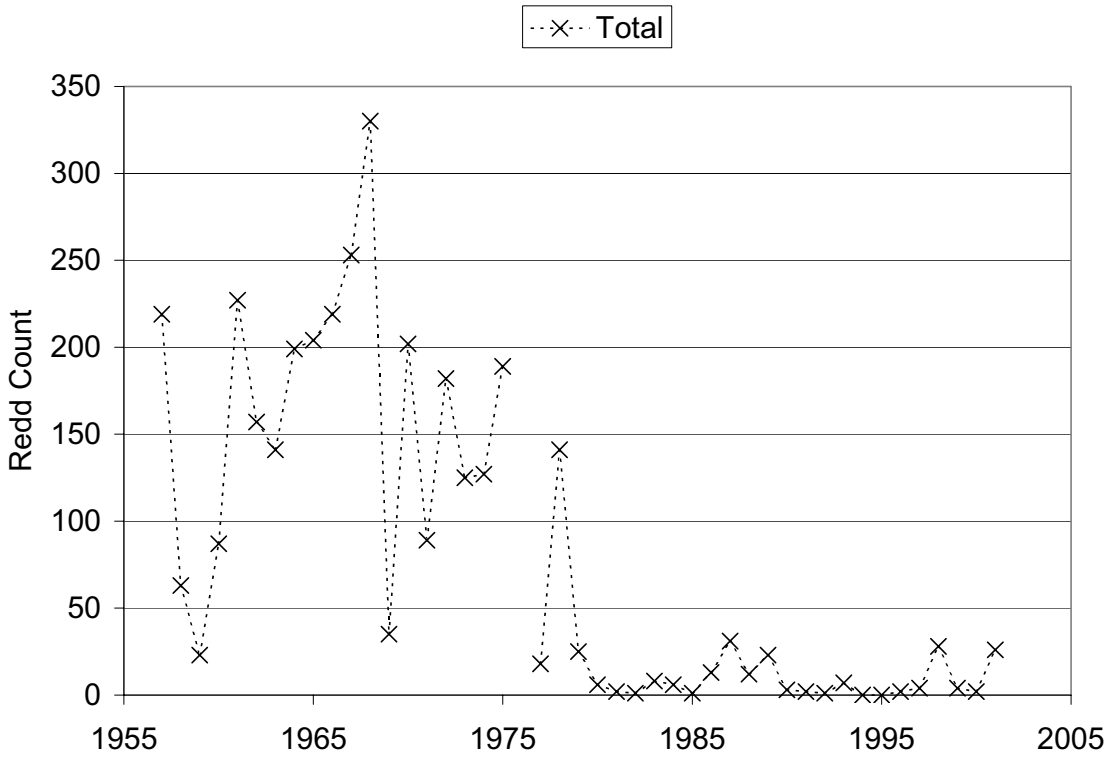


Figure A.2.2.15. Upper Valley Creek spring-run chinook salmon redd counts.

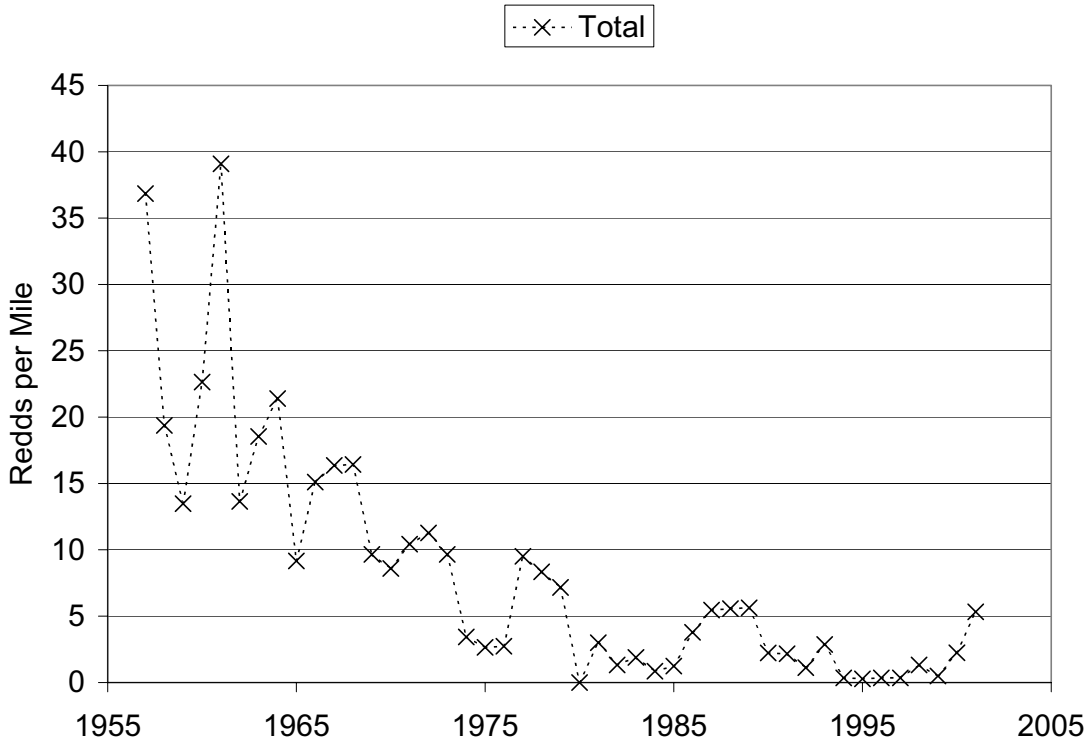


Figure A.2.2.16. East Fork Salmon summer-run chinook salmon redds/mile.

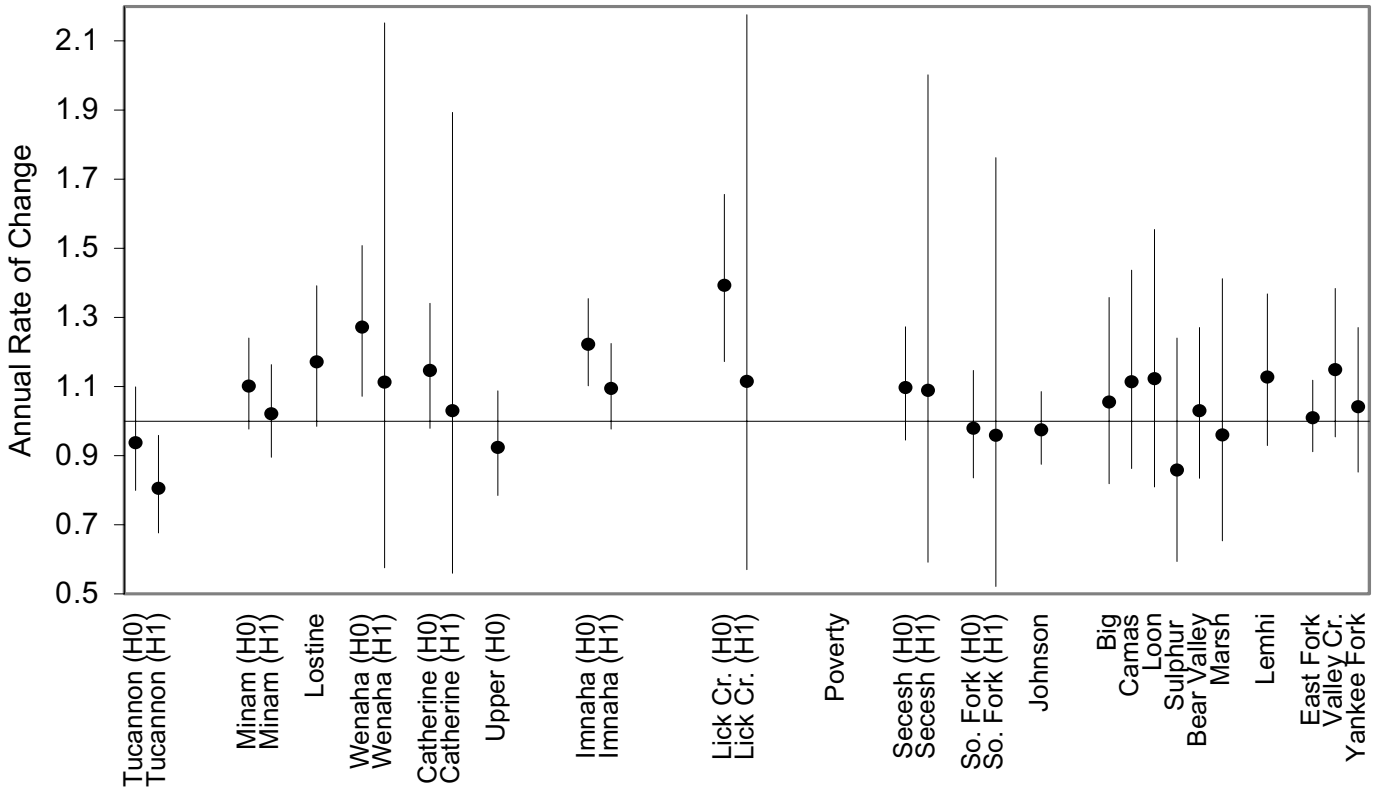


Figure A.2.2.17. Short-term median growth rate (1990-2001) for total spawners for Snake River spring/summer-run production areas. Error bars represent 95% confidence limits of the trend (H0 – hatchery-origin spawners are assumed to have zero reproductive success; H1 – hatchery-origin spawners are assumed to have the same reproductive success as natural-origin fish).

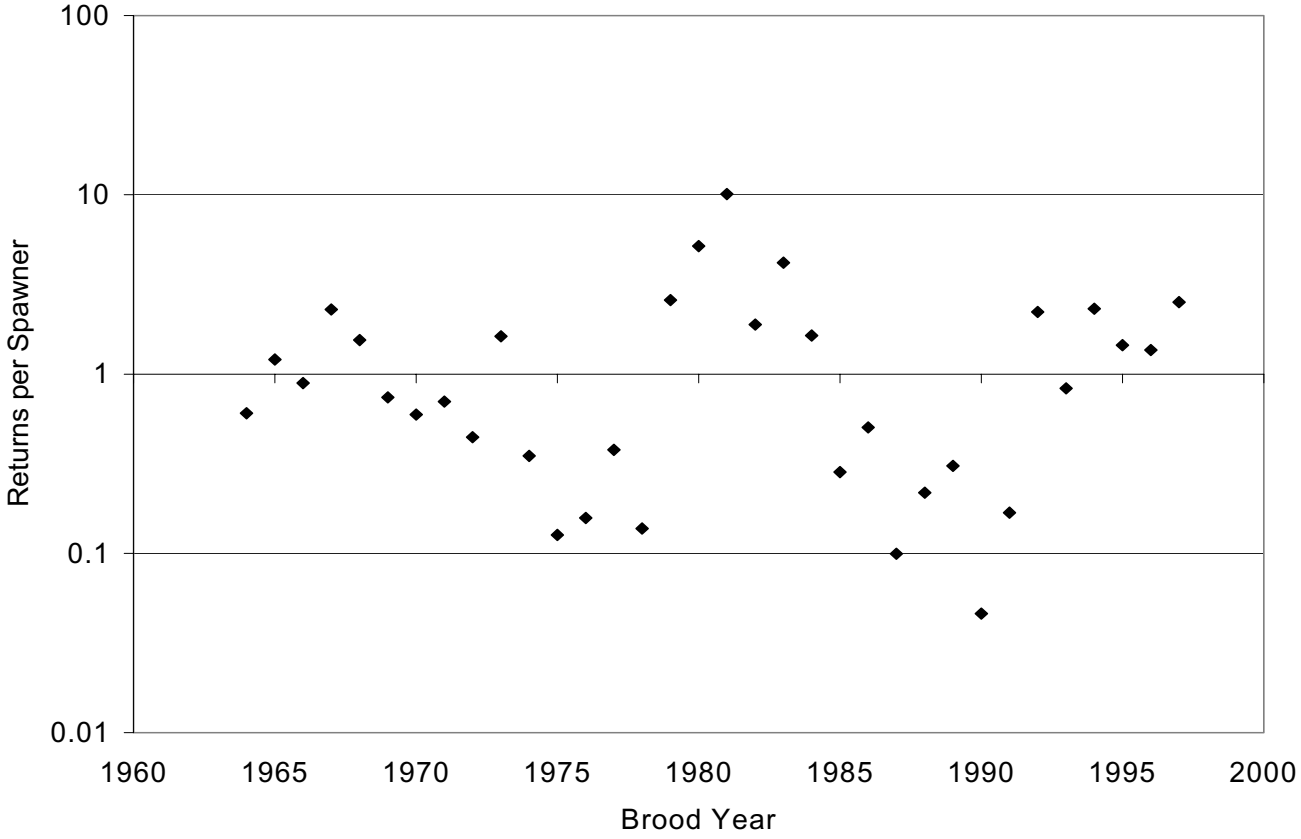


Figure A.2.2.18. Spring/summer chinnok salmon return per spawner for Minam River, calculated as estimated natural returns to the spawning grounds divided by brood year total spawners.

A.2.3 UPPER COLUMBIA RIVER SPRING-RUN CHINOOK SALMON

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

There are no estimates of historical abundance specific to this ESU prior to the 1930s. The drainages supporting this ESU are all above Rock Island Dam on the upper Columbia River. Rock Island Dam is the oldest major hydroelectric project on the Columbia River; it began operations in 1933. Counts of returning chinook salmon have been made since the 1930s. Annual estimates of the aggregate return of spring-run chinook salmon to the upper Columbia River are derived from the dam counts based on the nadir between spring and summer return peaks. Spring-run chinook salmon currently spawn in three major drainages above Rock Island Dam--Wenatchee, Methow and Entiat Rivers. Historically, spring-run chinook salmon may have also used portions of the Okanogan River.

Grand Coulee Dam, completed in 1938, formed an impassable block to the upstream migration of anadromous fish. Chief Joseph Dam was constructed on the mainstem Columbia River downstream from Grand Coulee Dam and is also an anadromous block. There are no specific estimates of historical production of spring-run chinook salmon from mainstem tributaries above Grand Coulee Dam. Habitat typical of that used by spring-run chinook salmon in accessible portions of the Columbia River basin is found in the middle/upper reaches of mainstem tributaries above Grand Coulee Dam. It is possible that the historical range of this ESU included these areas; alternatively, fish from the upper reaches of the Columbia River may have been in a separate ESU.

Artificial production efforts in the area occupied by the Upper Columbia River spring-run chinook salmon ESU extend back to the 1890s. Hatchery efforts were initiated in the Wenatchee and Methow systems to augment catches in response to declining natural production (e.g., Craig and Soumela 1941). While there are no direct estimates of adult production from early efforts, it is likely contributions were small.

In the late 1930s, the Grand Coulee Fish Maintenance Program (GCFMP) was initiated to address the fact that the completion of the Grand Coulee dam cut off anadromous access above site of the dam. Returning salmonids, including spring-run chinook salmon, were trapped at Rock Island Dam and either transplanted as adults or released as juveniles into selected production areas within the accessible drainages below Grand Coulee Dam. Nason Creek in the Wenatchee system was a primary adult transplantation area in this effort. The program was conducted annually from 1938 until the mid-1940s.

A.2.3.1 Summary of Previous BRT Conclusions

Previous BRT Review

The Upper Columbia River spring-run chinook salmon ESU was reviewed by the BRT in late 1998 (NMFS 1998). "The BRT was mostly concerned about risks falling under the abundance/distribution and trends/productivity risk categories for the ESU...average recent

escapement to the ESU has been less than 5,000 hatchery plus wild chinook salmon, and individual populations all consist of less than 100 fish. The BRT was concerned that at these population sizes, negative effects of demographic and genetic stochastic processes are likely to occur. Furthermore, both long- and short-term trends in abundance are declining, many strongly so." The BRT noted that the implementation of emergency natural broodstocking and captive broodstocking efforts for the ESU "...indicate(s) the severity of the population declines to critically small sizes." The BRT recognized that "(h)abitat degradation, blockages and hydrosystem passage mortality all have contributed to the significant declines in this ESU."

A.2.3.2 New Data and Updated Analyses

WDFW, the Yakima Tribe and the Fish and Wildlife Service conduct annual redd count surveys in nine selected production areas within the geographical area encompassed by this ESU (Mosey and Murphy 2002, Hubble and Crampton 2000, Carie 2000). Prior to 1987, redd count estimates were single-survey peak counts. From 1987 on, annual redd counts are generated from a series of on-the-ground counts and represent the total number of redds constructed in any particular year. The agencies use annual dam counts from the mainstem Mid-Columbia River dams as the basis for expanding redd counts to estimates of total spring-run chinook salmon returns. In theWenatchee basin, video counts at Tumwater Dam are available for recent years. Returns to hatchery facilities are subtracted from the dam counts prior to the expansion. Updated returns are summarized in Table A.2.3.1 and in Figures (A.2.3.1-A.2.3.6).

An initial set of population definitions for Upper Columbia River spring-run chinook salmon ESU along with basic criteria for evaluating the status of each population were developed using the Viable Salmonid Population (VSP) guidelines described in McElhany et al. (2000). The definitions and criteria are described in Ford et al. (2000) and have been used in the development and review of Mid-Columbia River PUD plans and the FCRPS Biological Opinion. The interim definitions and criteria are being reviewed as recommendations by the Interior Columbia Technical Recovery Team. Briefly, the joint technical team recommended that the Wenatchee River, the Entiat River and the Methow River be considered as separate populations within the Upper Columbia River Steelhead ESU. The historical status of spring-run chinook salmon production in the Okanogan River is uncertain. The committee deferred a decision on the Okanogan to the Technical Recovery Team. Abundance, productivity and spatial structure criteria for each of the populations in the ESU were developed and are described in Ford et al. (2001).

A.2.3.3 New Hatchery Information

Three national fish hatcheries operated by the U. S. Fish and Wildlife Service are located within the geographic area associated with this ESU. These hatchery programs were established as mitigation programs for the construction of Grand Coulee Dam. Leavenworth National Fish Hatchery, located on Icicle Creek, a tributary to the Wenatchee River system (rkm 42), has released chinook salmon since 1940. Entiat National Fish Hatchery is located on the Entiat River, approximately 10 km upstream of the confluence with the Columbia River mainstem. Spring-run chinook salmon have been released from this facility since 1974. Winthrop National Fish Hatchery is on the Methow River main stem, approximately 72 km upstream of the

confluence with the Columbia River. Spring-run chinook salmon were released from 1941-1961, and from 1974 to the present. Initial spring-run chinook salmon releases from these facilities were for the GCFMP project. Leavenworth Hatchery returns served as the principle stock source for all three facilities until the early 1990s. Production was augmented with eggs transferred into the programs from facilities outside of the ESU, primarily Carson Hatchery. Broodstocking for each hatchery program has been switched to emphasize locally returning broodstocks. Management objectives for the Winthrop National Fish Hatchery have been modified to this conservation strategy. The Entiat and Leavenworth Hatchery programs retain the original harvest augmentation objectives, but are managed to restrict interactions with natural populations. Carcass surveys and broodstocking efforts in the upstream natural spawning areas of the Wenatchee River and the Entiat River support the assumption that the stray rate from the downstream hatchery facilities is low—on the order of 1%-5%. Significantly higher contribution rates have been observed in mainstem Methow natural spawning areas, possibly due to the close proximity of the hatchery and to the recent shift to locally adapted stocks.

Additional spring-run chinook salmon hatchery production efforts were initiated in the 1980s as mitigation for smolt losses at mainstem mid-Columbia River projects operated by public utility districts. These programs are aimed at directly supplementing targeted natural production areas in the Wenatchee and Methow River systems. In the Wenatchee River drainage, this program has targeted the Chiwawa River, a major spring chinook production tributary entering at rkm 78.2. Broodstock are collected at a weir located approximately 2 km upstream of the mouth of the Chiwawa River. In some years broodstocking has been augmented by using marked adults collected at Tumwater Dam. Release groups are returned to an acclimation pond adjacent to the lower Chiwawa River for final acclimation and release.

In the Methow River, the supplementation program began in 1992 with broodstock collected from the natural runs to the Chewuch and Twisp Rivers. The Methow Fish Hatchery operated by WDFW has actively managed broodstock collection and mating to maintain separate groups for use in the Chewuch, Twisp and Methow Rivers. In 1996 and again in 1998, extremely low adult returns led to a decision to collect all adults at Wells Dam. Scale reading, elemental scale analysis, and extraction/reading of coded-wire tags have been used at the Methow National Fish Hatchery in support of maintaining broodstock separation.

Beginning in 1998, a composite stock was initiated and the management objectives for Winthrop National Fish Hatchery were established. Since that time, Methow and Winthrop Hatcheries have worked together on broodstock collection and spawning activities. Juveniles are reared at the Winthrop Facility and released into the mainstem Methow River in coordination with releases from acclimation sites on the Twisp River and Chewuch River. The Methow program was initiated with Winthrop Hatchery stock and is being converted to local broodstock. These supplementation programs have had two major impacts on natural production areas. Returns to natural spawning areas have included increasing numbers of supplementation fish in recent years, especially in the Methow mainstem spawning areas adjacent to the hatchery.

The WDFW SASSI report identified nine stocks of spring-run chinook salmon within the upper Columbia River spring-run chinook salmon ESU. Ford et al. (2001) describes the results of applying the population definition and criteria provided in McElhany et al. (2000) to current

upper Columbia springRiver spring-run chinook salmon production. The conclusions of the effort were that "...there are (or historically were) three or four independent viable populations of spring-run chinook salmon in the upper Columbia River basin, inhabiting the Wenatchee, Entiat, Methow and (possibly) the Okanogan River basins. There appears to be considerable population substructure within the Wenatchee and Methow basins, however, this substructure should be considered when evaluating recovery goals and management actions."[3]

Hatchery impacts

Hatchery impacts vary among the production areas. Large on-station production programs in the Wenatchee and Entiat River drainages are located in the lower reaches, some distance downstream of natural spawning areas. In the Methow River, Winthrop National Fish Hatchery is located upstream, adjacent to a portion of the mainstem spawning reach for spring-run chinook salmon and steelhead. Straying of returning hatchery-origin adults into the natural production areas is thought to be low for the Wenatchee River and Entiat River. The supplementation programs in the upper Wenatchee and the Methow River basins are designed to specifically boost natural production. In years when the return of natural-origin adults is extremely low, the proportion of hatchery-origin adults on the spawning grounds can be high, even if the dispersal rate of the returning hatchery fish is low. It is likely that returning hatchery fish contribute to spawning in natural production areas in the Methow River at a higher rate. Carcass sampling data are available for a limited number of year/area combinations for the upper Columbia River drainages (e.g., WDF 1992).

Spring-run chinook salmon returns to the Wenatchee and the Methow River systems have included relatively large numbers of supplementation program fish in recent years. The total return to natural spawning areas in the Wenatchee River system for 2001 is estimated to be approximately 4,000-1,200 returning from natural spawning and 2,800 from the hatchery-based supplementation program. The return to spawning areas for the Methow in 2001 is estimated at well over 9,000. Carcass surveys indicate that returning supplementation adults accounted for approximately 80% of the 2001 run to the Methow spawning areas. Supplementation programs have contributed substantially to getting fish on the spawning grounds in recent years. Little information is available to assess the long-term impact of high levels of supplementation on productivity. Categorization for Upper Columbia River spring-run chinook salmon hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.3.4 Comparison with Previous Data

All three of the existing upper Columbia River spring-run chinook salmon populations have exhibited similar trends and patterns in abundance over the past 40 years. The 1998 Chinook salmon status review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia River spring-run chinook salmon populations were generally negative, ranging from -5% to +1%. Analyses of the data series, updated to include 1996-2001 returns, indicate that those trends have continued. The long-term trend in spawning escapement is

[3]Spring chinook spawning in Icicle Creek, Peshastin Creek, Incgalls Creek and the Leavenworth Hatchery are considered an independent, hatchery-derived population that is not part of the ESU (NMFS 1999).

downward for all three systems. The Wenatchee River spawning escapements have declined an average of 5.6% per year, the Entiat River population at an average of 4.8%, and the Methow River population an average rate of 6.3% per year since 1958. These rates of decline were calculated from the redd count data series[4].

Mainstem spring-run chinook salmon fisheries harvested chinook salmon at rates between 30%-40% per year through the early1970s. Harvest was substantially reduced by restricting mainstem commercial fisheries and sport harvest in the mid-1970s. The calculated downward trend in abundance for the upper Columbia River stocks would be higher if the early redd counts had been revised to reflect the potential 'transfer' from harvest to escapement for the early years in the series.

In the 1960s and 1970s, spawning escapement estimates were relatively high with substantial year-to-year variability. Escapements declined in the early 1980s, then peaked at relatively high levels in the mid 1980s. Returns declined sharply in the late 1980s and early 1990s. Returns in 1990-94 were at the lowest levels observed in the 40-plus years of the data sets. The Upper Columbia Biological Requirements Workgroup (Ford et al. 2001) recommended interim delisting levels of 3,750, 500, and 2,200 spawners for the populations returning to the Wenatchee, Entiat, and Methow drainages, respectively. The most recent 5-year geometric mean spawning escapements (1997-2001) were at 8%-15% of these levels. Target levels have not been exceeded since 1985 for the Methow run and the early 1970s for the Wenatchee and Entiat populations.

Short-term trends for the aggregate population areas reported in the 1998 Status Review (Myers et al. 1998) ranged from -15.3% (Methow R.) to a -37.4% (Wenatchee R.). The Escapements from 1996-1999 reflected that downward trend. Escapements increased substantially in 2000 and 2001 in all three systems. Returns to the Methow River and the Wenatchee River reflected the higher return rate on natural production as well as a large increase in contributions from supplementation programs. Short-term trends (1990-2001) in natural returns remain negative for all three upper Columbia River spring-run chinook salmon populations. Natural returns to the spawning grounds for the Entiat, Methow, and Wenatchee River populations continued downward at average rates of 3%, 10%, and 16% respectively.

Short- and long-term trends in returns to the individual subpopulations within the Wenatchee and Methow systems were consistent with the aggregate population level trends. Long-term and short-term trends for Upper Columbia River spring-run chinook salmon populations are shown in Figures A.2.3.7-A.2.3.8.

McClure et al. (in press) reported standardized quantitative risk assessment results for 152 listed salmon stocks in the Columbia River basin, including representative data sets (1980-2000 return years) for upper Columbia River spring-run chinook salmon. Average annual growth rate

[4]Prior to 1987, annual redd counts were obtained from single surveys and reported as peak counts. From 1987 on, redd counts were derived from multiple surveys and are reported as annual total counts. An adjustment factor of 1.7 was used to expand the pre-1987 redd counts for comparison with the more recent total counts. (Beamesderfer et al. 1997).

(λ) for the upper spring-run chinook salmon population was estimated as 0.85, the lowest average reported for any of the Columbia River ESUs analyzed in the study. Assuming that population growth rates were to continue at the 1980-2000 levels, upper Columbia River spring-run chinook salmon populations are projected to have a very high probability of a 90% decline within 50 years (0.87 for the Methow River population, 1.0 for the Wenatchee and Entiat runs).

The major harvest impacts on upper Columbia River spring-run chinook salmon have been in mainstem fisheries below McNary Dam and in sport fisheries in each tributary. There are no specific estimates of historical harvest impacts on upper Columbia River spring-run chinook salmon runs. Assuming that upper Columbia River spring-run chinook salmon runs were equally available to mainstem commercial fisheries as were the runs to other areas of the Snake and Columbia rivers, harvest rates in the lower river commercial fisheries were likely on the order of 20%-40% of the in-river run. Lower river harvest rates on up-river spring-run chinook salmon stocks were sharply curtailed beginning in 1980 and were again reduced after the listing of Snake River spring/summer-run chinook salmon in the early 1990s. Sport fishery impacts were also curtailed. Harvest impacts are currently being managed under a harvest management schedule—harvest rates are curtailed even further if the average return drops below a predefined level, increases area allowed at high run sizes.

Mainstem hydropower impacts

Upper Columbia spring chinook runs are subject to passage mortalities associated with mainstem hydroelectric projects. Production from all of these drainages passes through the four lower river federal projects and a varying number of Mid-Columbia River Public Utility District projects. The Wenatchee River enters the Columbia River above seven mainstem dams, the Entiat above eight dams; the Methow River and Okanogan Rivers above nine dams. The draft Mid-Columbia Habitat Conservation Plan establishes salmonid survival objectives for Wells, Rocky Reach, and Rock Island dams. After 1998, Douglas PUD began operating Wells Dam in accordance with the draft HCP. Although some operational improvements were implemented throughout the 1990's, measures to fully implement the provisions of the draft HCP were not in place at all three projects until 2003. Interim operating guidelines designed to improve survival have been applied at Wanapum and Priest Rapids Dams. Operational improvements have been made to increase outmigrant survival through the lower Columbia mainstem hydroelectric dams (FCRPS Biological Opinion 2000).

Each of the upper Columbia River spring-run chinook salmon areas has a particular set of habitat problems. In general, tributary habitat problems affecting this ESU include the effects of increasing urbanization on the lower reaches, irrigation/flow diversions in up-river sections of the major drainage, and the impacts of grazing on middle reaches.

Previous assessments of stocks within this ESU have identified several as being at risk or of concern. WDF et al. (1993) considered nine stocks within this ESU, of which eight were considered to be of native origin and predominately natural production. The status of all nine stocks was considered as depressed.

Nehlsen et al. (1991) listed six additional stocks from the upper Columbia River as extinct. All of those stocks were associated with drainages entering the Columbia River main stem above Chief Joseph and Grand Coulee Dams. Those projects blocked off access by adult anadromous fish to the upper basin.

Table A.2.3.1. Summary of abundance and trend information for Upper Columbia River spring-run chinook salmon relative to previous BRT status review. Five-year geometric means calculated using years 1997 to 2001 unless otherwise noted. Interim targets from Ford et al. (2001). Previous years 1987-1996.

Population(s)	Recent 5-year geometric mean				Short-Term Trend (%/yr)		Interim Target	Current vs. Interim Target
	% Natural Origin (prev.)	Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Methow Total *	41	680 (79 – 9,904)	282	144	+2.0	-15.3	2,000	34%
Methow R. Main stem *	41	161 Redds (17 –2,864)			+6.5			
Twisp R. *	46	58 Redds (10 – 369)		87	-9.8	-27.4		
Chewuch R. *	59	58 Redds (6 – 1105)		62	-2.9	-28.1		
Lost/Early Winters Cr. *	46	12 (3 – 164)	6	62**	-14.1	-23.2**		
Entiat R.	58	111 (53 – 444)	65	89	-1.2	-19.4	500	22%
Wenatchee Total	58	470 (119 – 4,446)	274	27	-1.5	-37.4	3,750	13%
Chiwawa R.	53	109 Redds (34 – 1,046)		134	-0.7	-29.3		
Nason Cr.	61	54 Redds (8 – 374)		85	-1.5	-26.0		
Upper Wenatchee	34	8 Redds (0 – 215)			-8.9			
White R.	92	9 Redds (1 – 104)		25	-6.6	-35.9		
Little Wenatchee	79	11 Redds (3 – 74)		57	-25.8	-25.8		

* 5 year geometric mean calculated without year 1998; no data available
** Lost River Only

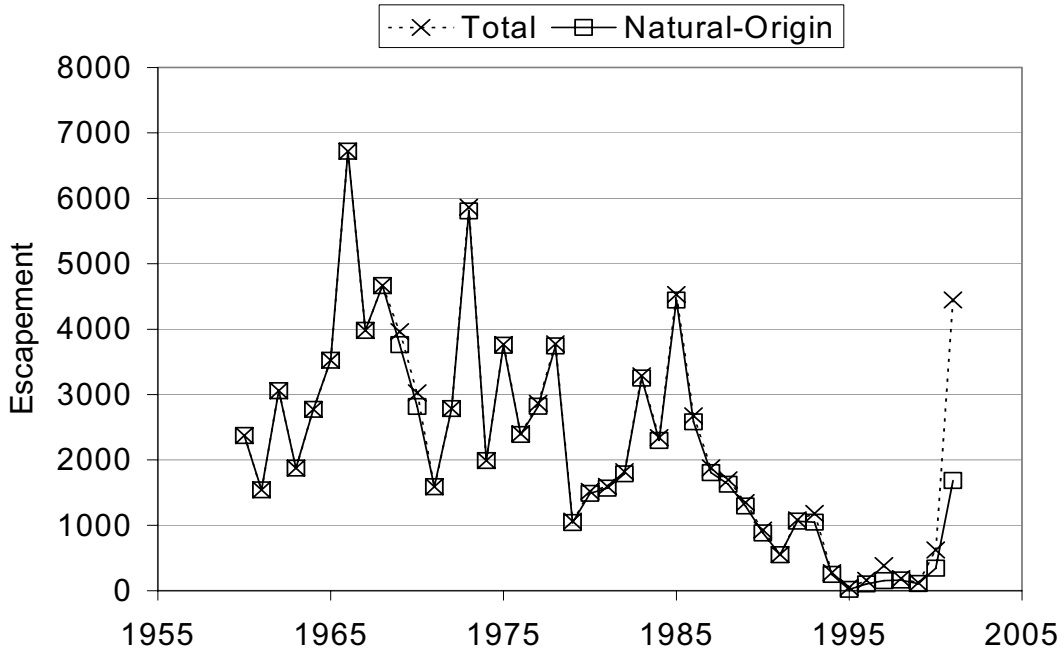


Figure A.2.3.1. Wenatchee spring-run chinook salmon spawning escapement; estimates expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Mosey & Murphy (2002).

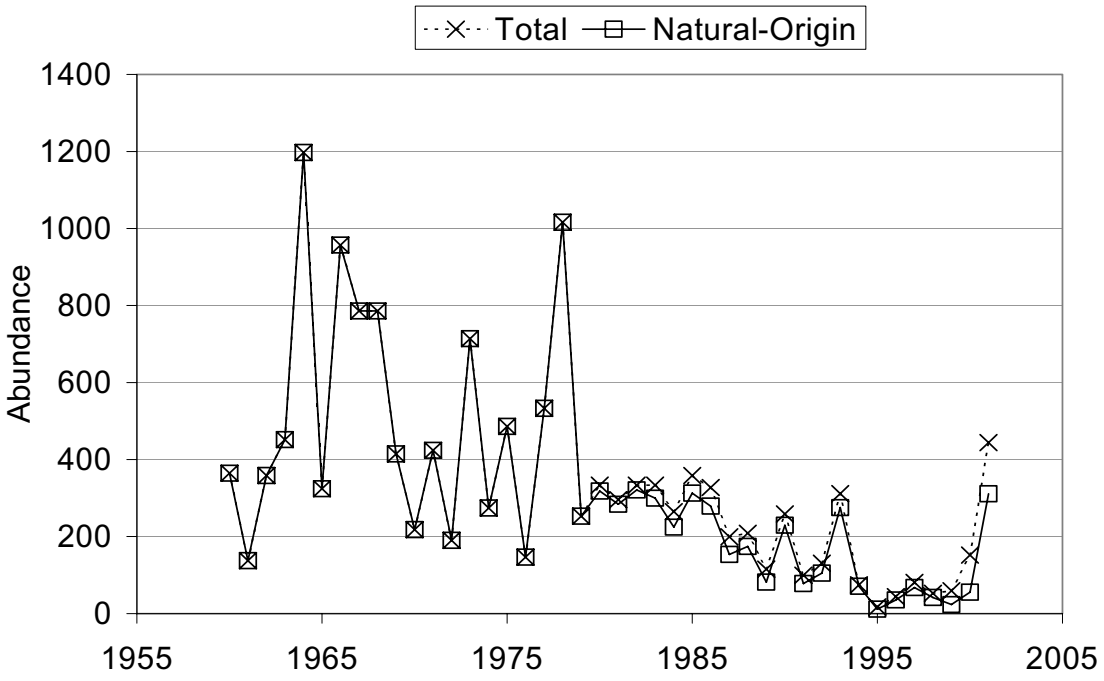


Figure A.2.3.2. Entiat spring-run chinook salmon spawning escapement; estimates from expanded redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent-year data from Carie (2002).

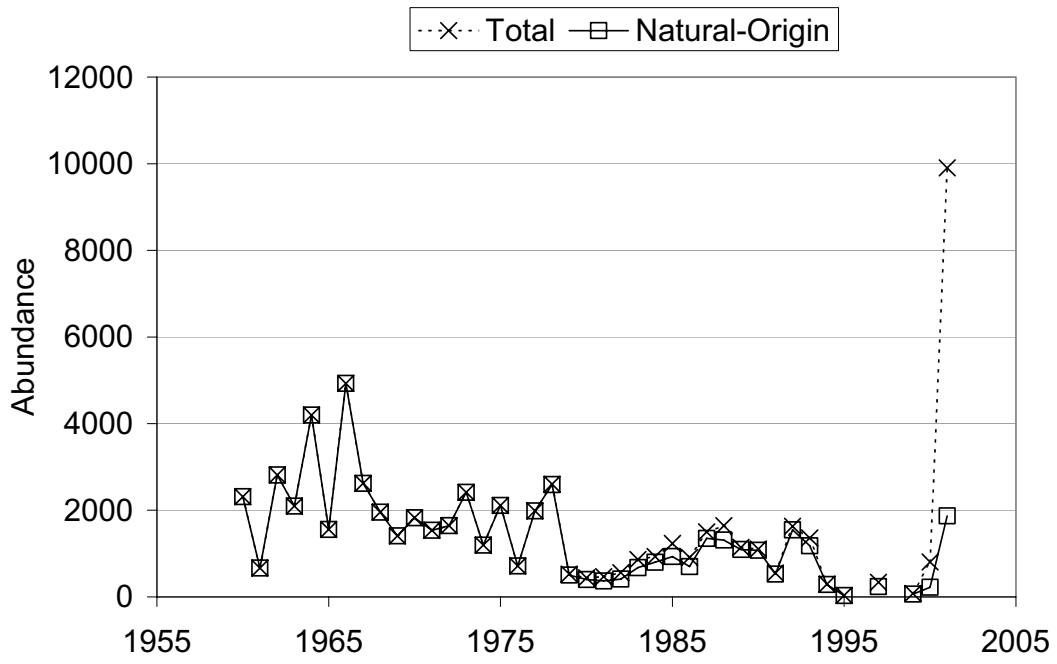


Figure A.2.3.3. Methow spring-run chinook salmon spawning escapement; estimates expanded from redd counts (Beamesderfer et al. 1997, Cooney 2001). Recent year data from Yakima Indian Nation Fisheries (J. Hubbell, pers. comm.).

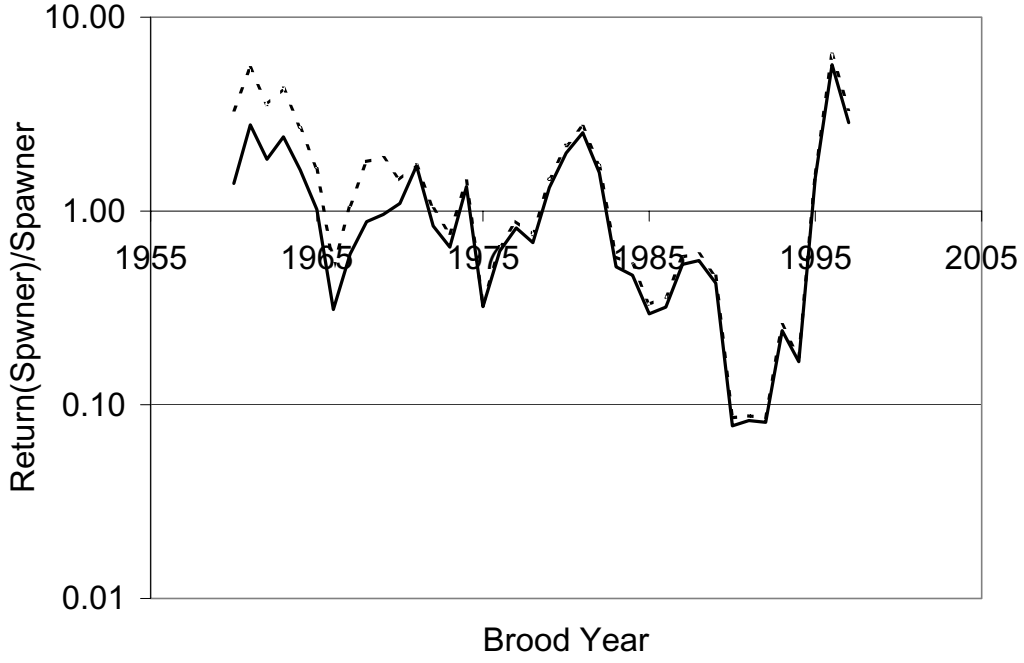


Figure A.2.3.4. Wenatchee spring-run chinook salmon returns/spawner by broodyear (returns to spawning grounds), calculated as estimated natural returns to the spawning grounds divided by brood year total spawners (solid line) and returns adjusted to recent average harvest rate (1985-2001; dashed line)

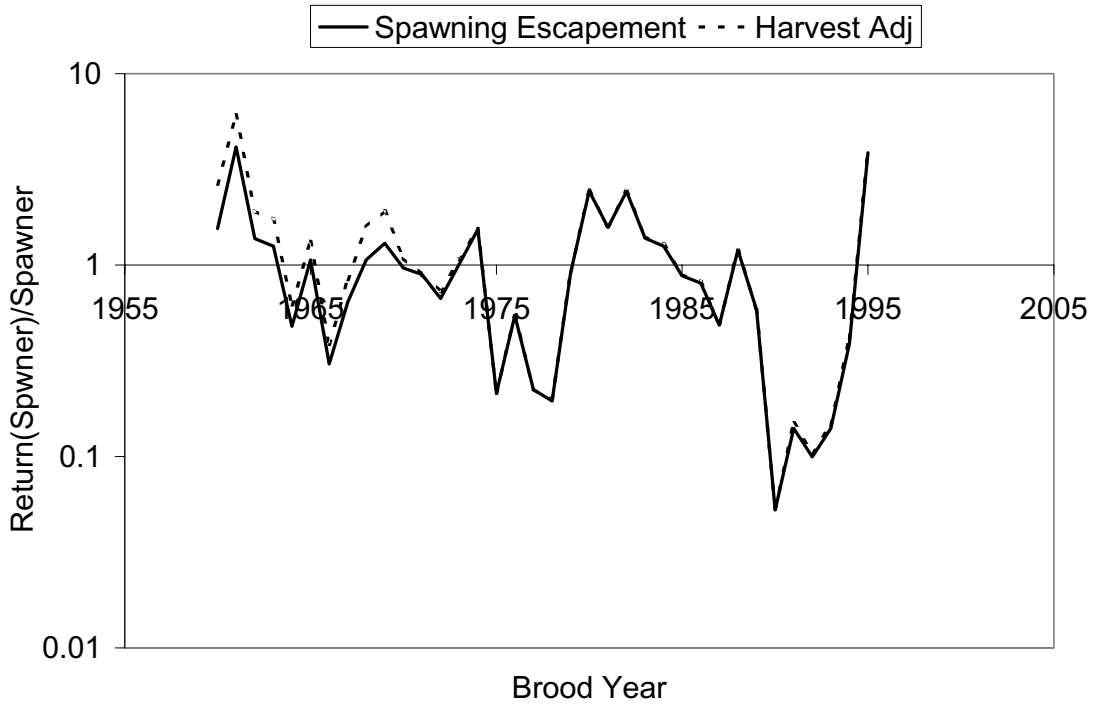


Figure A.2.3.5. Methow spring-run chinook salmon returns/spawner by brood year (returns to spawning grounds).

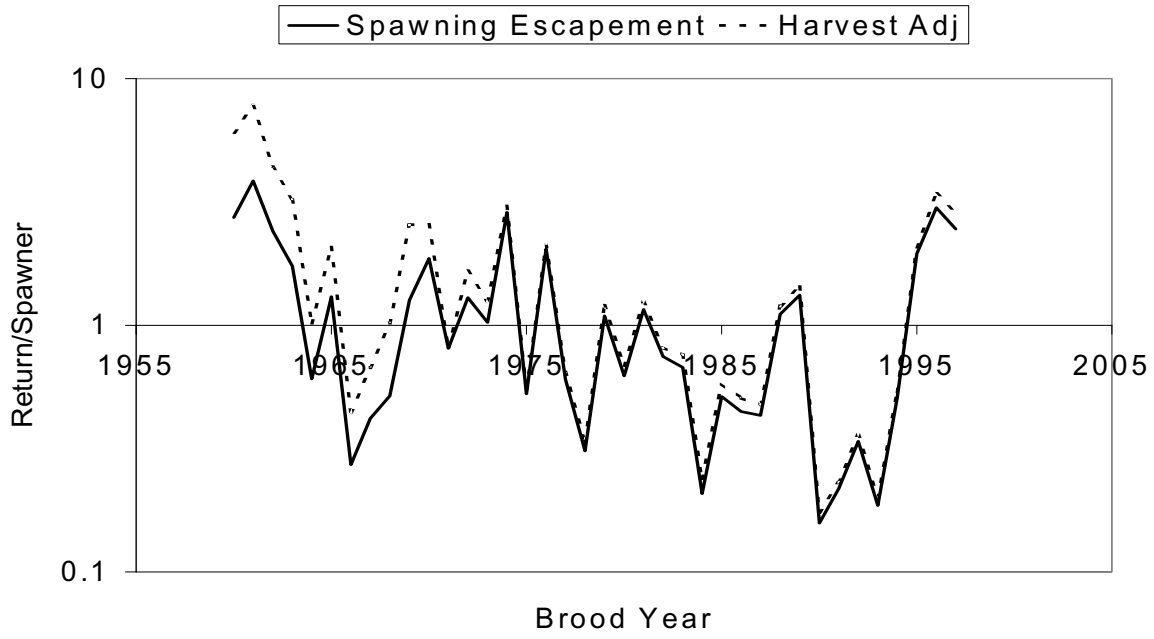


Figure A.2.3.6. Entiat spring-run chinook salmon returns/spawner by brood year (returns to spawning grounds).

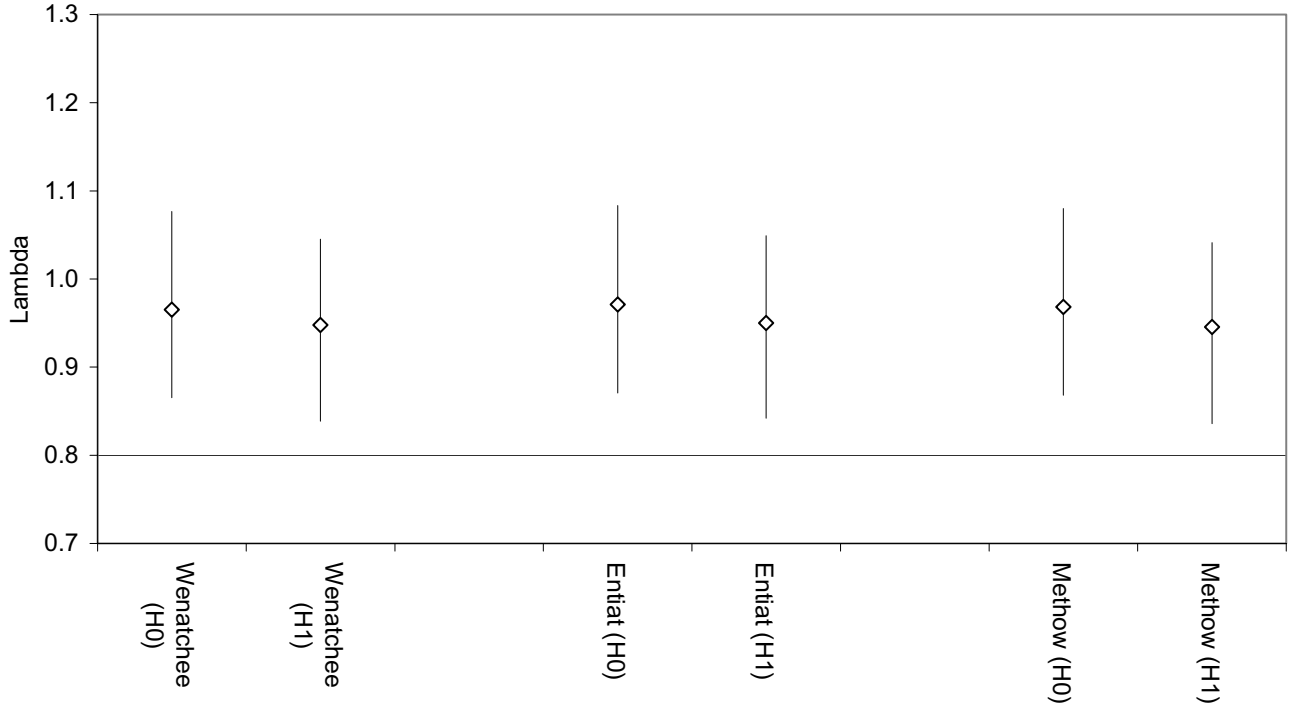


Figure A.2.3.7. Long-term annual growth rates (λ) for upper Columbia River spring chinook salmon populations. Error bars represent 95% confidence limits (H0 - hatchery fish are assumed to have zero reproductive success; H1 - hatchery –origin spawners are assumed to have the same reproductive success as natural-origin fish.).

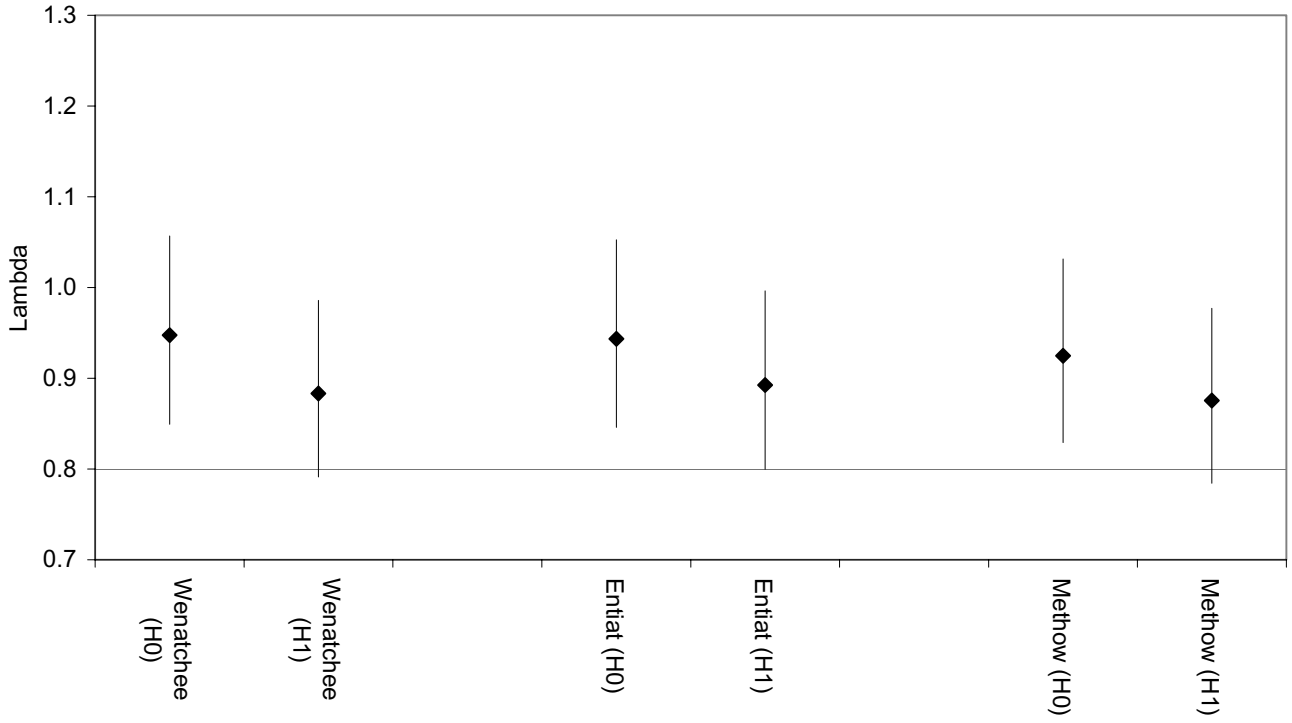


Figure A.2.3.8. Short-term (1990-2001) annual growth rates (λ) for upper Columbia River spring chinook salmon populations. Error bars represent 95% confidence limits of the trend (H0 - hatchery fish are assumed to have zero reproductive success; H1 – hatchery-origin spawners are assumed to have the same reproductive success as natural-origin fish).

A.2.4 PUGET SOUND CHINOOK SALMON

Primary contributors: Mary Ruckelshaus and Norma Jean Sands
(Northwest Fisheries Science Center)

The status of Puget Sound chinook salmon was formally assessed during a coastwide status review (Myers et al. 1998). In November 1998, a BRT was convened to update the status of this ESU by summarizing information received since that review and comments on the 1997 status review (NMFS 1998). The following section ("*Summary of Previous BRT Conclusions*") summarizes the findings and conclusions made at the time of the 1998 status review update; the section after that *("Summary of New Information*") reports on new information received through March, 2003 and the conclusions of the 2003 BRT based on the new information.

A.2.4.1. Summary of Previous BRT conclusions

Status and trends

The BRT concluded in 1998 that the Puget Sound chinook ESU was likely to become endangered in the foreseeable future. The estimated total run size of chinook salmon to Puget Sound in the early 1990s was 240,000 chinook, down from an estimated 690,000 historical run size. The 5-year geometric mean of spawning escapement of natural chinook salmon runs in North Puget Sound during the period from 1992-1996 was approximately 13,000. Both long- and short-term trends for these runs were negative, with few exceptions. In south Puget Sound, spawning escapement of the natural runs averaged 11,000 spawners at the time of the last status review update. In this area, both long- and short-term trends were predominantly positive. In Hood Canal, spawning populations in six streams were considered a single stock by the co-managers because of extensive transfers of hatchery fish (WDF et al. 1993). Fisheries in the area were managed primarily for hatchery production and secondarily for natural escapement; high harvest rates directed at hatchery stocks resulted in failure to meet natural escapement goals in most years (USFWS 1997a). The 5-year geometric mean natural spawning escapement at the time of the last update was 1,100, with negative short- and long-term trends (except in the Dosewallips River). The ESU also includes the Dungeness and Elwha Rivers, which have natural chinook salmon runs as well as hatcheries. The Dungeness River had a run of spring/summer-run chinook salmon with a 5-year geometric mean natural escapement of 105 fish at the time of the last status review update. The Elwha River has a 5-year geometric mean escapement of 1,800 fish during the mid-1990s, which includes a large, but unknown fraction of naturally spawning hatchery fish. Both the Elwha and Dungeness populations exhibited downward trends in abundance in the 1990s.

Threats

Habitat throughout the ESU has been blocked or degraded. In general, upper tributaries have been impacted by forest practices and lower tributaries and mainstem rivers have been impacted by agriculture and/or urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban

development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of critical habitat issues for streams in the range of this ESU, including changes in flow regime (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish Rivers), streambed instability (most basins), estuarine loss (most basins), loss of large woody debris (Elwha, Snohomish, and White Rivers), loss of pool habitat (Nooksack, Snohomish, and Stillaguamish Rivers), and blockage or passage problems associated with dams or other structures (Cedar, Elwha, Green/Duwamish, Snohomish, and White Rivers). The Puget Sound Salmon Stock Review Group (PFMC 1997a) provided an extensive review of habitat conditions for several of the stocks in this ESU. It concluded that reductions in habitat capacity and quality have contributed to escapement problems for Puget Sound chinook salmon, citing evidence of direct losses of tributary and mainstem habitat due to dams, and of slough and side-channel habitat due to diking, dredging, and hydromodification. It also cited reductions in habitat quality due to land management activities.

WDF et al. (1993) classified 11 out of 29 stocks in this ESU as being sustained, in part, through artificial propagation. Nearly 2 billion fish have been released into Puget Sound tributaries since the 1950s (Myers et al. 1998). The vast majority of these have been derived from local returning fall-run adults. Returns to hatcheries have accounted for 57% of the total spawning escapement, although the hatchery contribution to spawner escapement is probably much higher than that, due to hatchery-derived strays on the spawning grounds. Almost all of the releases into this ESU have come from stocks within this ESU, with the majority of within ESU transfers coming from the Green River Hatchery or hatchery broodstocks that have been derived from Green River stock (Marshall et al. 1995). The electrophoretic similarity between Green River fall-run chinook salmon and several other fall-run stocks in Puget Sound (Marshall et al. 1995) suggests that there may have been a significant effect from some hatchery transplants. Overall, the pervasive use of Green River stock throughout much of the extensive hatchery network that exists in this ESU may reduce the genetic diversity and fitness of naturally spawning populations.

Harvest impacts on Puget Sound chinook salmon stocks were quite high. Ocean exploitation rates on natural stocks averaged 56%-59%; total exploitation rates averaged 68%-83% (1982-89 broodyears) (PSC 1994). Total exploitation rates on some stocks have exceeded 90% (PSC 1994).

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern (reviewed in Myers et al. 1998).

A.2.4.2 New Data and Updated Analyses

ESU status at a glance

Historical peak run size	~690,000
Historical populations	31

Extant populations	22
5-year geometric mean natural spawners per population	222 – 9,489 (median = 766)
Long-term trend per population	0.92 – 1.2 (median = 1.0)
Recent λ (H1) per population	0.67 – 1.2 (median = 1.0)

Listing status Threatened

ESU structure

The Puget Sound ESU is comprised of 31 historically quasi-independent populations of chinook, 22 of which are believed to be extant currently (Puget Sound TRT 2001 and 2002). The populations that are presumed to be extinct are mostly of early-returning fish, and most of these are in the mid- to southern parts of the Puget Sound or in Hood Canal/Strait of Juan de Fuca (Table A.2.4.1). The populations in the ESU with the greatest estimated fractions of hatchery fish tend to be in the mid- to southern parts of Puget Sound, in Hood Canal, and in the Strait of Juan de Fuca (Table A.2.4.2).

Table A.2.4.1. Historical populations of chinook salmon in the Puget Sound ESU (PSTRT 2001). Run-timing types for each population and the biogeographic region within which each population occurs also are noted (Puget Sound TRT 2001 and 2002).

Population	Status	Run-Timing	Bio-Geographic Region	Reference
N. Fork Nooksack	Extant	early	Strait of Georgia	
S. Fork Nooksack	Extant	early	Strait of Georgia	
Nooksack late	**Extinct**	late	Strait of Georgia	1
Lower Skagit	Extant	late	Whidbey Basin	
Upper Skagit	Extant	late	Whidbey Basin	
Lower Sauk	Extant	late	Whidbey Basin	
Upper Sauk	Extant	early	Whidbey Basin	
Suiattle	Extant	early	Whidbey Basin	
Upper Cascade	Extant	early	Whidbey Basin	
N. Fork Stillaguamish	Extant	late	Whidbey Basin	
S. Fork Stillaguamish	Extant	late	Whidbey Basin	
Stillaguamish early	**Extinct**	early	Whidbey Basin	2,3
Skykomish	Extant	late	Whidbey Basin	
Snoqualmie	Extant	late	Whidbey Basin	
Snohomish early	**Extinct**	early	Whidbey Basin	2,3
Cedar	Extant	late	Main Basin/ South Basin	
N. Lake Washington	Extant	late	Main Basin/ South Basin	
Green/Duwamish	Extant	late	Main Basin/ South Basin	
Green/Duwamish early	**Extinct**	early	Main Basin/ South Basin	2,3
Puyallup	Extant	late	Main Basin/ South Basin	
White	Extant	early	Main Basin/ South Basin	
Puyallup early	**Extinct**	early	Main Basin/ South Basin	2
Nisqually	Extant	late	Main Basin/ South Basin	
Nisqually early	**Extinct**	early	Main Basin/ South Basin	2,4
Skokomish	Extant	late	Hood Canal	
Skokomish early	**Extinct**	early	Hood Canal	2,3,5
Dosewallips	Extant	late	Hood Canal	
Dosewallips early	**Extinct**	early	Hood Canal	2,4
Dungeness	Extant	late	Strait of Juan de Fuca	
Elwha	Extant	late	Strait of Juan de Fuca	
Elwha early	**Extinct**	early	Strait of Juan de Fuca	2,3

1=PS TRT 2001; 2= Nehlsen et al. 1991; 3= WDF et al. 1993; 4= ONRC 1995; 5= Deschamps 1954

New information obtained for the 22 populations of chinook salmon in the Puget Sound ESU is summarized in Appendix A.5.2. Sources of data and detailed information on data years are provided for each population separately in the Appendix.

Abundance of natural spawners

The most recent 5-year (1998-2002) geometric mean of natural spawners in populations of Puget Sound chinook salmon ranges from 222 (in the Dungeness) to almost 9,500 fish (in the upper Skagit population). Most populations contain natural spawners numbering in the high hundreds (median recent natural escapement = 766); of the ten populations with greater than 1,000 natural spawners, only two are thought to have a low fraction of hatchery fish (Table A.2.4.2; Figure A.2.4.1). Estimates of the fraction of natural spawners that are of hatchery origin are sparse—data are available for only twelve of the 22 populations in the ESU, and such information is available for only the most recent 5-10 years (Table A.2.4.2). Estimates of the hatchery fraction of natural spawners come from counts of otolith-marked local hatchery fish sampled from carcasses (Nooksack River Basin, Snohomish River Basin), adipose fin clip counts from redd count surveys (Skagit River Basin), and coded-wire tag sampling (NF Stillaguamish and Green River). In general, populations in the Skagit river basin are the only ones with presumed low estimates of naturally spawning hatchery fish. The Stillaguamish and Snohomish populations have moderate estimates of naturally spawning hatchery fish. Estimates of historical equilibrium abundance from predicted pre-European settlement habitat conditions range from 1,700 to 51,000 potential chinook salmon spawners per population (Mobrand 2000). The historical estimates of equilibrium abundance are several orders of magnitude higher than realized spawner abundances currently observed throughout the ESU.

Table A.2.4.2. Abundance of natural spawners, estimates of the fraction of hatchery fish in natural escapements, and estimates of historical capacity of Puget Sound streams (Puget Sound TRT, unpublished data and Puget Sound co-managers).

Population	**Geometric mean natural spawners (1998-2002)**	**Arithmetic mean natural spawners (1998-2002) (min, max)**	**Geometric mean natural-origin spawners (1998-2002)**	**Average% hatchery fish in escapement[5] 1997-2001 (min, max since 1992)**	**Chinook salmon hatcheries in basin?**	**Hatchery fraction data? (years)**	**EDT estimate of historical abundance[3]**
NF Nooksack[1]	1,538	2,275 (366-4,671)	125	91 (88 –95)	Kendall (NF; rm 45)	Yes (1995-2002)	26,000
SF Nooksack[1]	338	372 (157-620)	197	40 (24 - 55)	Kendall (NF; rm 45)	Yes (1999-2002)	13,000
Lower Skagit	2,527	2,833 (1,043-4,866)	2,519	0.2 (0 – 0.7)	Marblemount (mouth of Cascade)[a]	Yes (1998-2001)	22,000
Upper Skagit	9,489	10,468 (3,586-13,815)	9,281	2 (2 – 3)	Marblemount (mouth of Cascade)[a]	Yes (1995-2000)	35,000
Upper Cascade	274	329 (83-625)	274	0.3	Marblemount (mouth of Cascade)[a]	No (assume low)	1,700
Lower Sauk	601	669 (295-1,103)	601	0	Marblemount (mouth of Cascade)[a]	Yes (2001)	7,800
Upper Sauk	324	349 (180-543)	324	0	Marblemount (mouth of Cascade)[a]	No (assumed)	4,200
Suiattle	365	399 (208-688)	365	0	Marblemount (mouth of Cascade)[a]	No (assumed)	830
NF Stillaguamish	1,154	1,172 (845-1,403)	671	40 (13 – 52)	Tribal (NF)	Yes (1988-1999)	24,000

SF Stillaguamish	270	272 (243-335)	NA	NA	Tribal (NF)	none	20,000
Skykomish	4,262	4,286 (3,455-4,665)	2,392	40 (11 - 66)	Wallace R.	Yes (1979-2001)	51,000
Snoqualmie	2,067	2,229 (1,344-3,589)	1,700	16 (5 – 72)	Wallace R.	Yes (1979-2001)	33,000
NL Washington	331	351 (227-537)	NA	NA	Lake Wash, Issaquah, UW	none	NA
Cedar	327	394 (120-810)	NA	NA	Lake Wash, Issaquah, UW	none	NA
Green	8,884	9,286 (6,170-13,950)	1,099	83 (35 -100)	Soos, Icy and Keta Cr.	Yes (1989-1997)	NA
White[2]	844	1,039 (316-2,002)	NA	NA	White R (rm 23); Voights Cr. (Carbon R), Diru (rm 5)	none	NA
Puyallup	1,653	1,679 (1,193-1,988)	NA	NA	Voights Cr. (Carbon R), Diru (rm 5)	none	33,000
Nisqually	1,195	1,221 (834-1,542)	NA	NA	Kalama, Clear Cr	none	18,000
Skokomish	1,392	1,437 (926-1,913)	NA	NA	George Adams (Purdy Cr., lower Skok)	none	NA
Dosewallips[4]	*48*	*50 (29-65)*	*NA*	*NA*	*none*	*none*	*4,700*

Duckabush[4]	*43*	*57 (20-151)*	*NA*	*NA*	*none*	*none*	*NA*
Hamma Hamma[4]	*196*	*278 (32-557)*	*NA*	*NA*	*none*	*none*	*NA*
Mid Hood Canal	311	381 (95-762)	NA	NA	none	none	NA
Dungeness[2]	222	304 (75-663)	NA	NA	Dungeness (and Hurd Cr)	none	8,100
Elwha[*6]	688	691 (633-813)	NA	NA	Tribal (rm 1) and State (rm 3.2)	none	NA

[*]2002 natural escapement data not available

[1]NF Nooksack natural escapement counts include estimated numbers of spawners from the MF Nooksack since the late 1990s and chinook salmon returning to the NF hatchery that were released back into the NF to spawn; SF Nooksack natural escapement estimates contain naturally spawning hatchery fish from the "early" and "late" run hatchery programs in the Nooksack River Basin.

[a]Previous summer-run chinook salmon hatchery program discontinued--last returns in 1996; current summer-run program (initiated in 1994) collects hatchery broodstock from spawners in upper Skagit River.

[2]Captive broodstock program for "early" run chinook salmon ended in 2000; estimates of natural spawning escapement include an unknown fraction of naturally spawning hatchery-origin fish from "late" and "early" run hatchery programs in the White and Puyallup river basins.

[3] Estimates of historical equilibrium abundance based on an EDT analysis conducted by the co-managers in Puget Sound (PSTRT 2002).

[4] The Puget Sound TRT considers chinook salmon spawning in the Dosewallips, Duckabush and Hamma Hamma rivers to be sub-populations of the same historically independent population; annual counts in those 3 streams are variable due to inconsistent visibility during spawning ground surveys.

[5]Estimates of the fraction of hatchery fish in natural spawning escapements are from the Puget Sound TRT database; Green River estimates are from Marianna Alexandersdottir, NWIFC, unpublished data.

[6]Estimates of natural escapement do not include volitional returns to the hatchery or those fish gaffed or seined from spawning grounds for broodstock collection

Trends in natural spawners

Long-term trends in abundance for naturally spawning populations of chinook salmon in Puget Sound indicate that approximately half of the populations are declining and half are increasing in abundance over the length of available time series (Table A.2.4.3; Figure A.2.4.1). The median over all populations of long-term trend in abundance is 1.0 (range 0.92 – 1.2), indicating that most populations are just replacing themselves. The most extreme declines in natural spawning abundance have occurred in the combined Dosewallips and Elwha populations over the long term. Those populations with the greatest long-term population growth rates are the North Fork Nooksack and the White. All of the populations reported above are likely to have a moderate-high fraction of naturally spawning hatchery fish, so it is not possible to say what the trends in naturally spawning, natural-origin chinook salmon might be in those populations.

Fewer populations exhibit declining trends in abundance over the short term than over the long term—4 of 22 populations in the ESU are declining from 1990-2002 (median = 1.06, range = 0.96-1.4) (Table A.2.4.3). In contrast, estimates of short-term population growth rates suggest a very different picture when the reproductive success of hatchery fish is assumed to be 1. As discussed in the *Methods* section, short-term population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally spawning hatchery fish: the reproductive success was 0 (H0), or the reproductive success was equivalent to that of natural-origin fish (H1). Short-term λ estimates assuming the reproductive success of hatchery fish was 0 are very similar to estimates of short-term trend, so they are not reported here. The median short-term λ over all populations (when the reproductive success of hatchery fish is assumed to be 1) is λ–H1 = 1.0 (range = 0.67-1.2).

The median estimate of short-term population growth would be even lower if the estimates of the fraction of naturally spawning hatchery fish were available for all populations in the ESU. As mentioned earlier, the 10 populations in the ESU for which no hatchery fraction information is available are all suspected to have a moderate-to-high fraction of hatchery-origin adults in natural escapements. In those cases where hatchery information is available and the fraction of hatchery-origin natural spawners is significant (e.g., North Fork Nooksack, Green River), the effect of the reproductive success of hatchery fish assumption on estimates of λ is dramatic. The most extreme short-term declines in natural spawner abundance have occurred in the Upper Sauk, Cedar, Puyallup, and Elwha populations. Of these populations, only the Upper Sauk is likely to have a low fraction of hatchery fish in escapements. When λ is calculated assuming the reproductive success of hatchery fish is equivalent to that of natural-origin fish, the biggest estimated short-term population declines are in the Green, Skykomish, North Fork Stillaguamish and North Fork Nooksack populations (Table A.2.4.3). Again, if hatchery fraction data were available for the additional 10 populations in the ESU for which such data are missing, more examples of significant short-term declines in population growth rate surely would emerge. The populations with the most positive short-term trends and population growth rates are the combined Dosewallips and White River populations. Both of these populations are thought to have a moderate fraction of naturally spawning hatchery fish, but since such estimates are not available, estimating the trends in natural-origin spawners is not possible.

Another indicator of the productivity of chinook salmon populations is presented in the time series figure showing the total number of spawners (natural and hatchery origin) and the number of preharvest recruits produced by those spawners against time (Figure A.2.4.2). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner. Generating this type of figure requires harvest and age structure information and therefore could be produced for only a limited number of years in some populations. Representing information this way can indicate if there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest. In most populations, the preharvest recruits exceeded spanwers in all but a few years for which data are available (Figure A.2.4.2).

Table A.2.4.3. Estimates of long- and short-term trends and the short-term median population growth rate (λ), and their 95% confidence intervals for spawners in Puget Sound chinook salmon populations (data are from the Puget Sound TRT, unpublished data). Long and short-term trends are calculated on all spawners; short-term λ is calculated assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for those populations where information on the fraction of hatchery fish in natural spawning abundance is available).

Population	**Data years**	**LT Trend (CI)**	**ST Trend (CI) (1990-2002)**	**ST λ ($\pm$ lnSE) (1990-2002)**
N. Fork Nooksack	1984-2001	1.16 (1.04-1.30)	1.42 (1.18-1.70)	0.75 (0.07)
S. Fork Nooksack	1984-2001	1.00 (0.96-1.05)	1.07 (0.98-1.15)	0.94 (0.05)
Lower Skagit	1952-2002	0.99 (0.97-1.00)	1.06 (0.94-1.18)	1.05 (0.09)
Upper Skagit	1952-2002	1.00 (0.99-1.01)	1.06 (0.98-1.14)	1.05 (0.06)
Upper Cascade	1984-2002	1.04 (1.00-1.08)	1.05 (0.98-1.14)	1.06 (0.05)
Lower Sauk	1952-2002	0.99 (0.98-1.00)	1.03 (0.91-1.17)	1.01 (0.12)
Upper Sauk	1952-2002	0.97 (0.96-0.99)	0.97 (0.89-1.06)	0.96 (0.06)
Suiattle	1952-2002	0.99 (0.98-0.99)	1.00 (0.92-1.08)	0.99 (0.06)
N. Fork Stillaguamish	1974-2002	1.01 (0.99-1.03)	1.06 (1.01-1.11)	0.92 (0.04)
S. Fork Stillaguamish[1]	1974-2002	1.02 (1.00-1.04)	1.00 (0.97-1.02)	0.99 (0.02)
Skykomish	1965-2002	0.99 (0.98-1.00)	1.07 (1.03-1.11)	0.87 (0.03)
Snoqualmie	1965-2002	1.03 (1.01-1.04)	1.10 (1.01-1.21)	1.00 (0.04)
N. Lake Washington[1]	1983-2002	0.97 (0.91-1.03)	1.04 (0.91-1.19)	1.07 (0.07)
Cedar[1]	1965-2002	0.97 (0.95-0.98)	0.97 (0.89-1.07)	0.99 (0.07)
Green[1]	1968-2002	1.02 (1.01-1.04)	1.05 (0.98-1.13)	0.67 (0.06)

White[1]	1970-2002	1.05 (1.00-1.10)	1.14 (1.06-1.22)	1.16 (0.06)
Puyallup[1]	1968-2002	1.02 (1.00-1.04)	0.96 (0.91-1.02)	0.95 (0.06)
Nisqually[1]	1968-2002	1.02 (0.99-1.05)	1.06 (0.93-1.20)	1.04 (0.07)
Skokomish[1]	1987-2002	0.99 (0.93-1.05)	1.04 (0.97-1.12)	1.04 (0.04)
Combined Dosewallips[1]	1968-2002	0.96 (0.93-0.98)	1.11 (0.99-1.20)	1.17 (0.10)
Dungeness[1]	1986-2002	1.02 (0.94-1.10)	1.07 (0.94-1.20)	1.09 (0.11)
Elwha[1]	1986-2001	0.92 (0.84-1.00)	0.97 (0.86-1.10)	0.95 (0.11)

[1]Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.

Updated threats information

The Puget Sound TRT (unpublished data) has estimated adult equivalent exploitation rates for each population of chinook salmon in the ESU (Table A.2.4.4). Exploitation rates are the proportion of the returning population that are caught in fisheries or are killed as a result of fishing activities (e.g., non-retention mortality). These harvest estimates include mortality from sport and commercial fisheries in the ocean, Puget Sound, and in rivers. Exploitation rate estimates are a function of coded-wire tag (i.e., CWT) recoveries, escapement estimates, and estimates of incidental mortalities provided by the Chinook Technical Committee (CTC 2001). These harvest rates are equivalent to exploitation rates provdied by the CTC, but they are different from exploitation rates estimated by the FRAM model.

Exploitation rates on Puget Sound chinook salmon populations averaged 75% (median = 85%; range 31-92%) in the earliest 5 years of data availability and have dropped to an average of 44% (median = 45; range 26-63%) in the most recent 5-year period.

Table A.2.4.4. Estimated brood-year adult-equivalent exploitation rates on populations of Puget Sound chinook salmon (Puget Sound TRT unpublished data).

Population	**Data years (brood year)**	**Earliest 5-year mean exploitation rate (%)**	**Most recent 5-year mean exploitation rate (%)**
N. Fork Nooksack	1982 - 1998	43	26
S. Fork Nooksack	1982 - 1998	44	26
Lower Skagit[1]	1969 - 1998	86	61
Upper Skagit[1]	1969 - 1998	88	63
Upper Cascade[1]	1982 - 1998	80	56
Lower Sauk[1]	1969 - 1998	88	63
Upper Sauk[1]	*1979 - 1998*	*72*	*56*
Suiattle[1]	1979 - 1998	73	58
N. Fork Stillaguamish	1972 - 1998	89	40
S. Fork Stillaguamish	1972 - 1998	89	40

Skykomish	1969 - 1998	86	49
Snoqualmie	1969 - 1998	85	45
N. Lake Washington	1981 - 1998	40	27
Cedar	1969 - 1998	52	31
Green	1969 - 1998	82	57
White	1972 - 1998	90	26
Puyallup	1971 - 1998	53	30
Nisqually	1977 - 1998	92	62
Skokomish	1985 - 1998	90	31
Dosewallips	1985 - 1998	92	38
Dungeness	1984 - 1998	31	32
Elwha	1984 - 1998	64	44

[1]The population-specific harvest rates for the Skagit River Basin are in dispute; Puget Sound TRT, NOAA Fisheries Northwest Regional Office, and the Puget Sound co-managers are working to resolve different estimates resulting from the Pacific Salmon Commission (Chinook Technical Committee) and the FRAM model.

The Puget Sound TRT (unpublished data) has amassed estimates of the total number of hatchery-origin chinook salmon returning to streams (Table A.2.4.5). These estimates for each population include the total return—returns to natural spawning grounds and to hatchery racks within a population's geographic boundaries. These estimates do not account for possible strays of hatchery fish from outside the population's boundaries. It is apparent from Table A.2.4.5 that even populations of chinook salmon in northern Puget Sound (not a hatchery production management area for co-managers) receive significant numbers of adult hatchery fish returning each year. The numbers of hatchery-origin juvenile chinook salmon released into Puget Sound streams each year also are reported in Table A.2.4.5. Average annual numbers of juvenile releases have declined since the time of the last Status Review (1990-1994 vs. 1995-2001) in the Nooksack, Skagit and Green river basins, and releases have remained roughly the same in the north Lake Washington/Cedar, White/Puyallup and in south Puget Sound streams. In contrast, juvenile chinook salmon releases have increased in the Snohomish and Elwha river basins, in eastern Kitsap streams, and in Hood Canal. With the exception of the Skagit and Stillaguamish river basins, all major watersheds in Puget Sound receive annual releases of over a million (close to 7 million in Hood Canal) juvenile chinook salmon. Hatchery stocks of chinook salmon in Puget Sound have been categorized (SSHAG 2003) and are provided in Appendix A.5.1.

Table A.2.4.5. Total estimated recent annual average returns of hatchery-produced chinook salmon (adults returning to hatchery racks and to spawning grounds) and total releases of juvenile chinook salmon in streams containing independent populations of chinook salmon in Puget Sound (Puget Sound TRT and B. Waknitz, unpublished data).

Population	**Average annual return to stream 1987–2001 (min-max)[1]**	**Previous (1990-1994) average annual releases of chinook salmon hatchery juveniles by life-stage (in thousands)**		**Most recent (1995-2001) average annual releases of chinook salmon hatchery juveniles by life-stage (in thousands)**
N. Fork Nooksack	1,720 (0 – 9,179)	5,500 (4,763 fall; 737 spring/summer)		3,081 fall
S. Fork Nooksack	1,254 (0 – 5,515)			
Lower Skagit	1,171 (70 – 4,110)	2,251 (1,292 fall; 491 spring, 468 summer)		754 (32 fall; 423 spring; 299 summer)
Upper Skagit				
Upper Cascade				
Lower Sauk				
Upper Sauk				
Suiattle				
N. Fork Stillaguamish	318 (2 – 777)	NA		178 summer
S. Fork Stillaguamish[2]	NA			
Skykomish	3,666 (824 – 8,530)	1,926 (1,316 fall; 610 summer)		2,574 (1,401 fall; 1,173 summer)
Snoqualmie	2,921 (19 – 6,514)			
N. Lake Washington[2]	NA	2,349 fall		2,077 fall
Cedar	NA			
Green	13,565 (3,211 – 23,014)	4,413 fall		3,681 fall
White[2]	NA	1,686 (1,672 fall, 14 spring)	70 fall in South Sound general	1,695 (1,669 fall; 26 spring)
Puyallup[2]	2,048 (762 – 3,484)			
Nisqually[2]	2,559 (0 – 13,481)	NA		NA
Misc. south Puget Sound streams	NA	6,947 fall		6,411 fall
Eastern Kitsap streams	NA	2,851(2,519 fall; 332 spring)		3,771 (3,447 fall; 324 spring)
Skokomish[2]	3,621 (294 – 8,816)	4,928 (4,637 fall; 291 spring)		6,856 (6,793 fall; 63 spring)
Comb.Dosewallips[2]	NA			
Dungeness[2]	NA	NA		1,283 spring
Elwha	634 (97 – 2,089)	1,831 fall		2,482 fall

[1]Hatchery rack-return data are not available for all streams.
[2]Estimates of hatchery-origin chinook salmon returning to spawn are not available.

A.2.4.3. Comparison with Previous Data

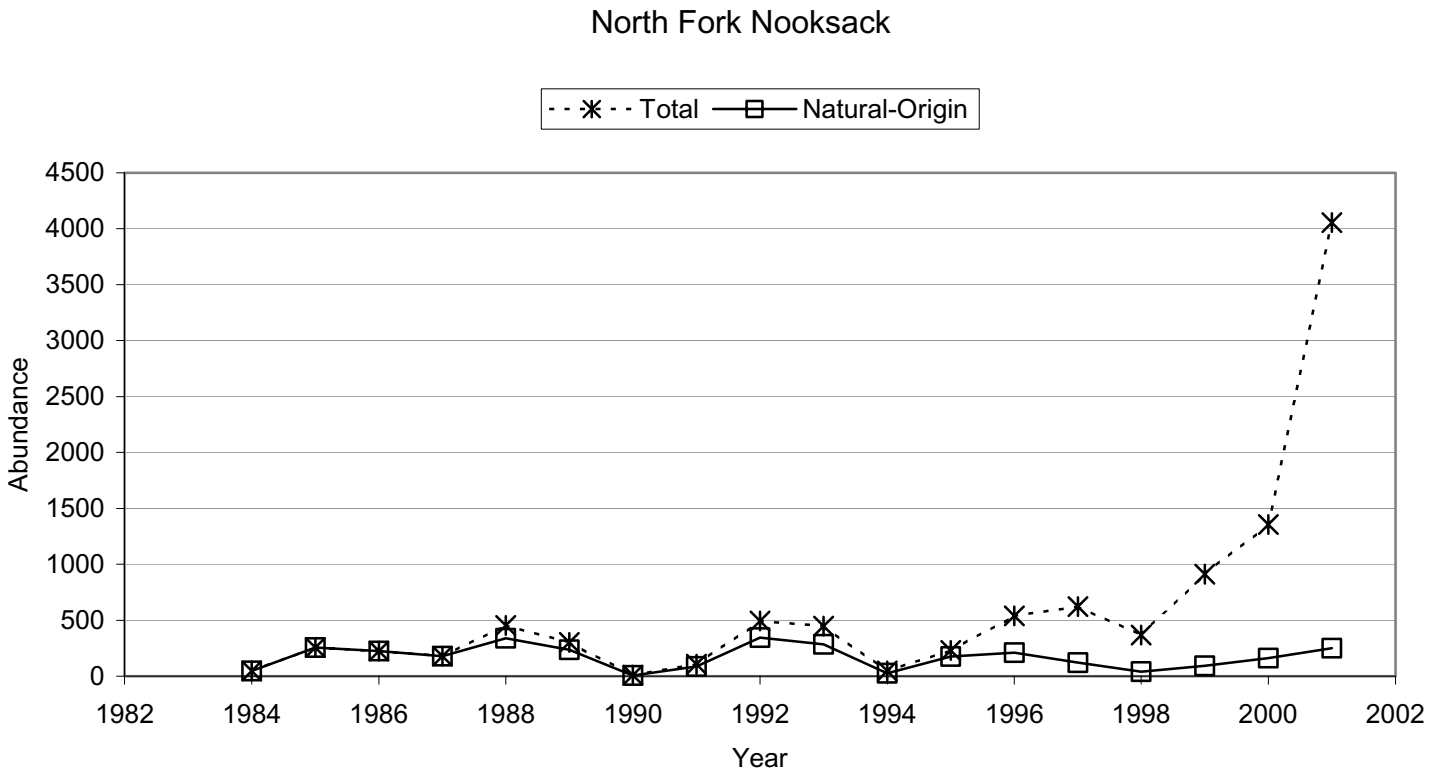
Overall, the natural spawning escapement estimates for Puget Sound chinook salmon populations are improved relative to those at the time of the previous status review of Puget Sound chinook salmon conducted with data through 1997. The differences between population escapement estimates between the previous status assessments using data from 1997 and the present assessment using data through 2002 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 5 years. The median across populations of the most recent 5-year geometric mean natural escapement for the same 22 populations through 1997 was N = 438 (compared to N = 771 through 2002), and the range was 1-5,400. As was the case at the time of the previous status review, it is not possible to determine the status of the natural-origin, natural spawners in half of the populations of chinook salmon in Puget Sound. The most dramatic change in recent natural escapement estimates from the previous status assessment was in the Green River—the recent natural-origin escapement estimate is lower than the previous one by almost 5,000 spawners. This apparent drop in natural escapement is probably due primarily to new information about the fraction of hatchery fish that are spawning naturally.

Throughout the ESU, the estimates of trends in natural spawning escapements for Puget Sound chinook salmon populations are similar to the previous status review of Puget Sound chinook salmon conducted with data through 1997. Some populations exhibit improvements in trends relative to the last status assessment, and others show more significant declines. As stated above for escapement estimates, the differences in trend estimates between the previous status assessments using data from 1997 and the present assessment using data through 2002 could be due to (1) revised pre-1997 data, (2) differences in which fish are counted as part of a population, (3) new information on the fraction of natural spawners that are hatchery fish, or (4) true differences reflected in new data on natural spawners obtained over the most recent 5 years. The median across populations of the long-term trend in natural spawners was a 1.1% decline per year through 1997, compared to a median estimate indicating a flat trend through 2002. Twelve populations had declining long-term trends through 1997, and 10 populations have declining long-term trends through 2002. Short-term trends are generally more positive in recent years—the median trend across 22 populations through 1997 was a 4% decline per year, and the median trend through 2002 was a 1.1% increase per year. Fourteen populations showed declining short-term trends at the time of the previous status reviews, and only four populations exhibit declining short-term trends in recent years. Nevertheless, as stated above for interpreting abundance estimates, we lack information on the fraction of naturally spawning, hatchery-origin fish for 10 of the 22 populations of chinook salmon in Puget Sound, so our understanding of the trend in natural-origin spawners among populations across the ESU is incomplete. An illustration of how misleading trend estimates on total natural spawners can be for estimating trends in natural-origin spawners can be found comparing the λ calculations assuming naturally spawning hatchery fish do (i.e., λ –H1) or do not (i.e., λ –H0) contribute naturally spawning offspring. For those 12 populations with information on the hatchery fraction of natural spawners in the ESU, 7 populations switched from an estimated positive short-term population growth rate to a negative one when hatchery fish were assumed to contribute naturally spawning offspring.

The spatial distribution of chinook salmon populations with a strong component of natural-origin spawners in the Puget Sound ESU has not changed since the time of the last status assessment. Populations containing significant numbers of natural-origin spawners whose status can be reliably estimated occur in the Skagit River Basin, the South Fork Stillaguamish, and the Snohomish River Basin. The remaining populations in mid- and south Puget Sound, Hood Canal and out the Strait of Juan de Fuca have significant (but non-quantifiable) fractions of hatchery-origin spawners, so their contribution to spatial structure in the ESU is not possible to estimate.

The change in diversity in the ESU from historical conditions also has not changed since the last status review. An estimated 31 independent populations of chinook salmon occurred historically in the ESU, and 22 remain extant. All but one of the 9 putatively extinct chinook salmon stocks is an early-run population (or component of a population). The loss of early-run chinook salmon stocks in Puget Sound represents an important loss of part of the evolutionary legacy of the historical ESU.

Figure A.2.4.1. Total and natural-origin spawner abundance estimates vs. year for populations of the Puget Sound chinook ESU.



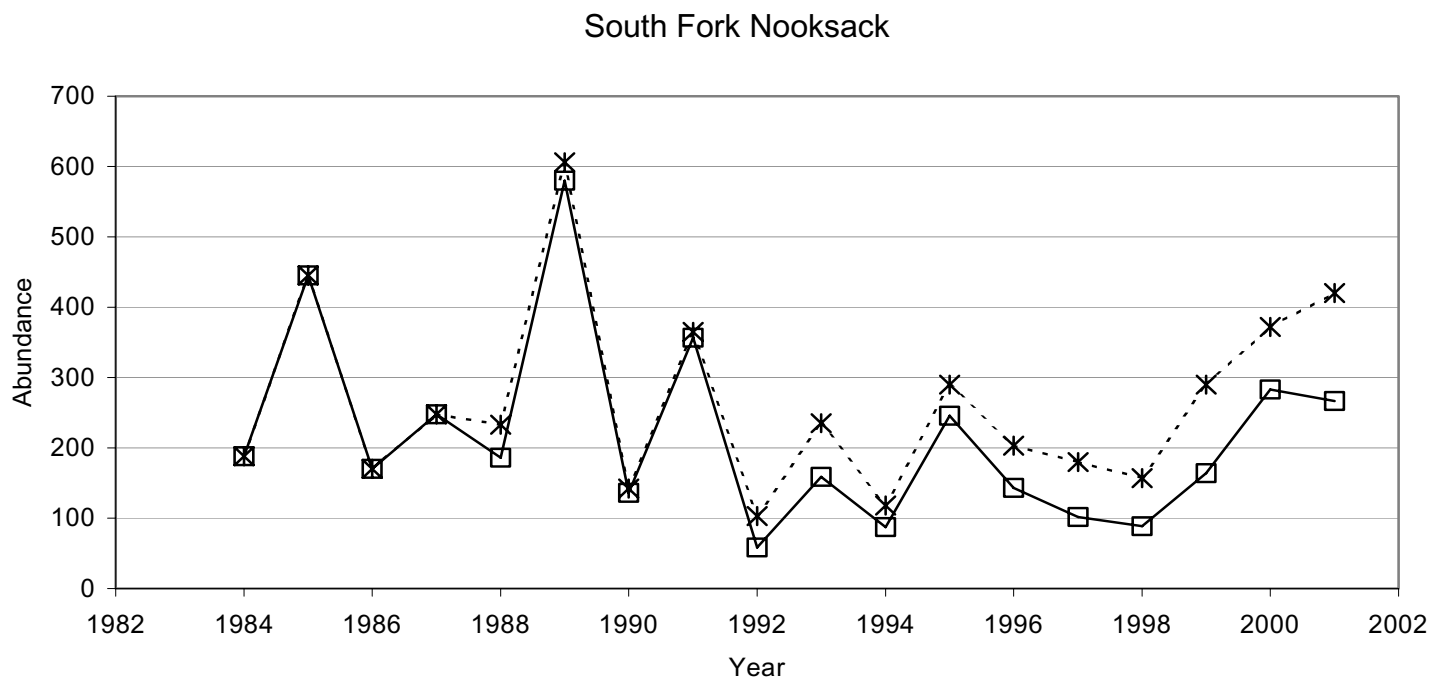
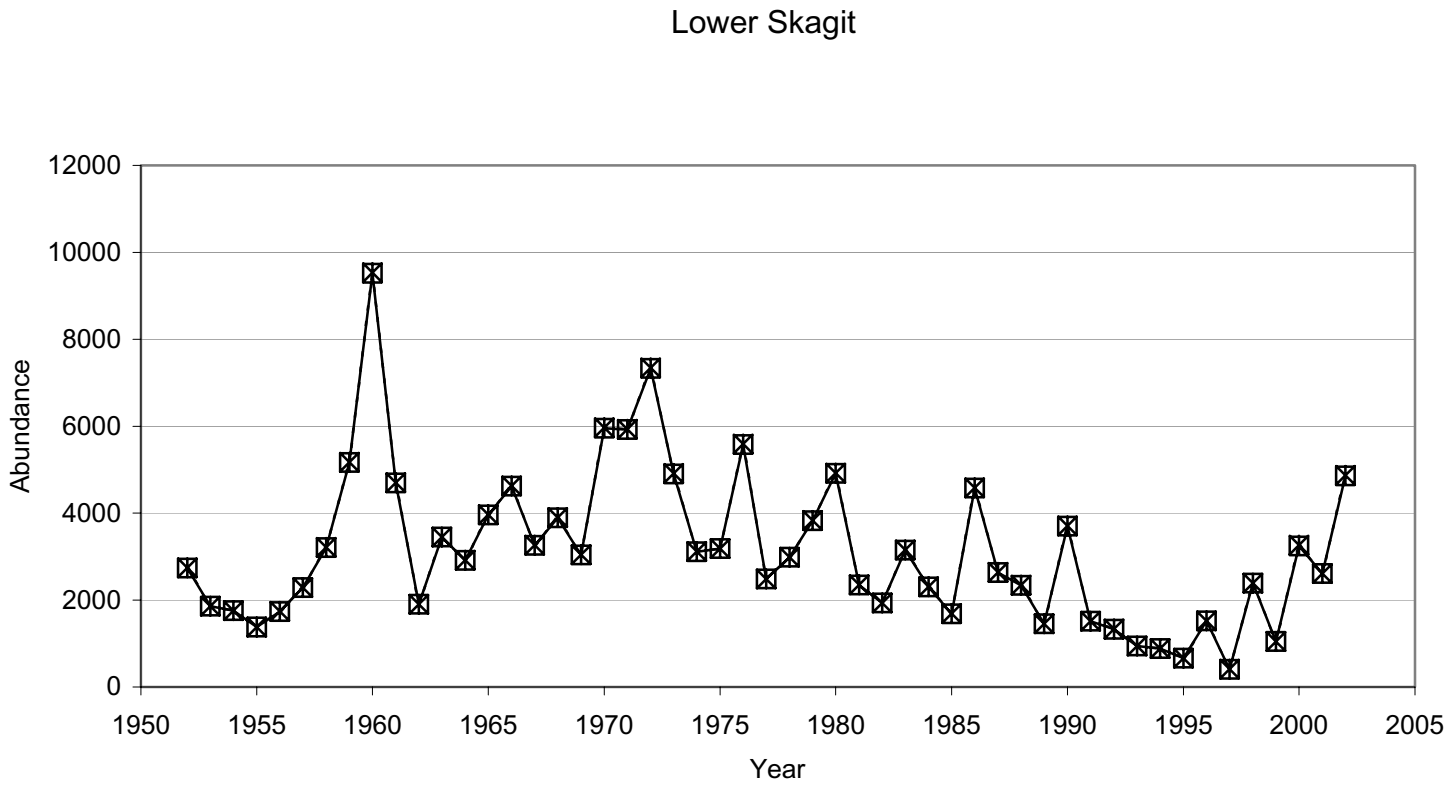


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



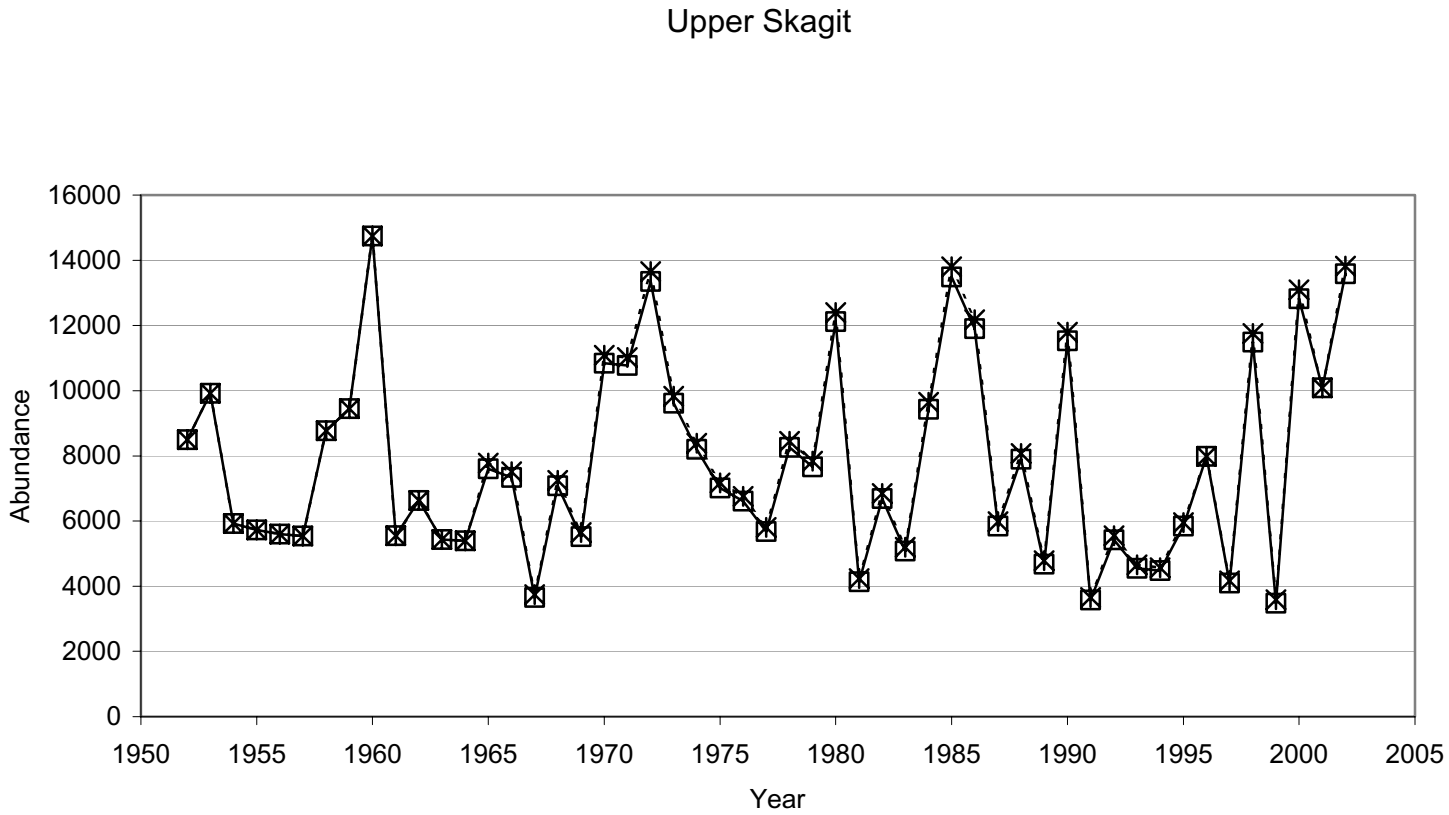
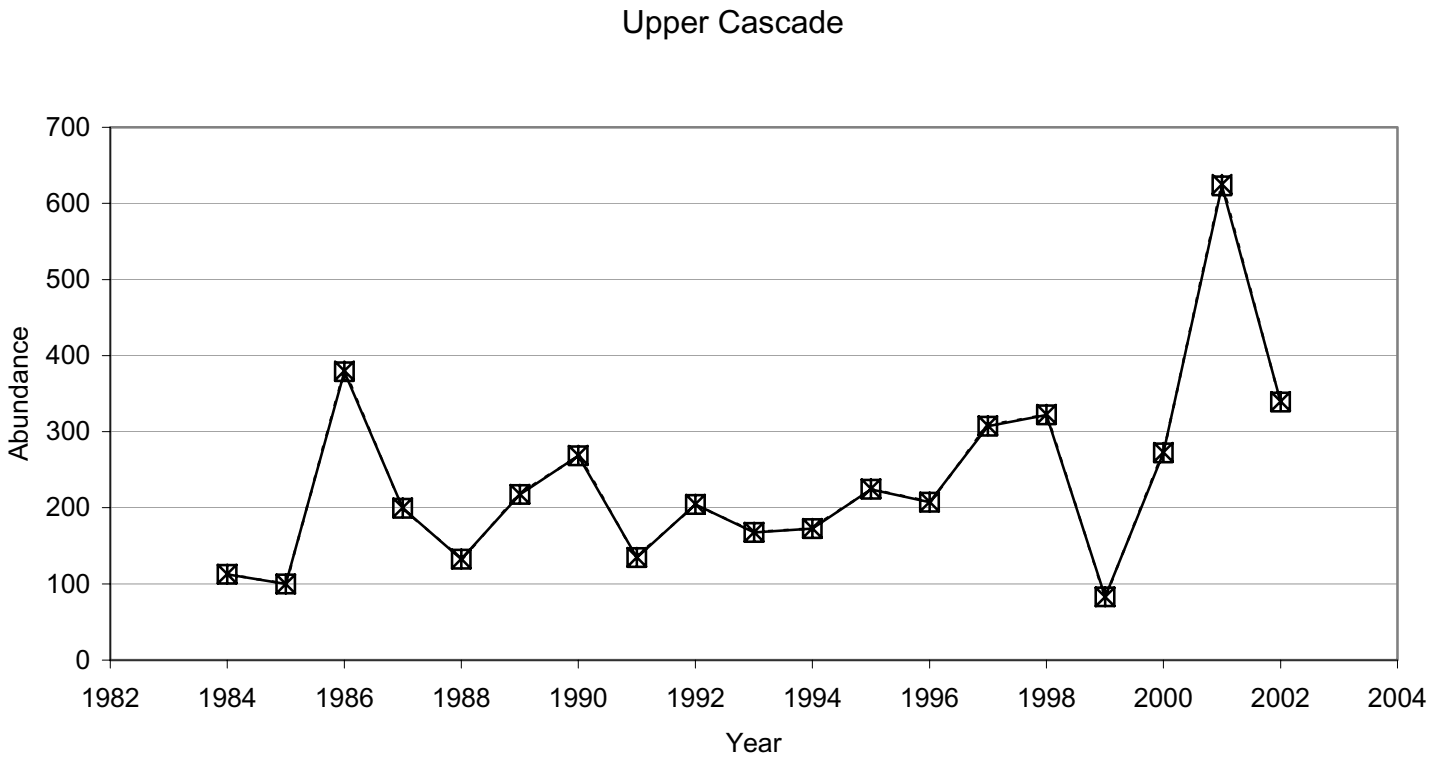


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



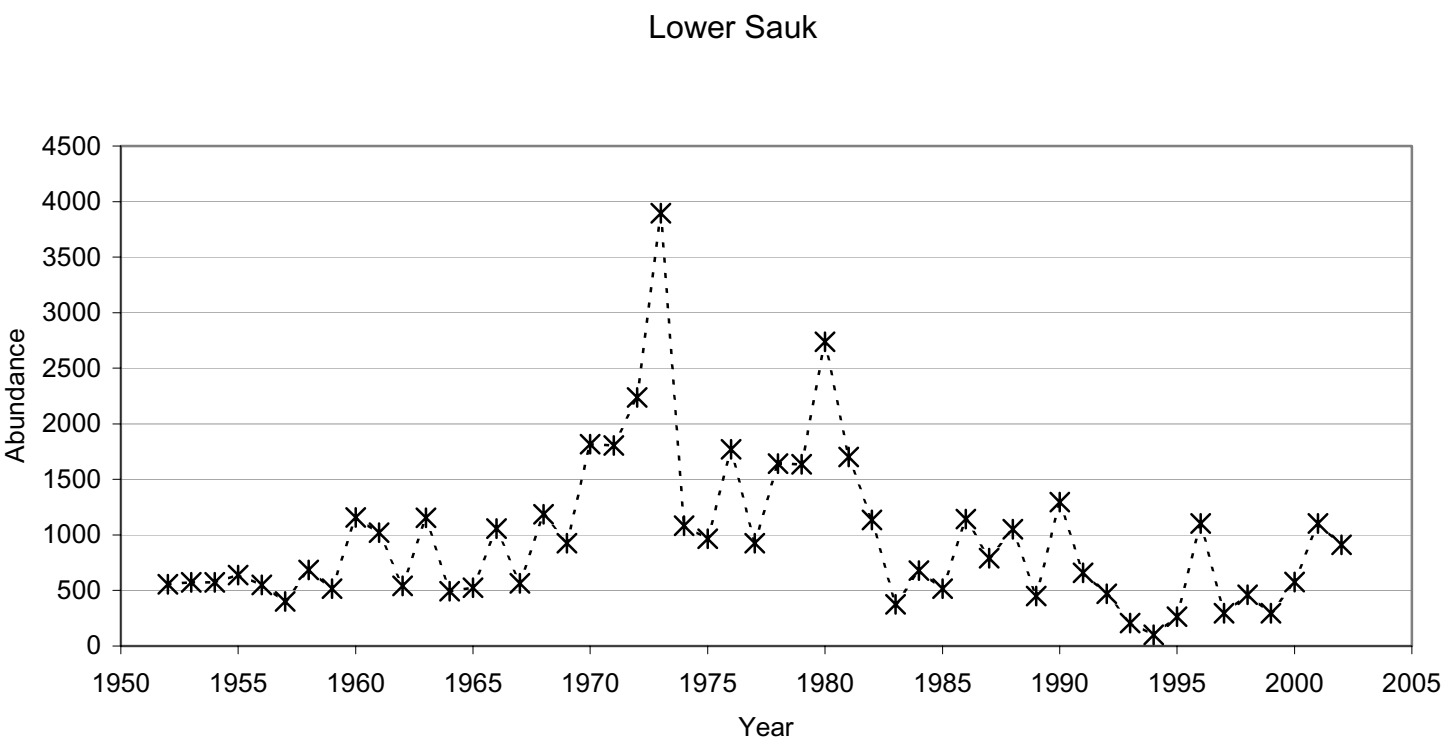
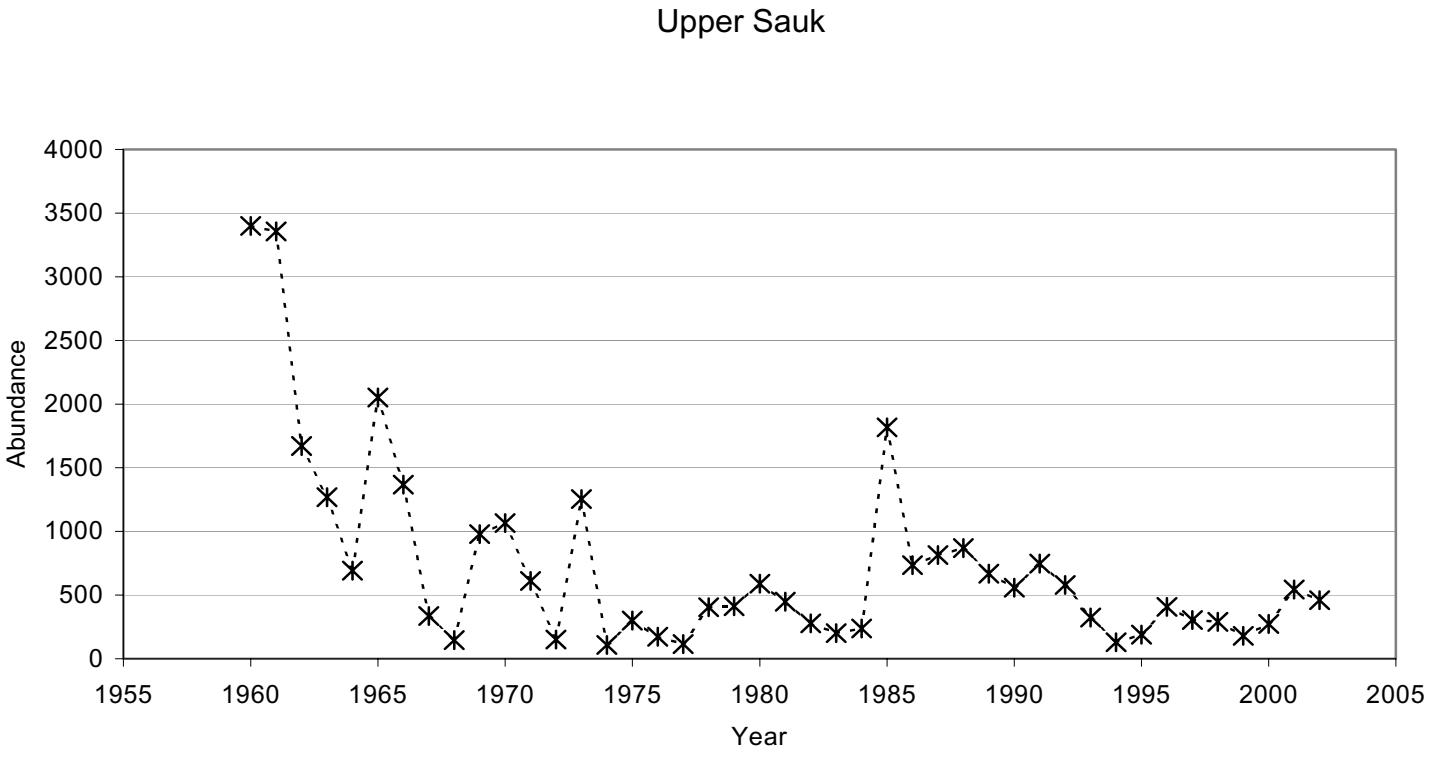


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



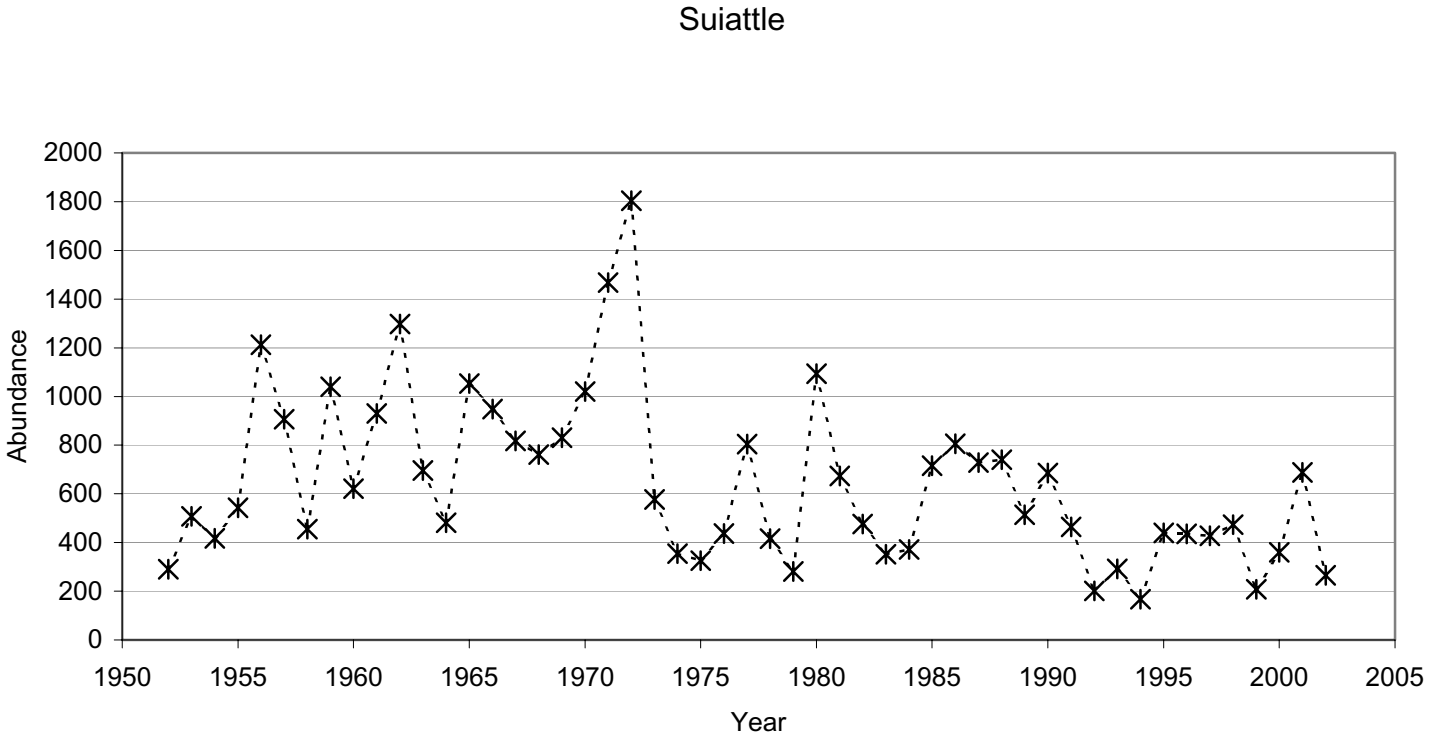
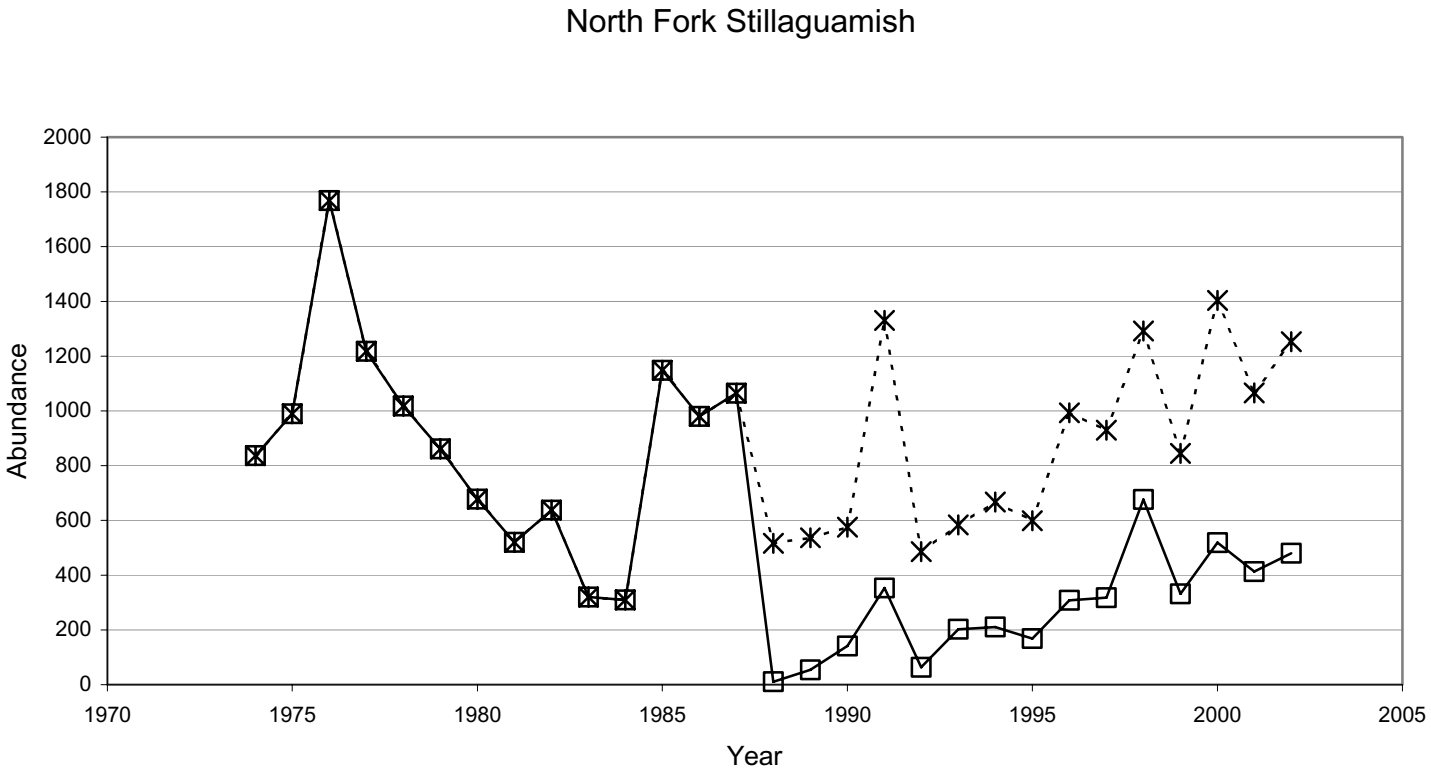


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



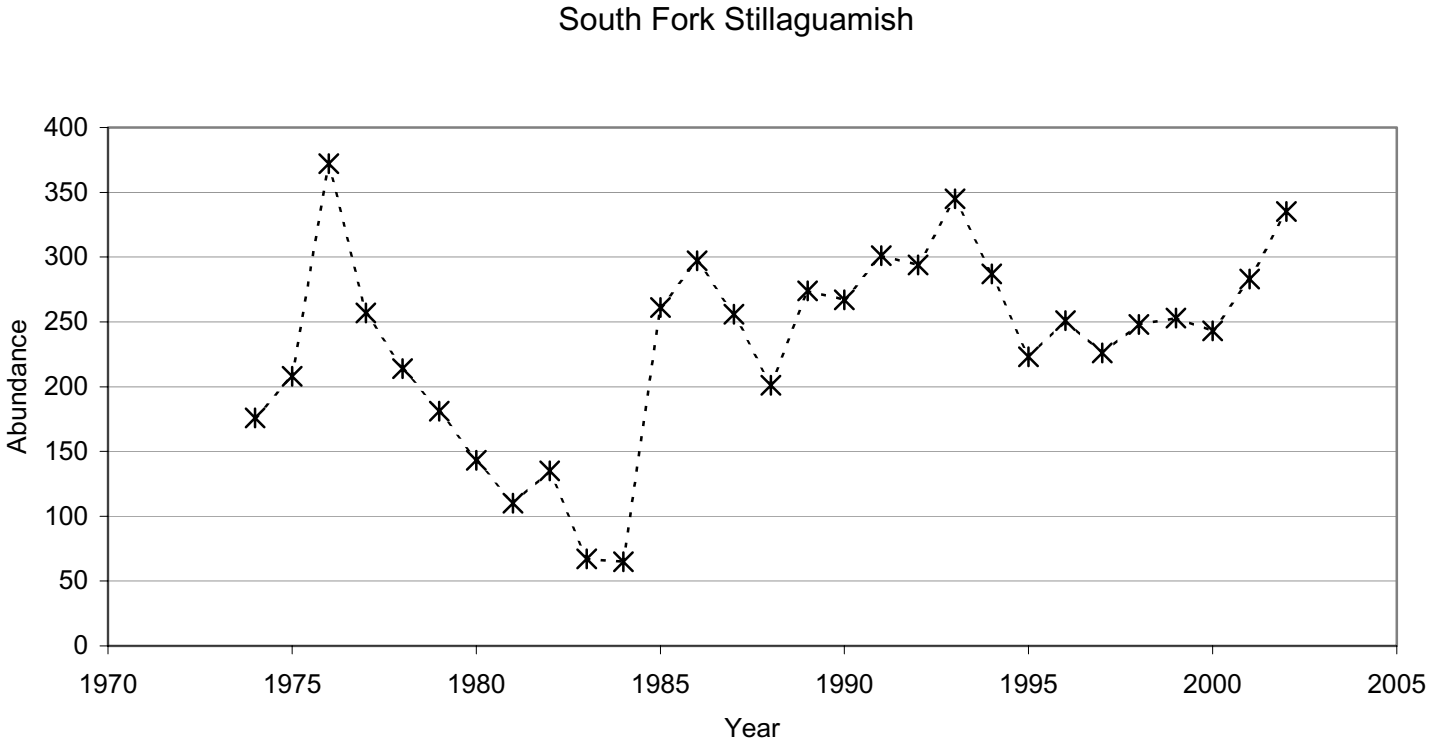
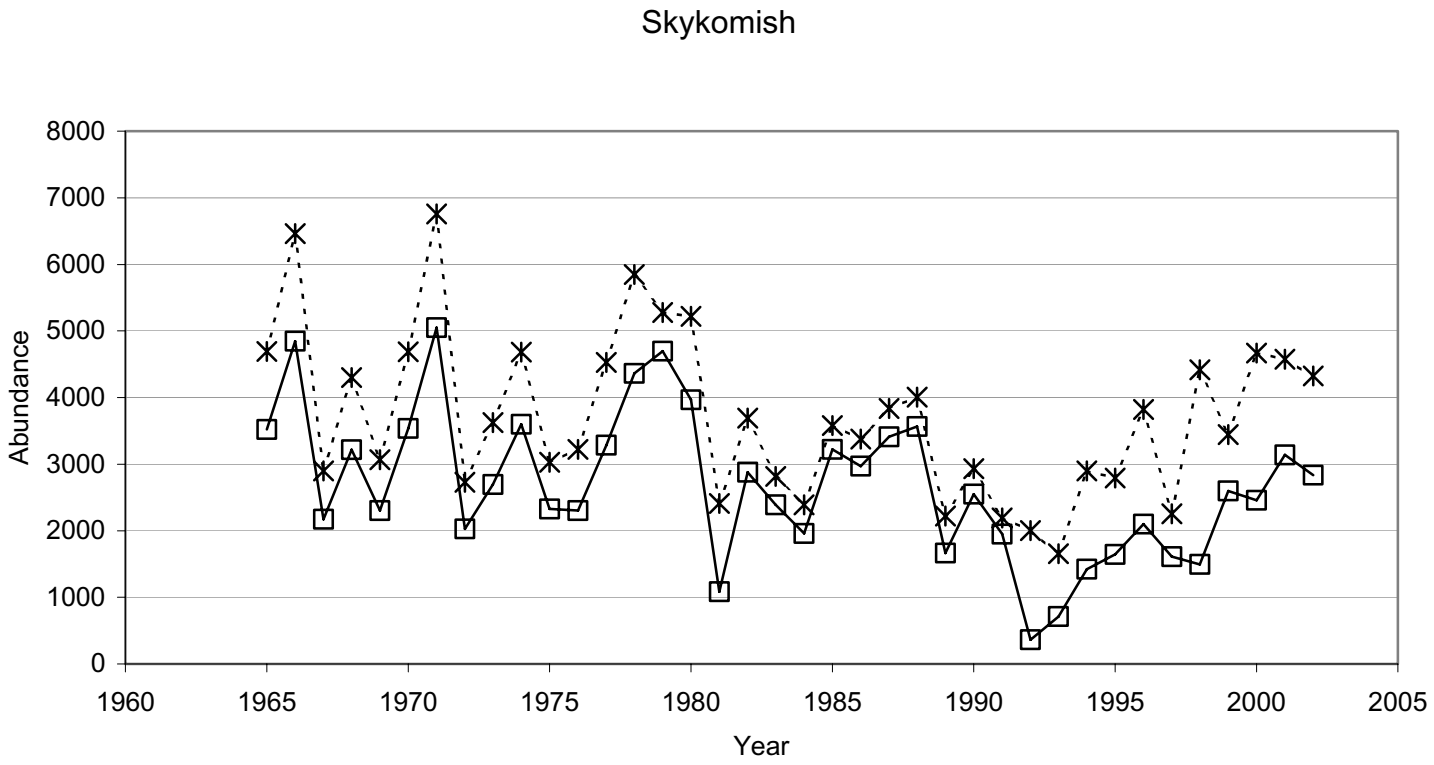


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



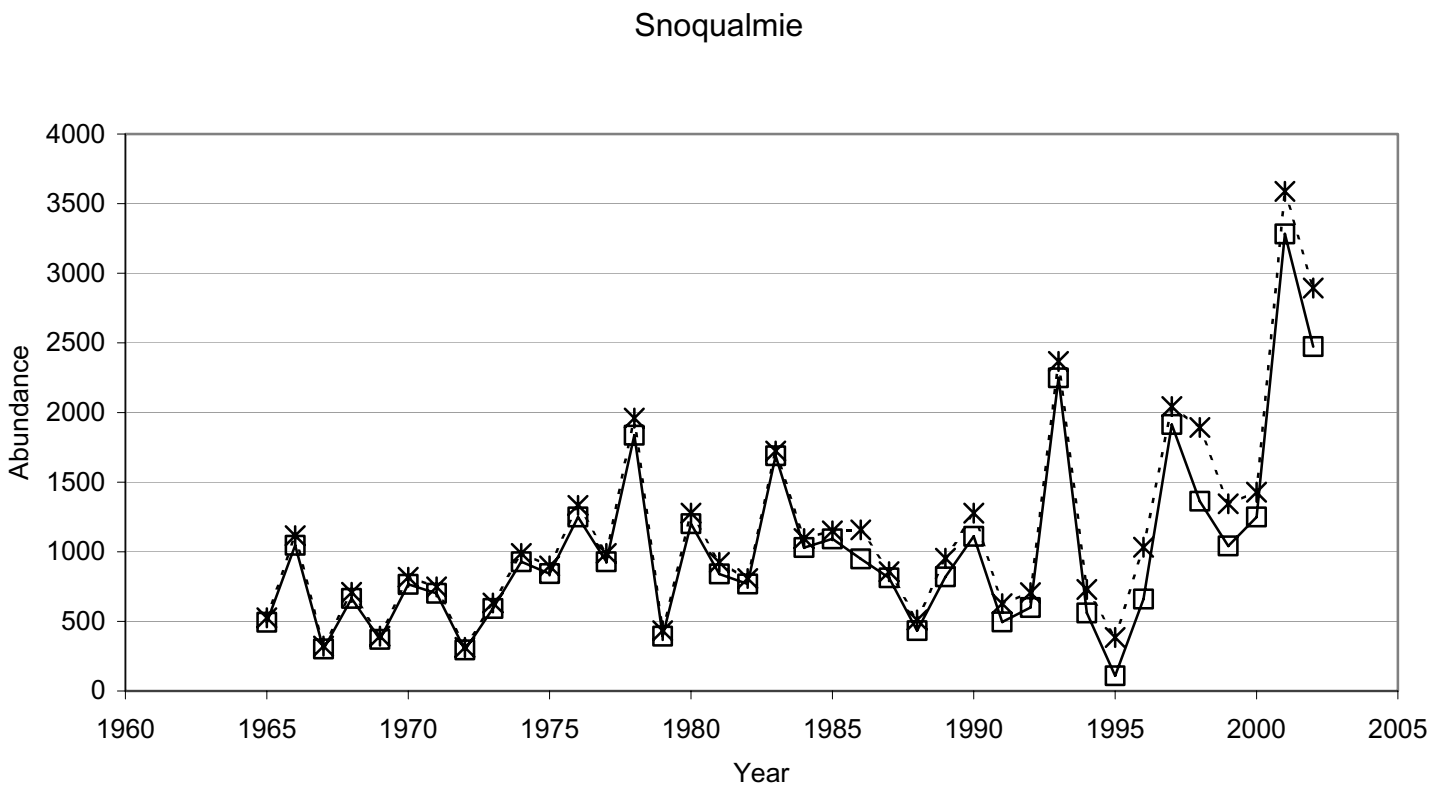
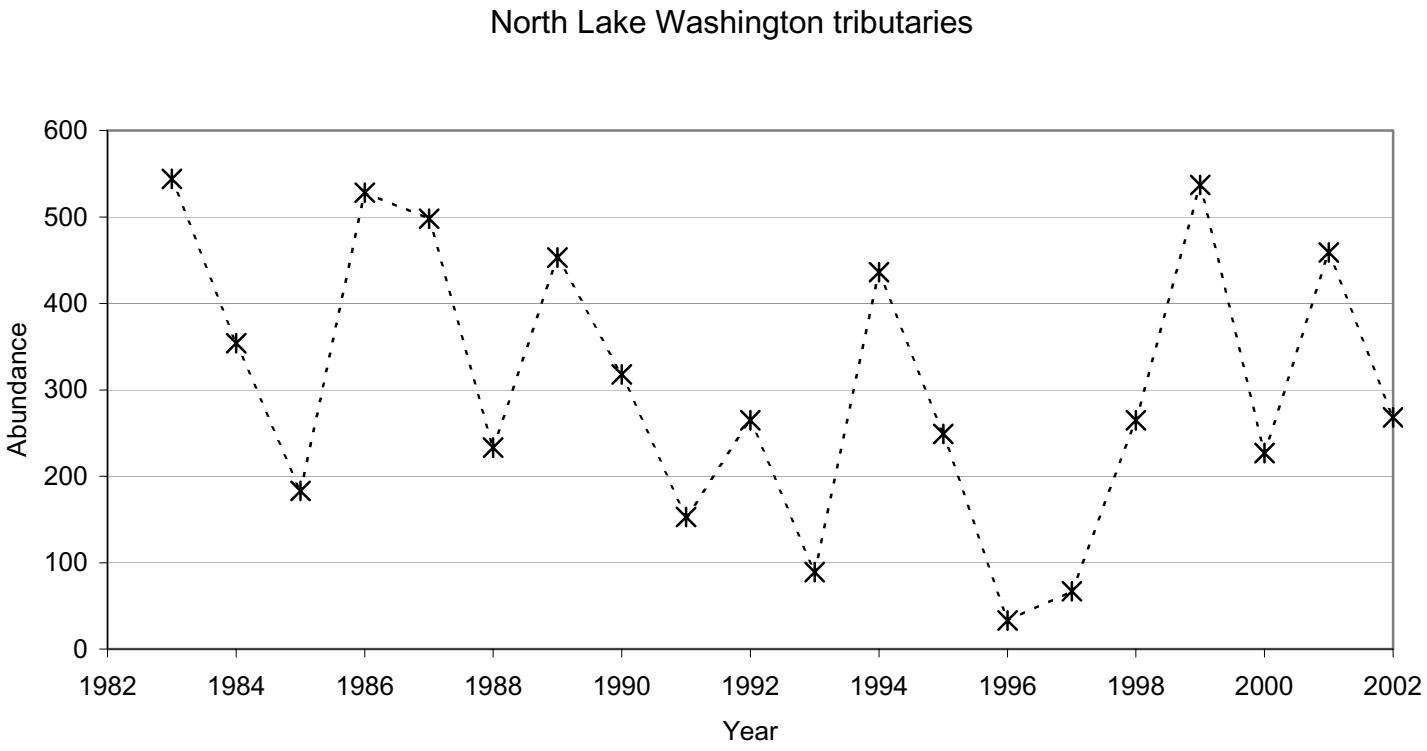


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



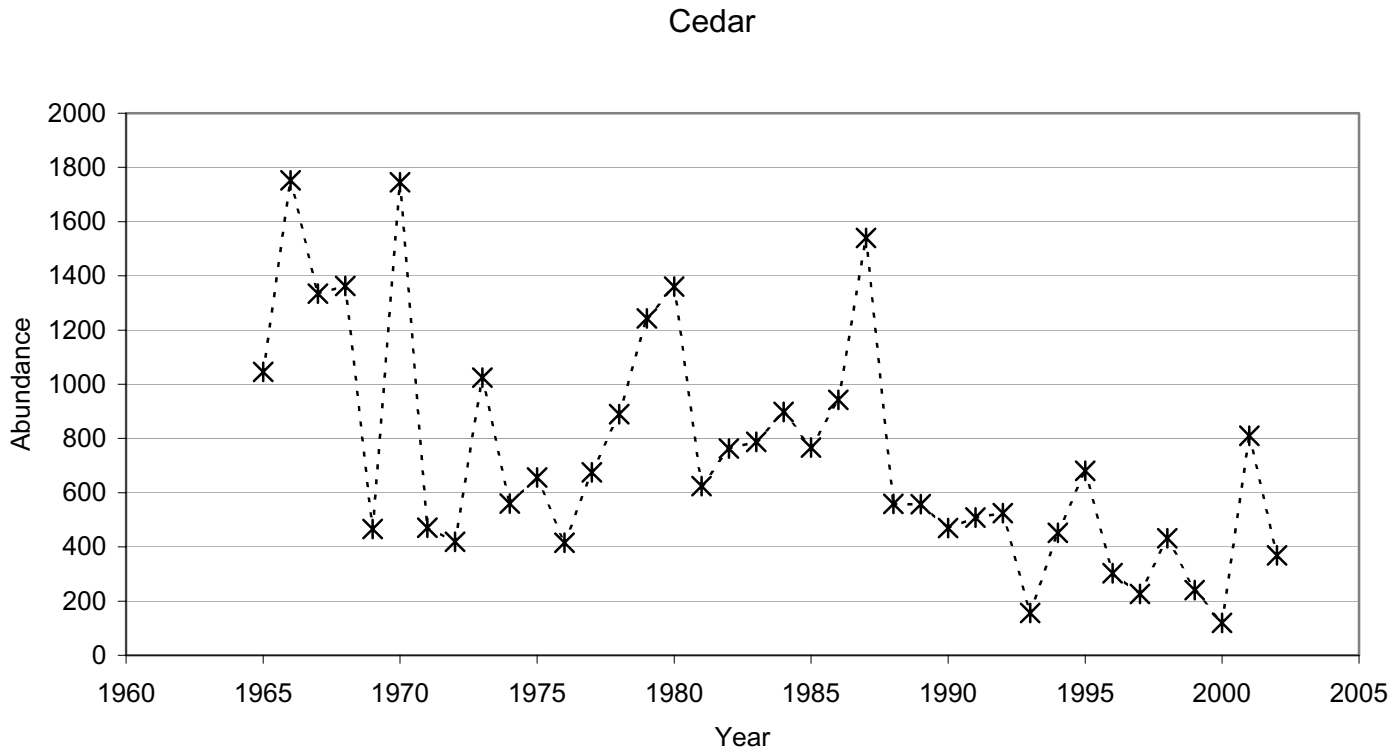
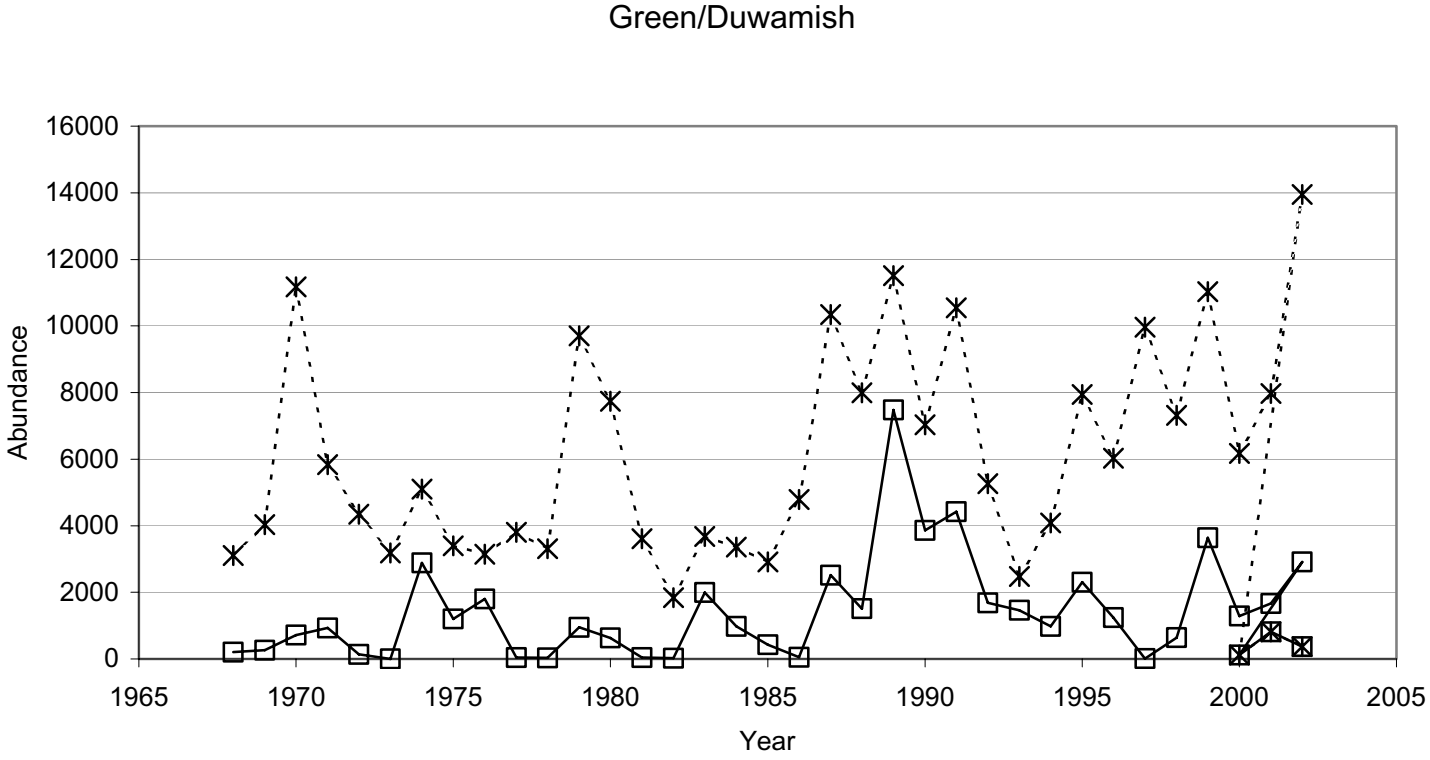


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



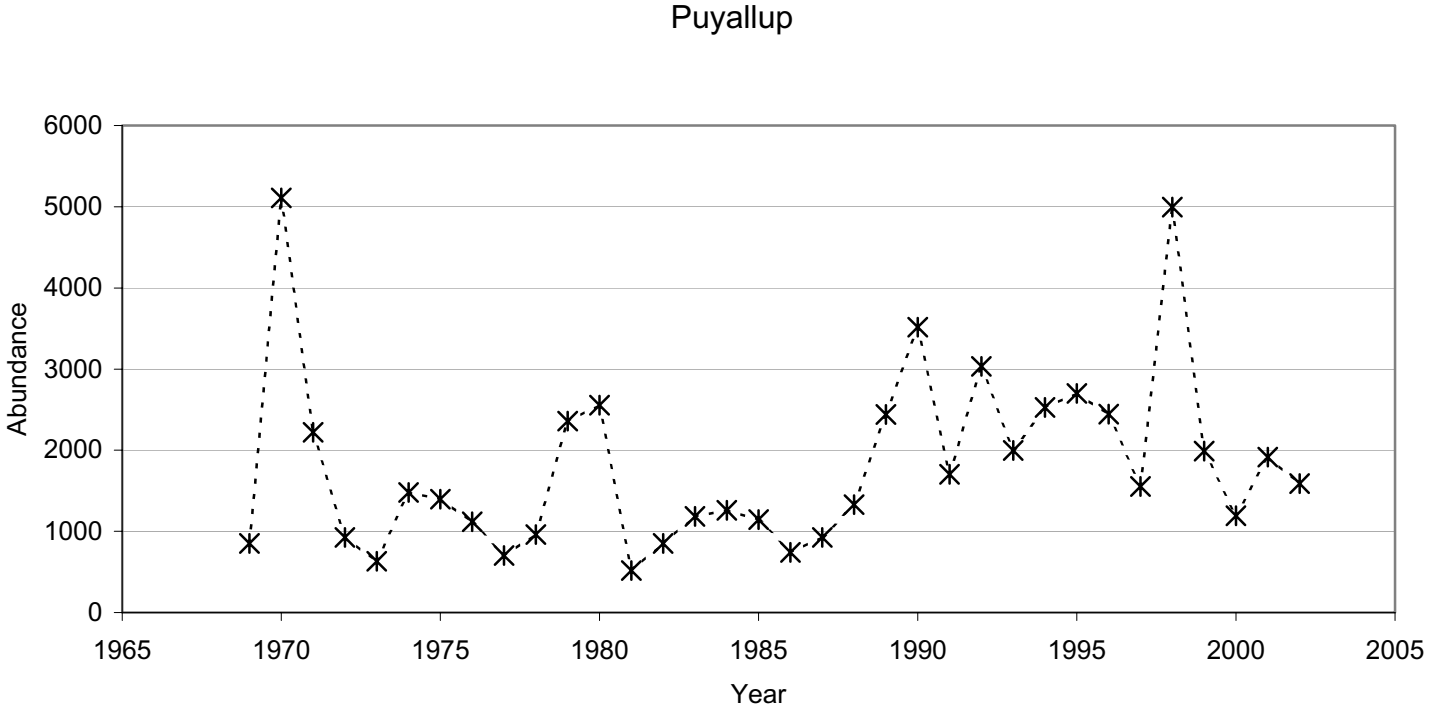
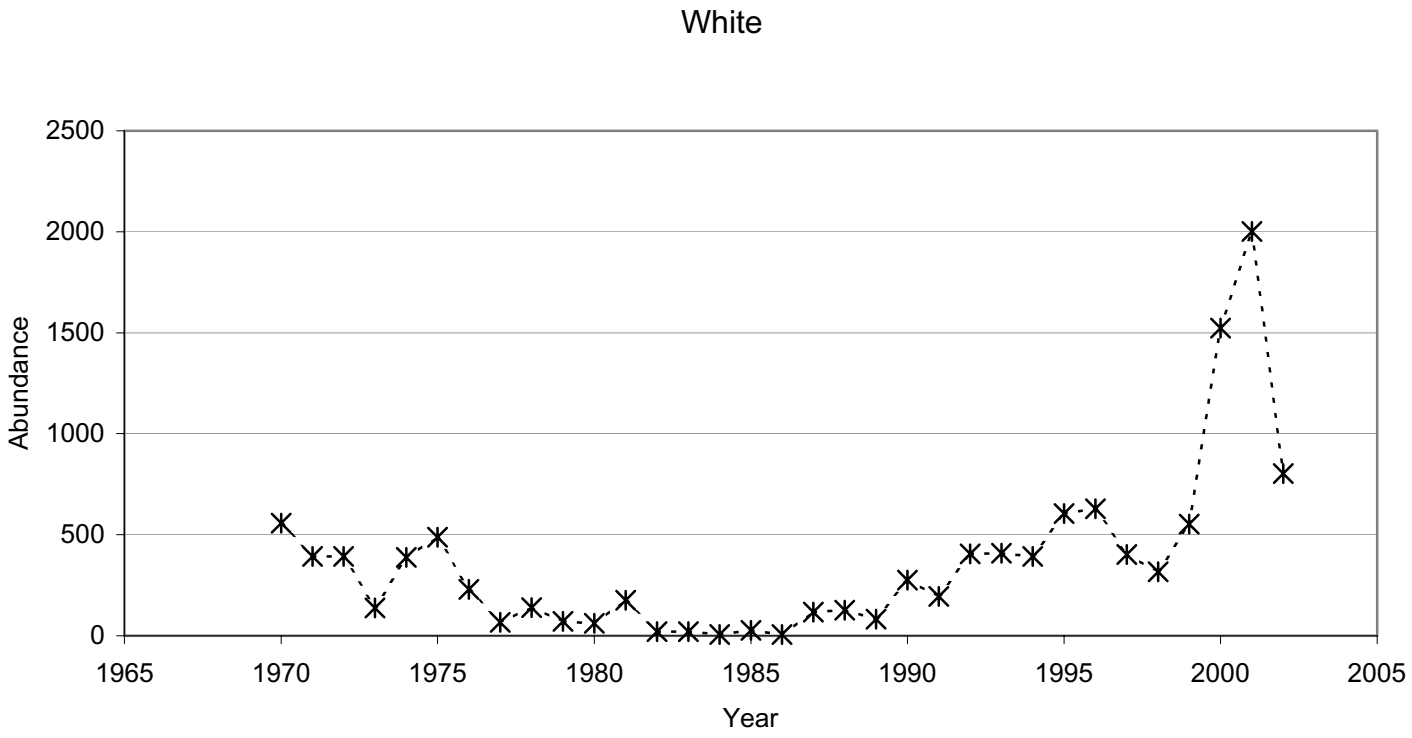


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



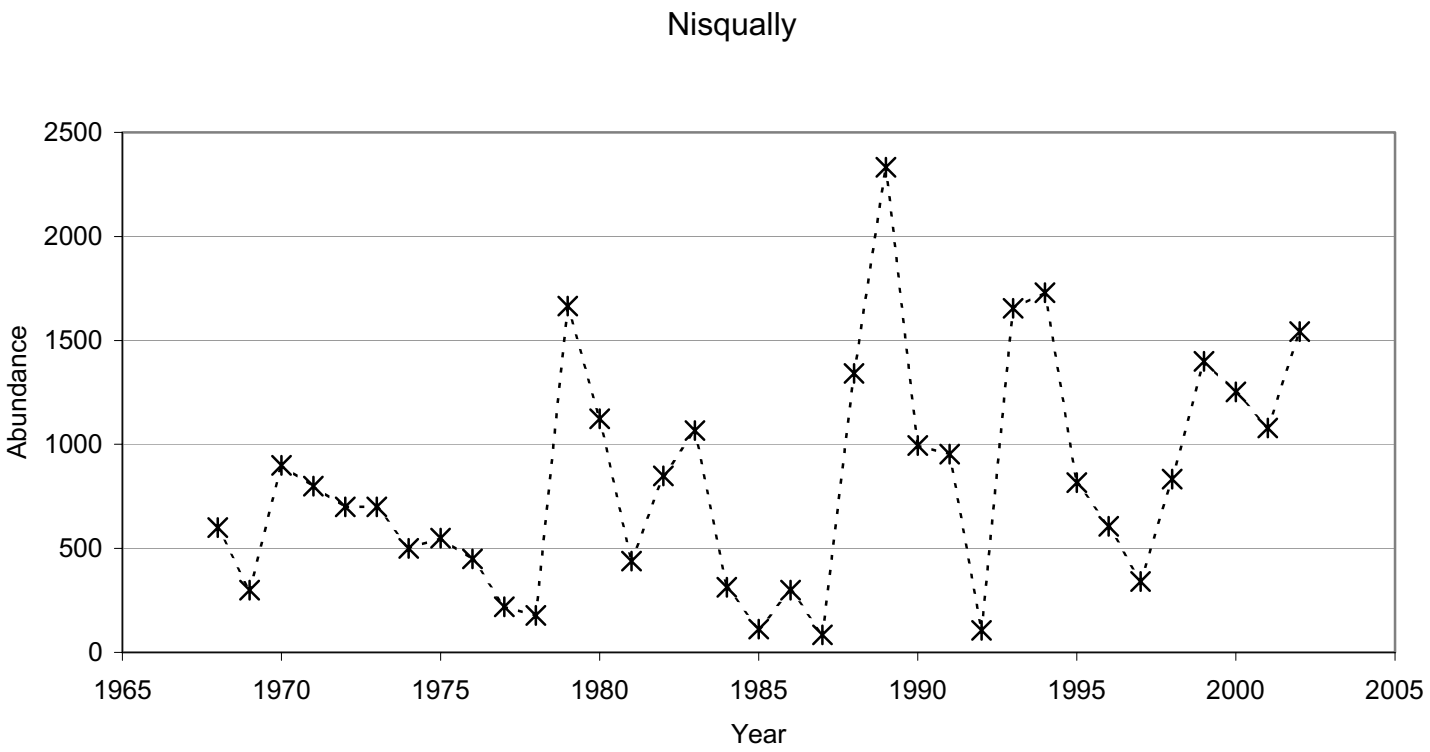
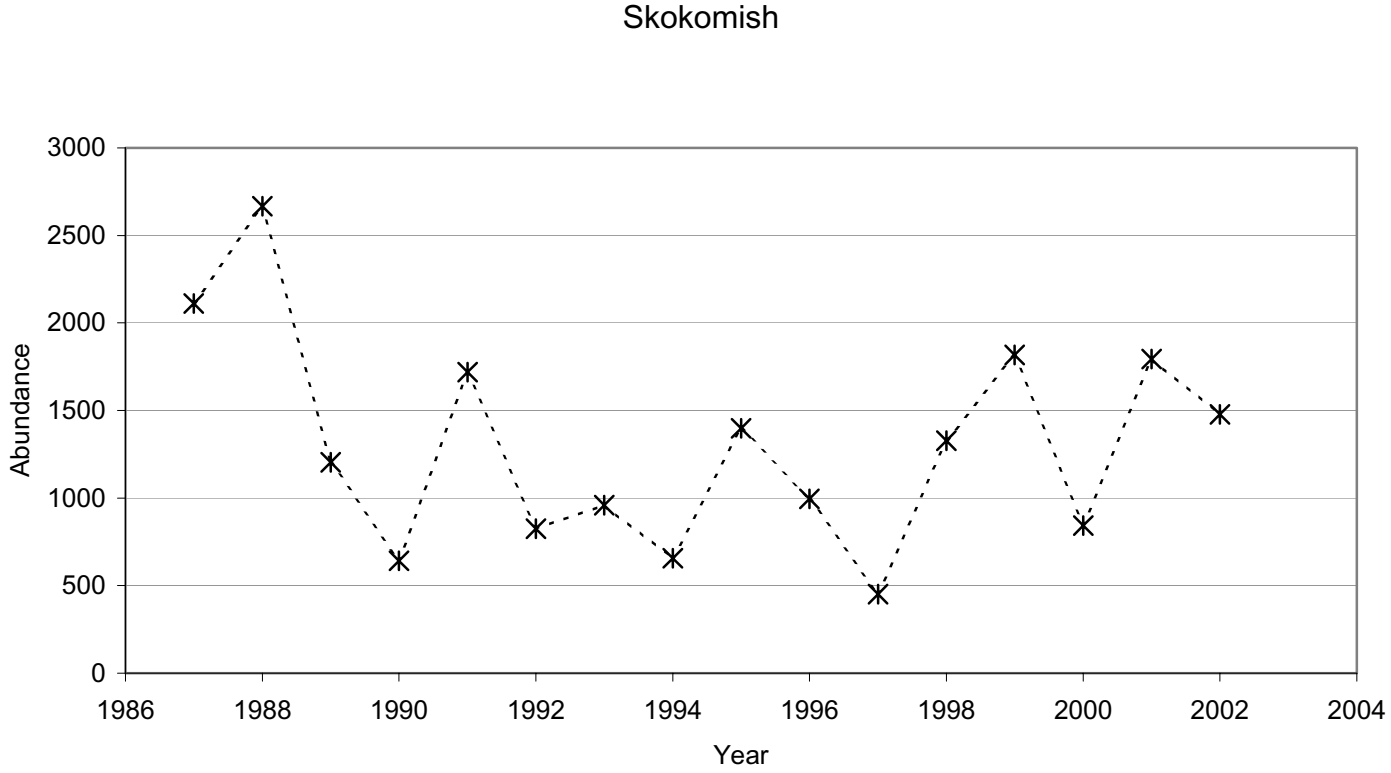


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



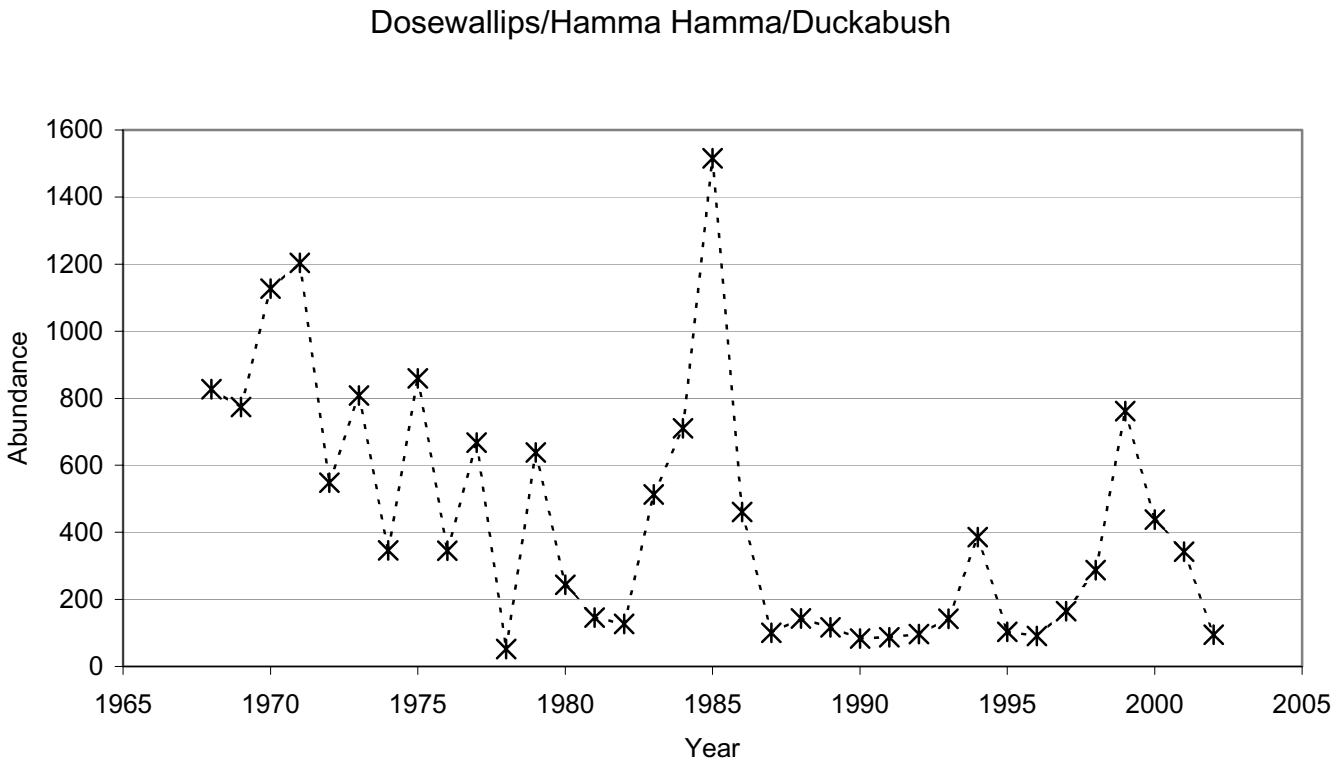
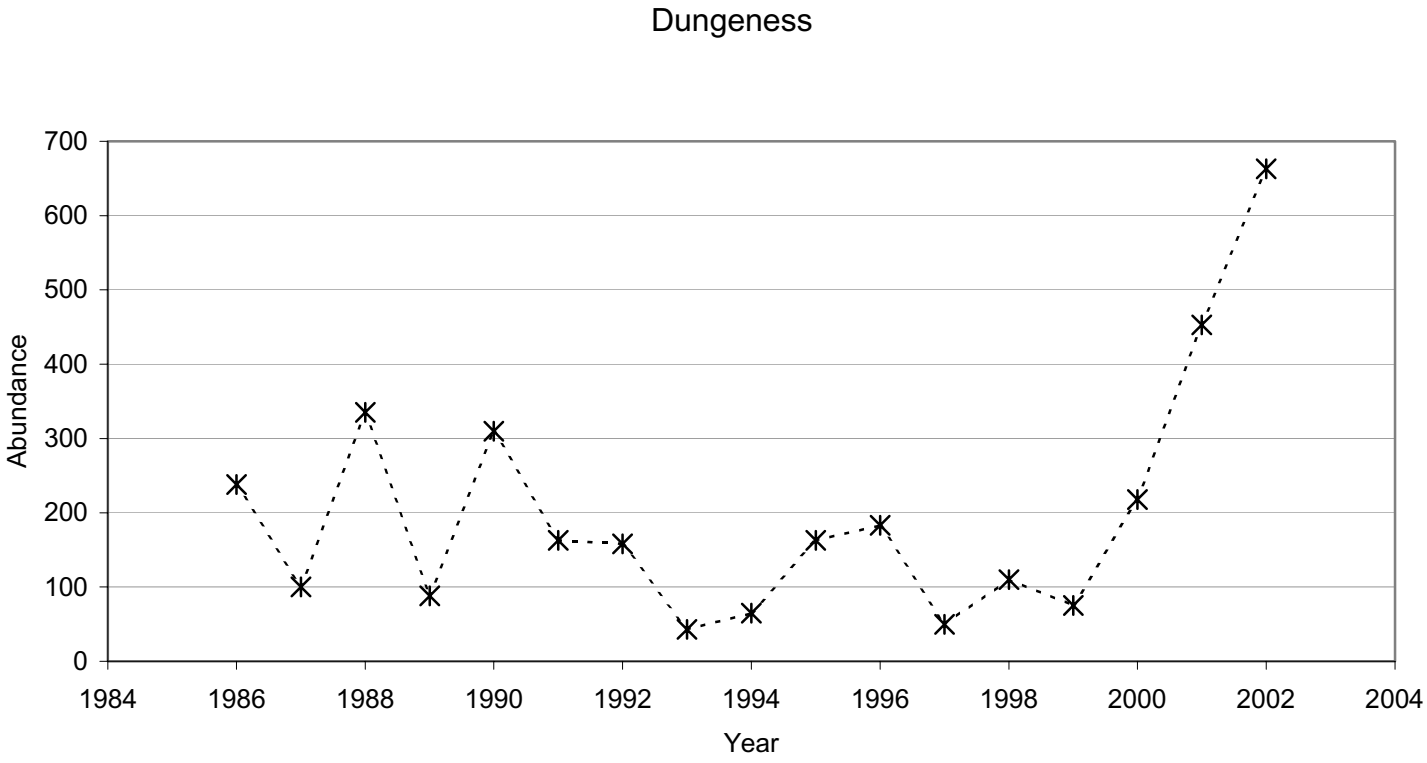


Figure A.2.4.1. Total and natural-origin spawner abundance estimates (cont.)



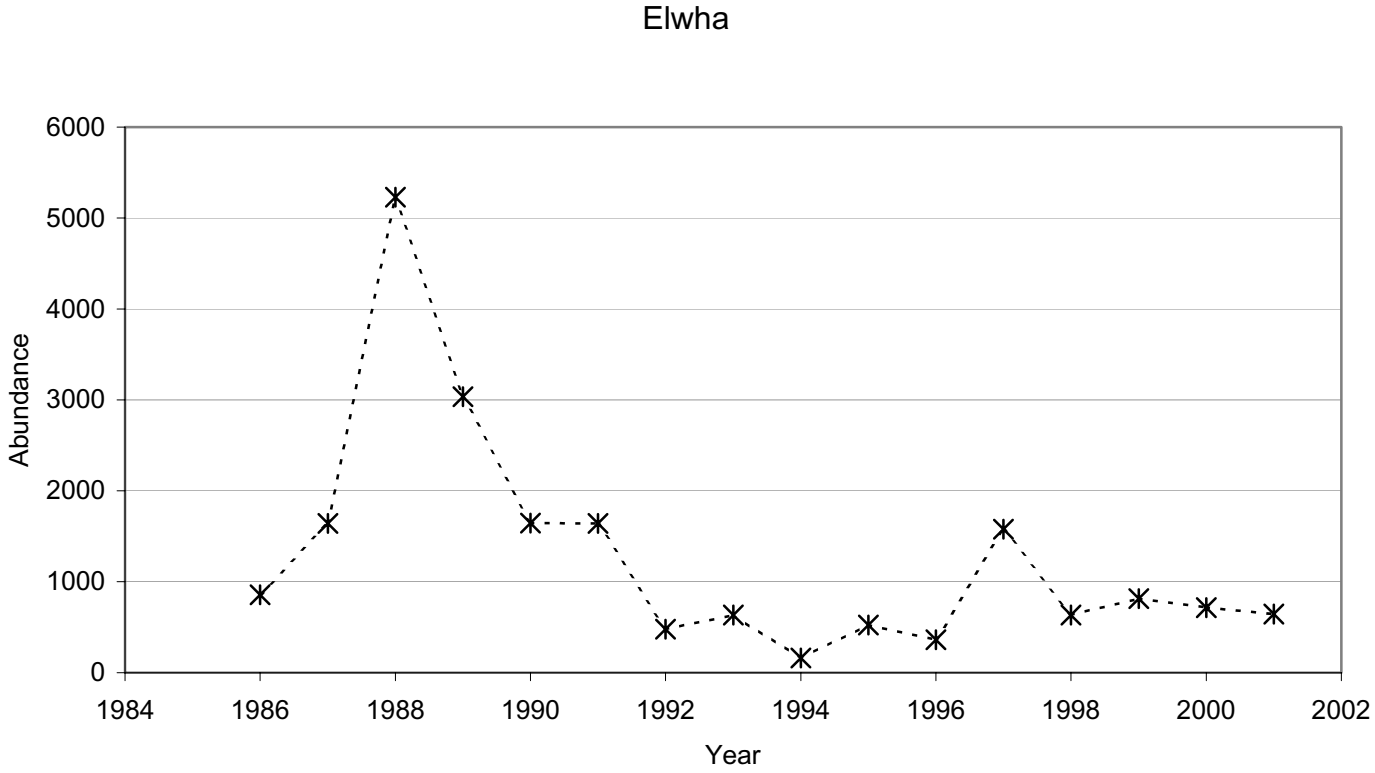
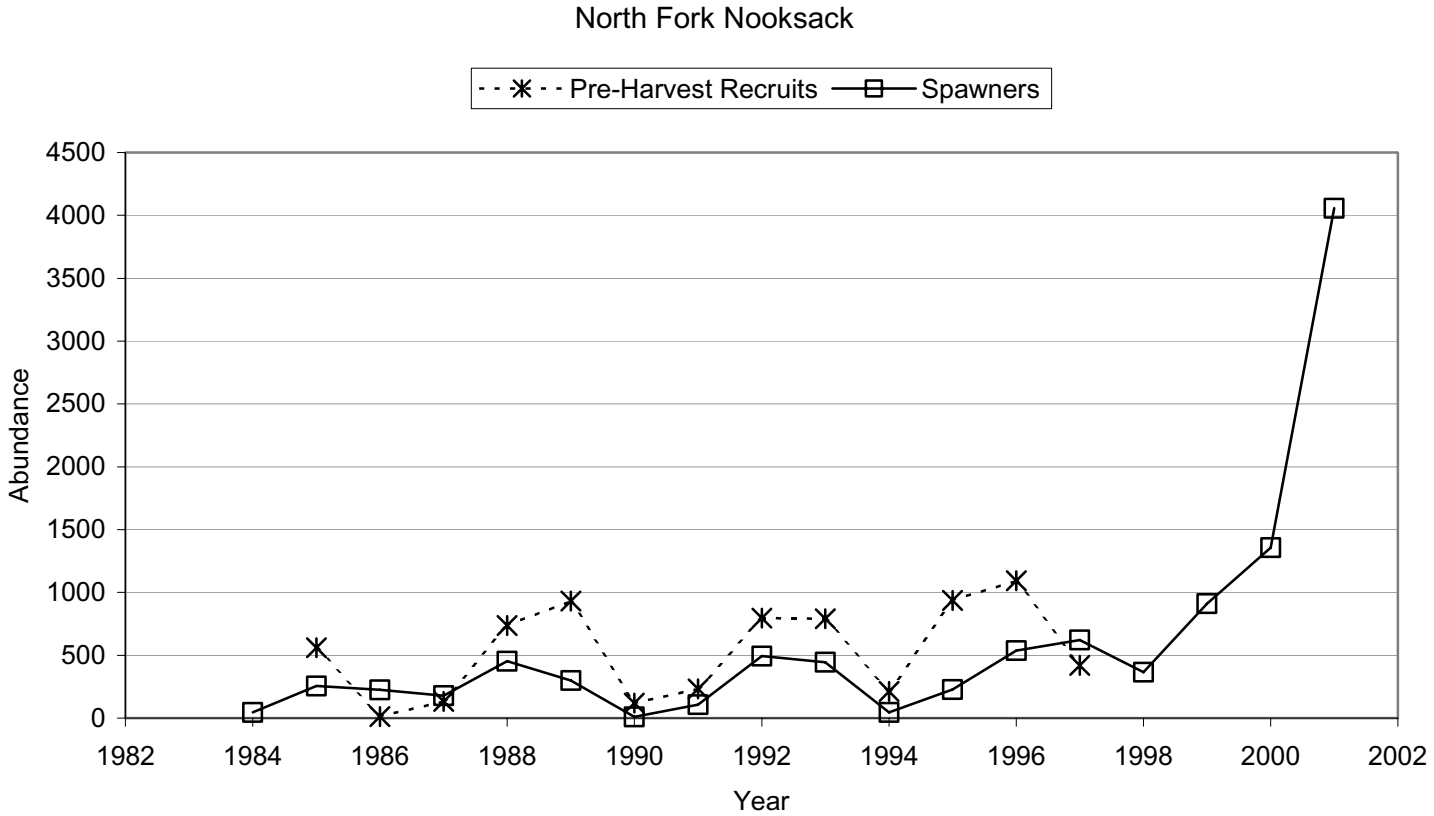


Figure A.2.4.2. Puget Sound Chinook pre-harvest recruits and spawners vs. brood year by population



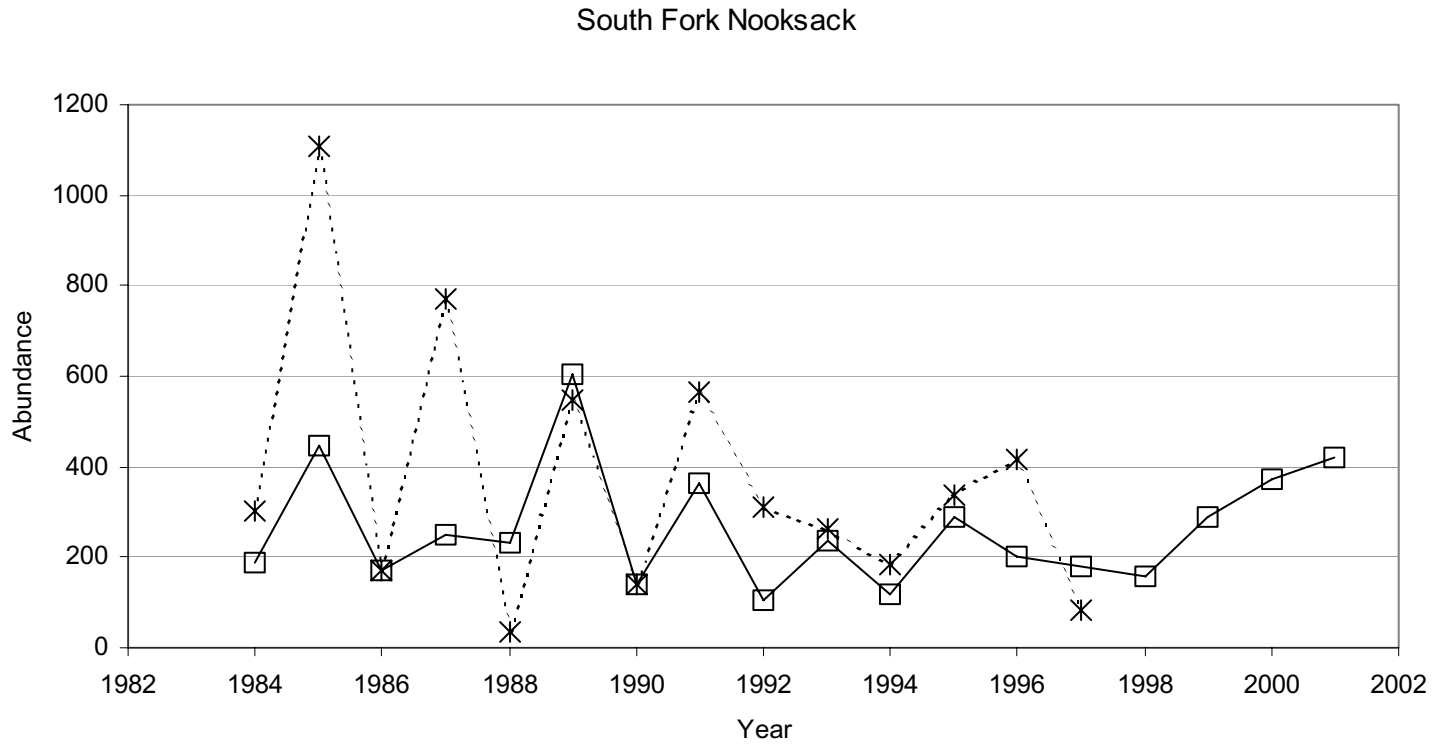
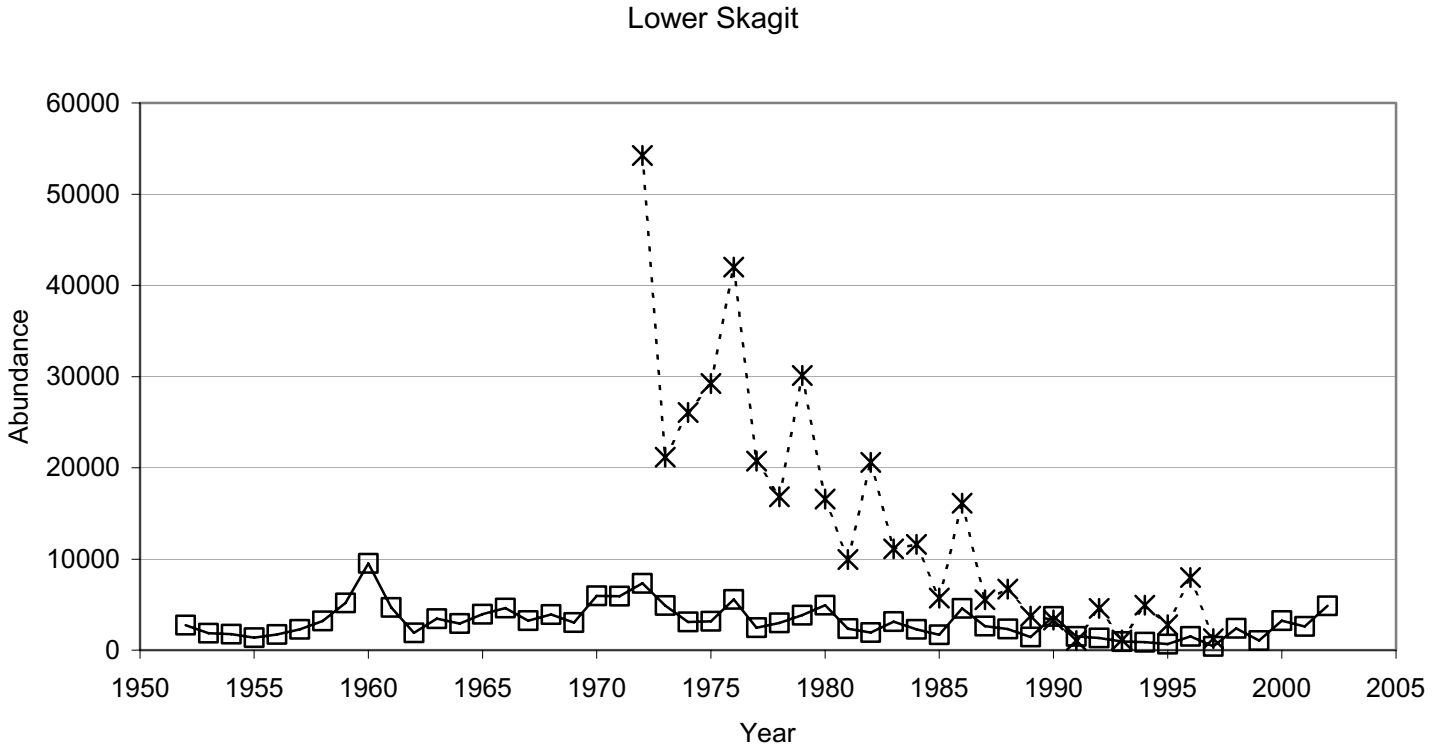


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



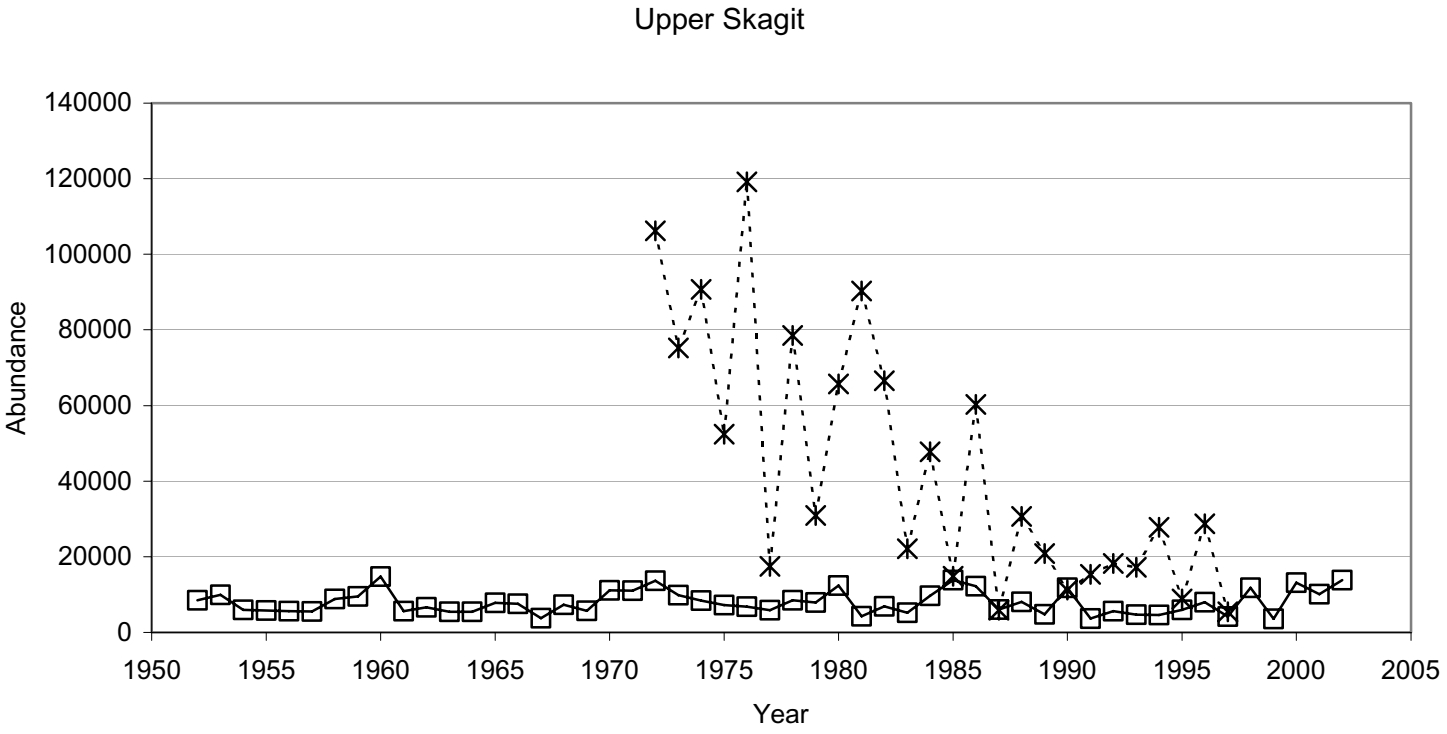
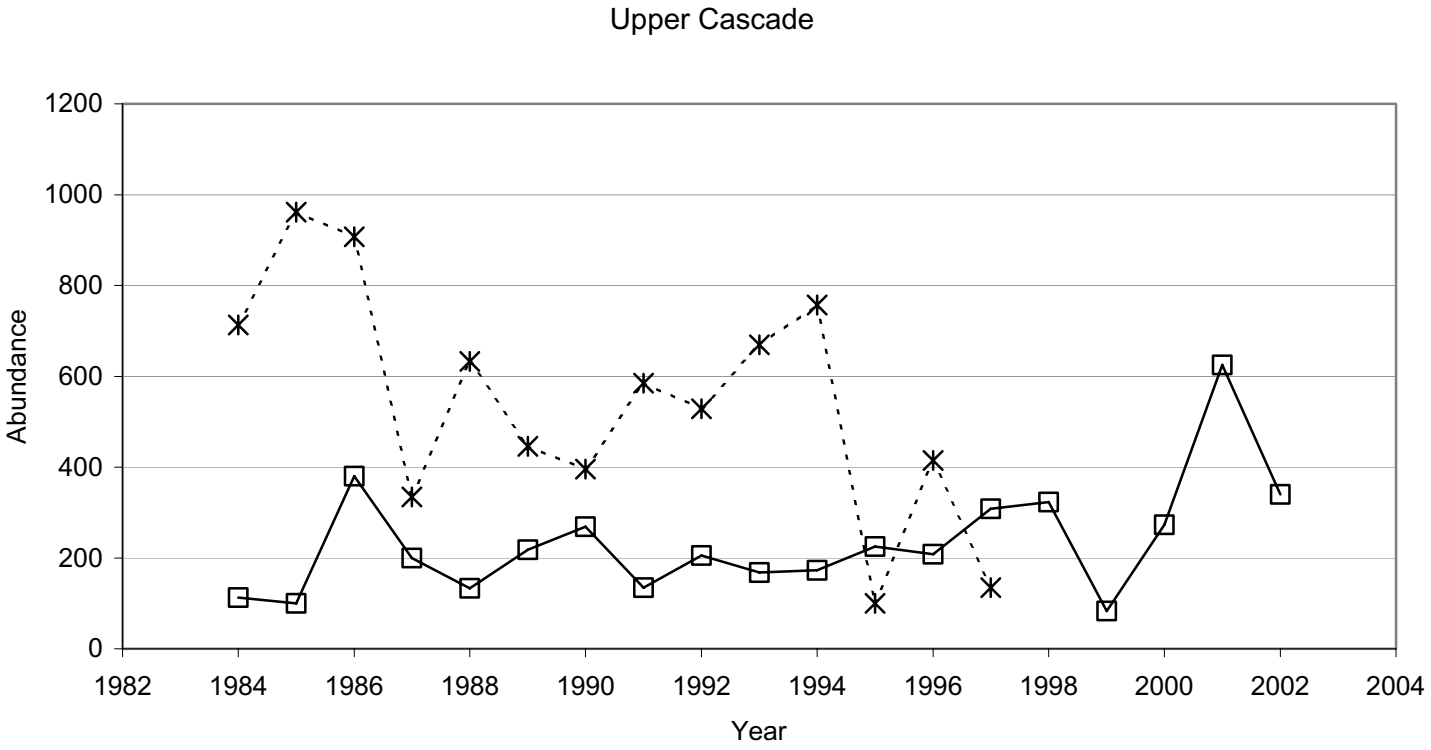


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



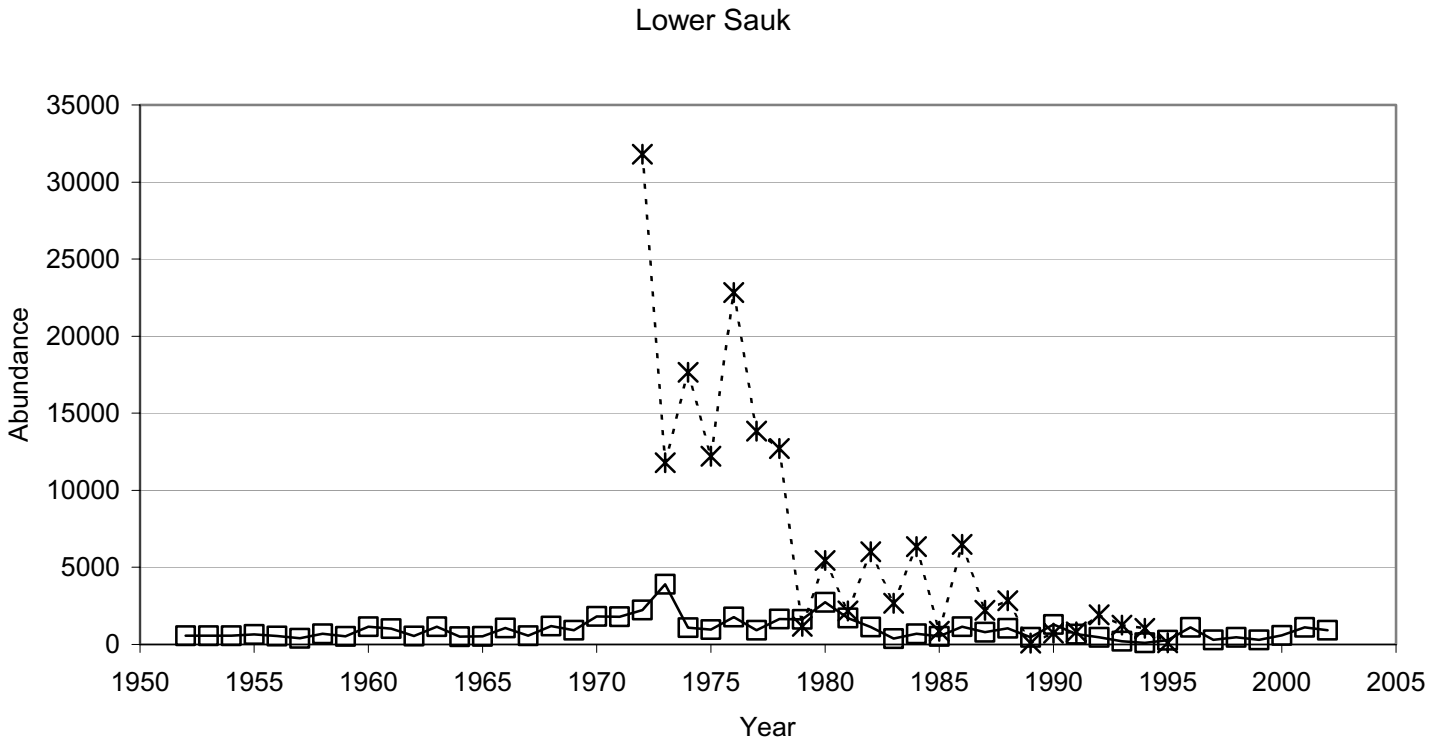
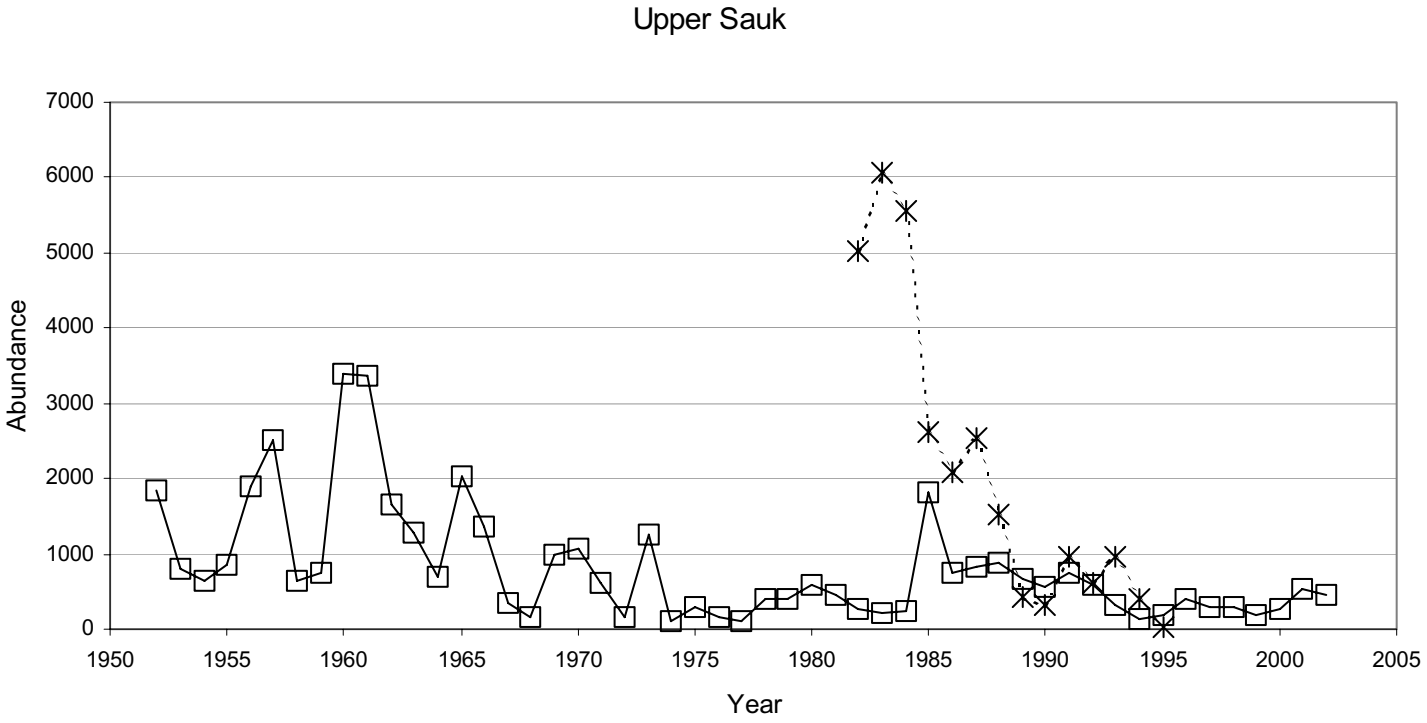


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



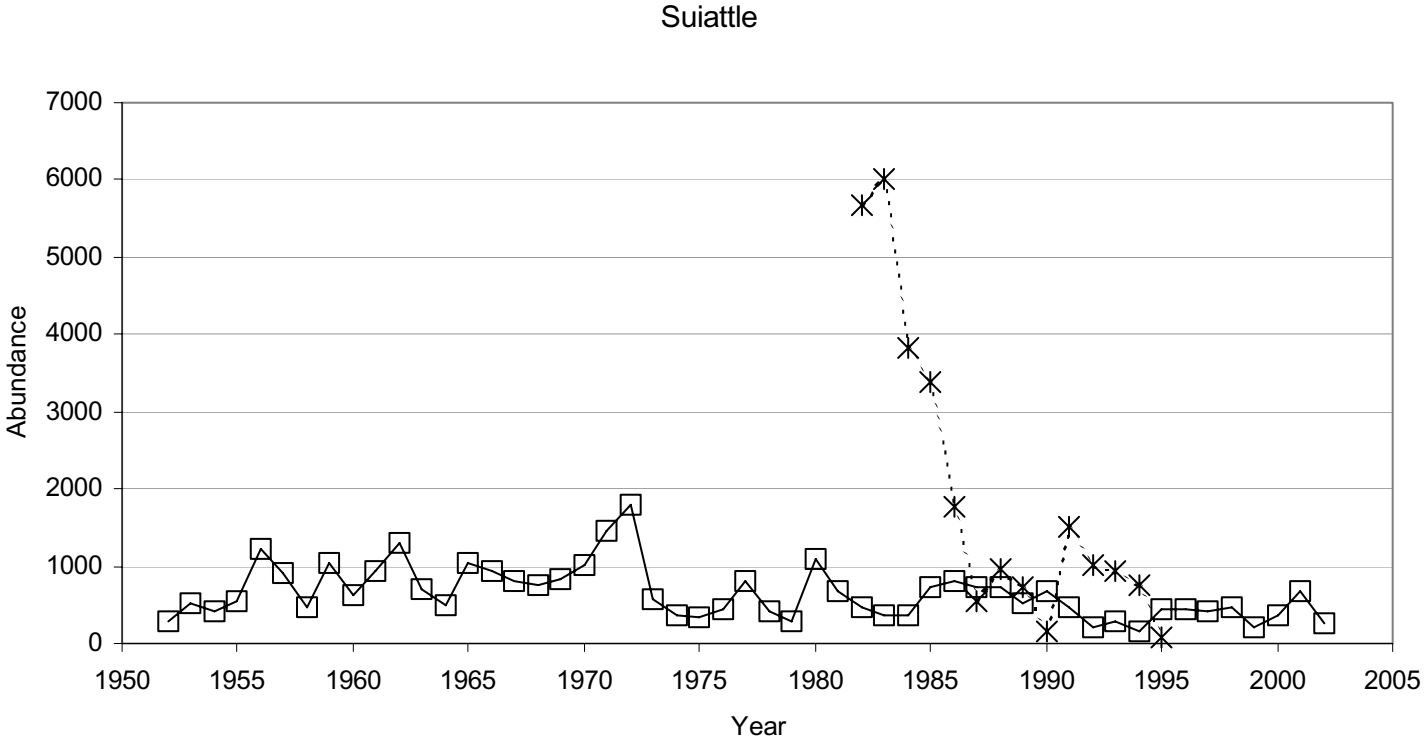
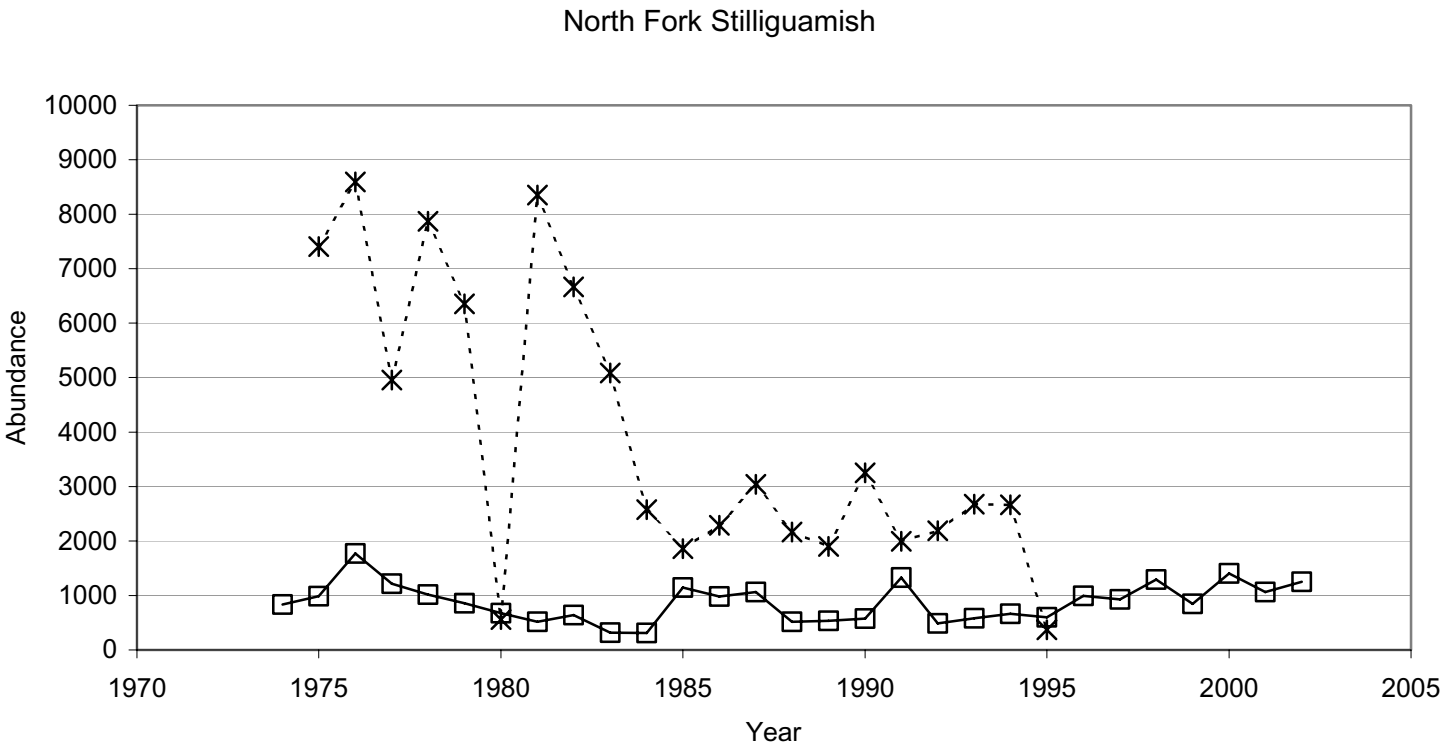


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



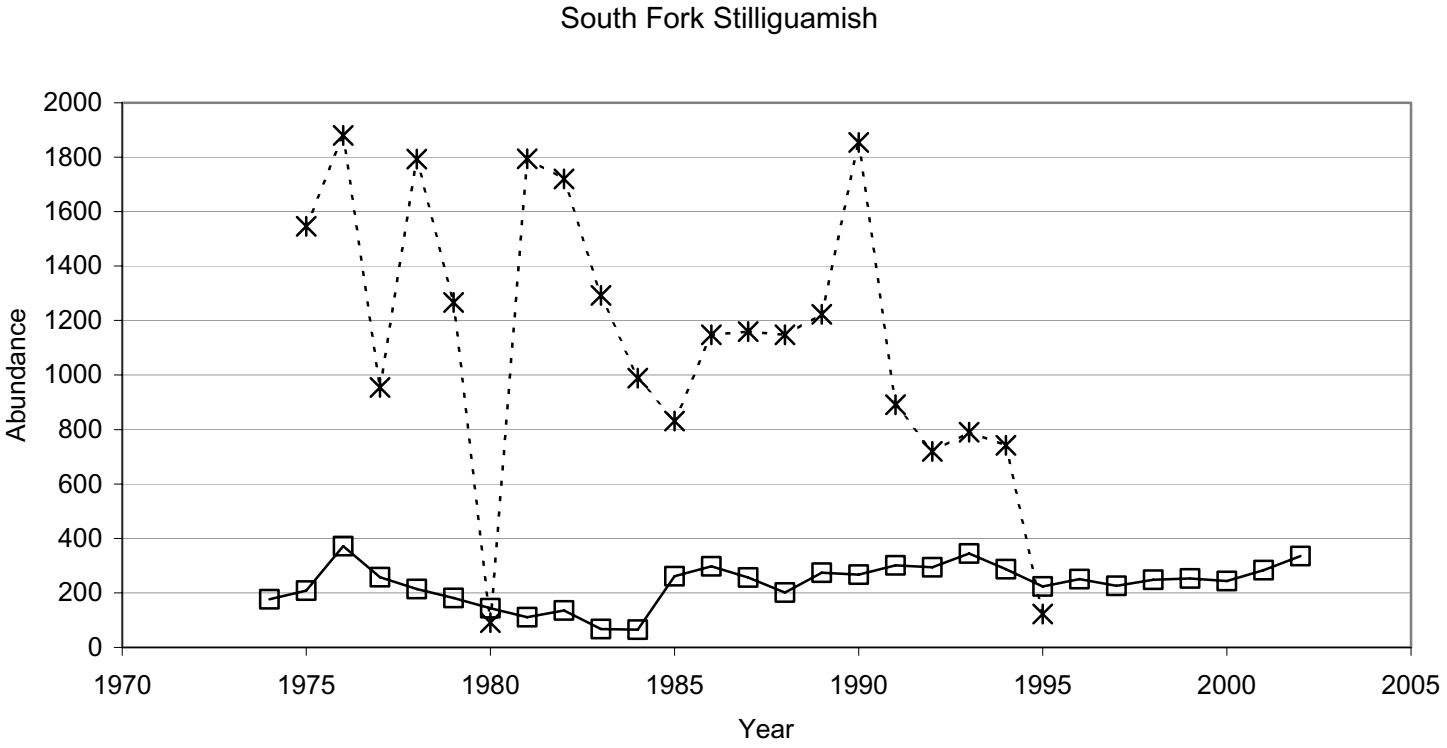
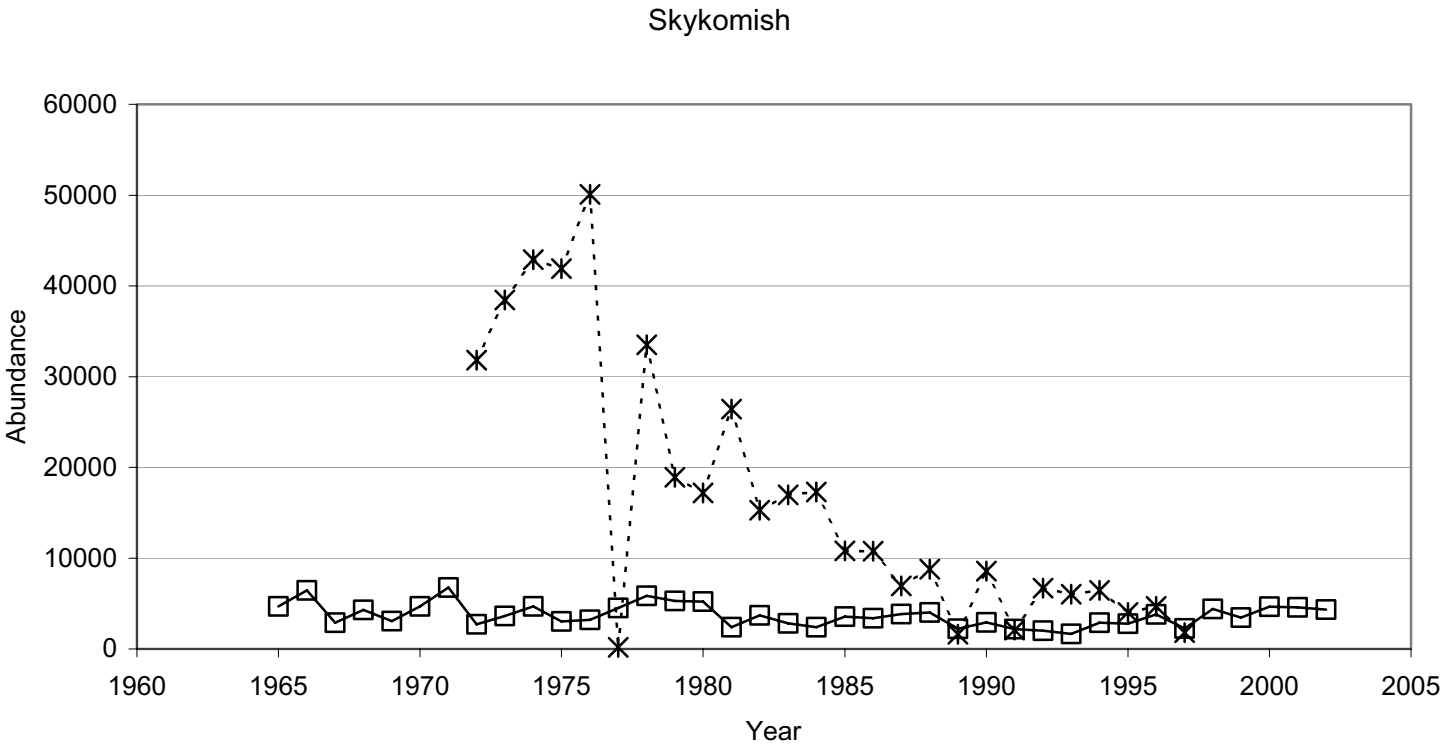


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



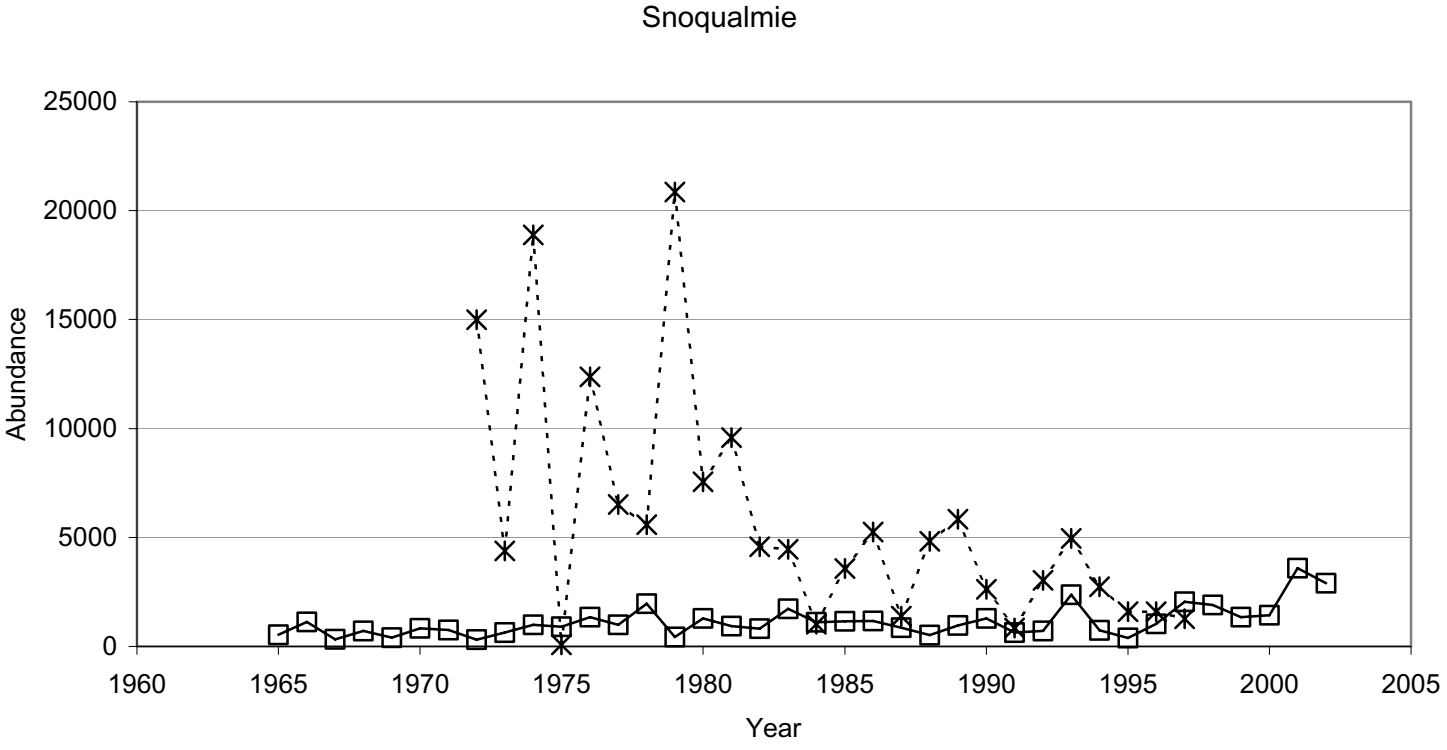
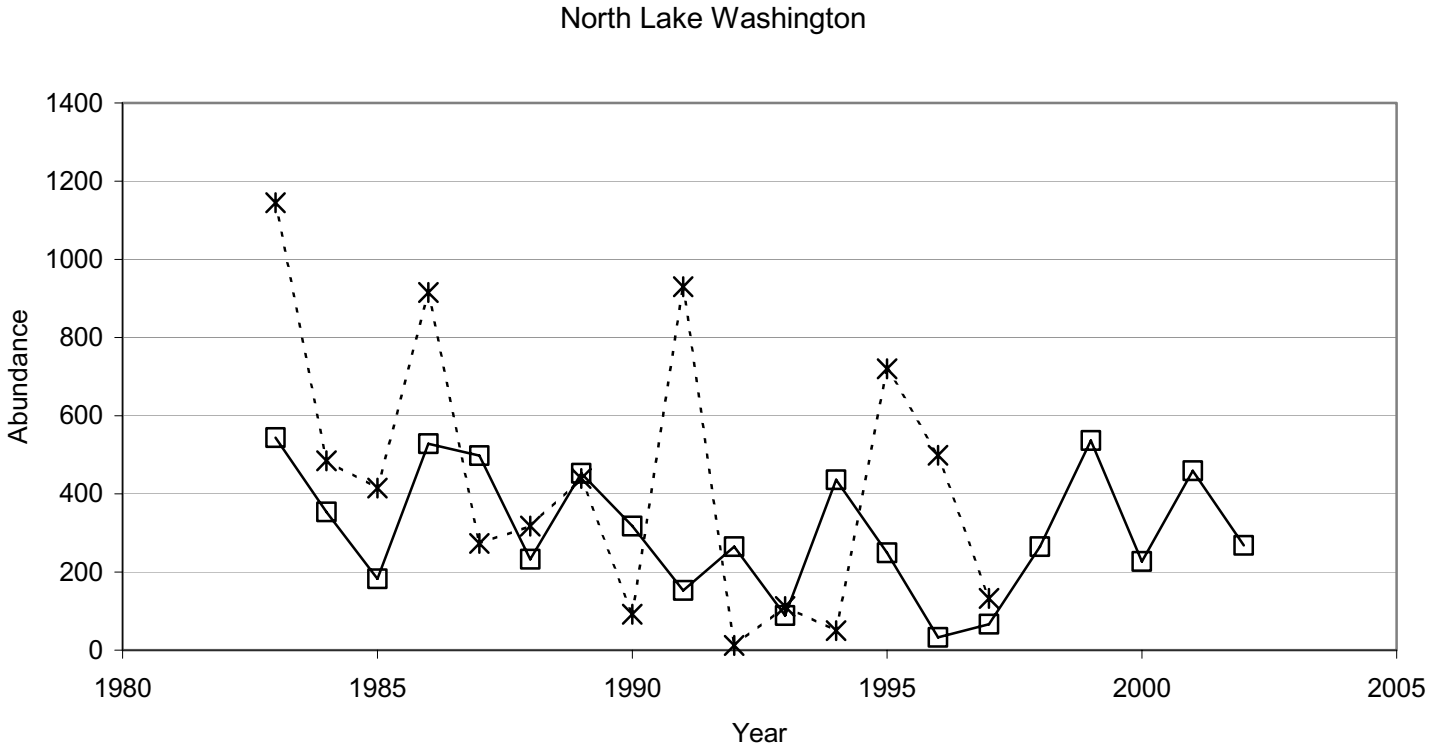


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



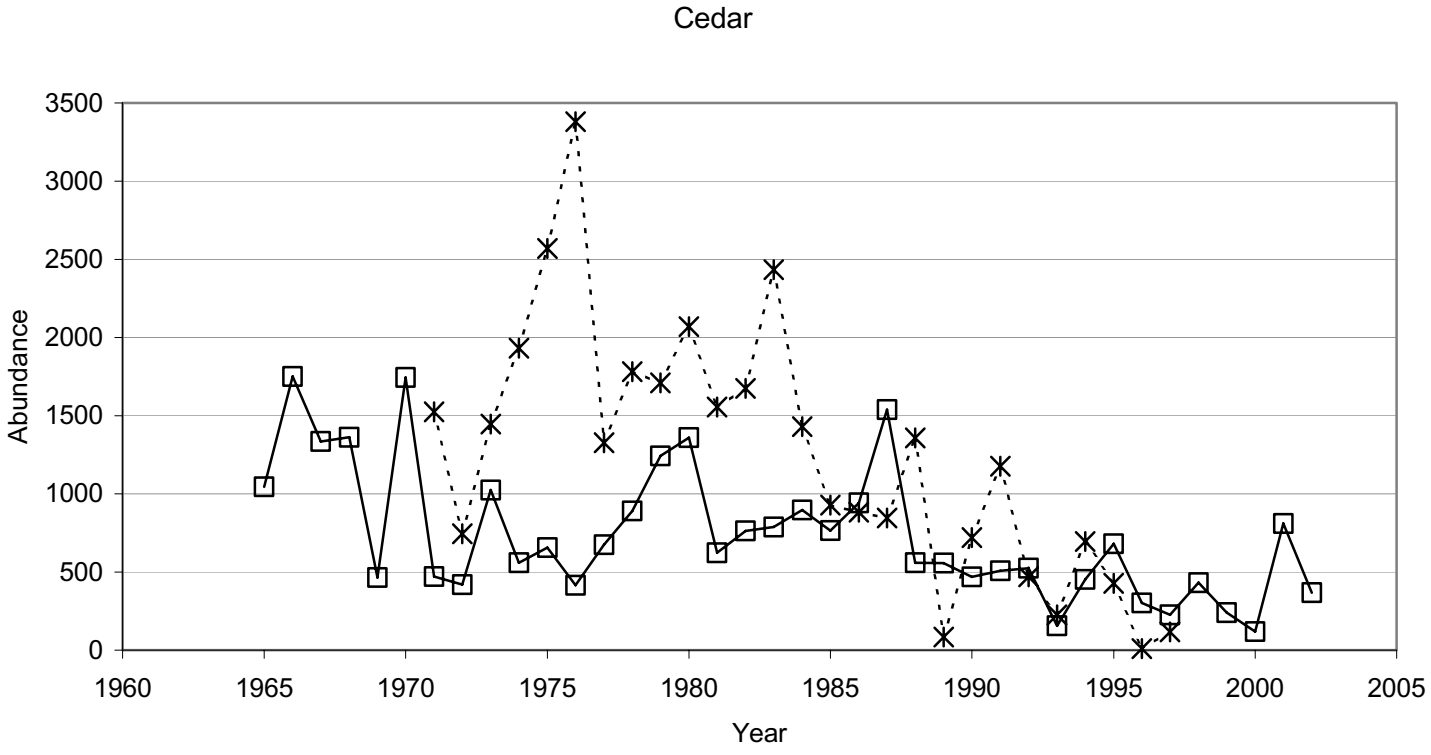
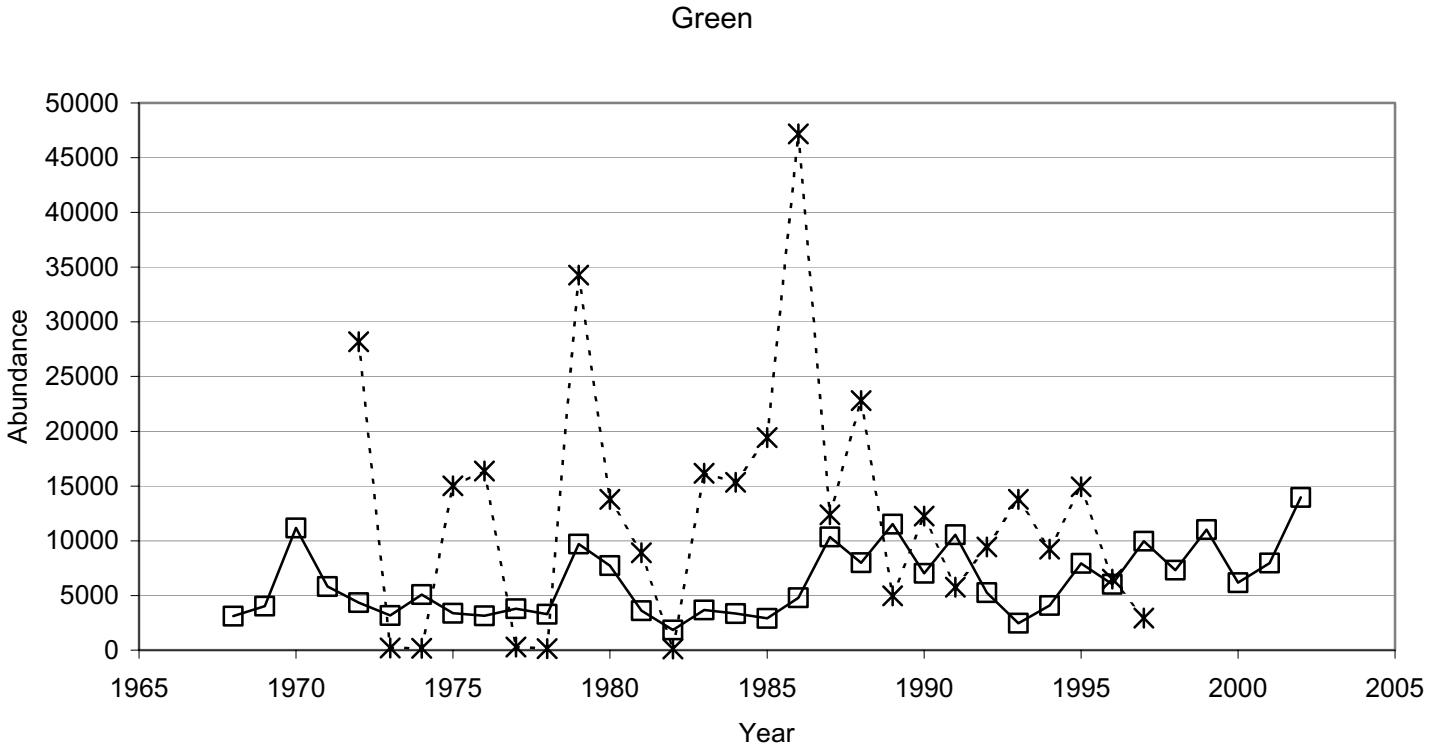


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



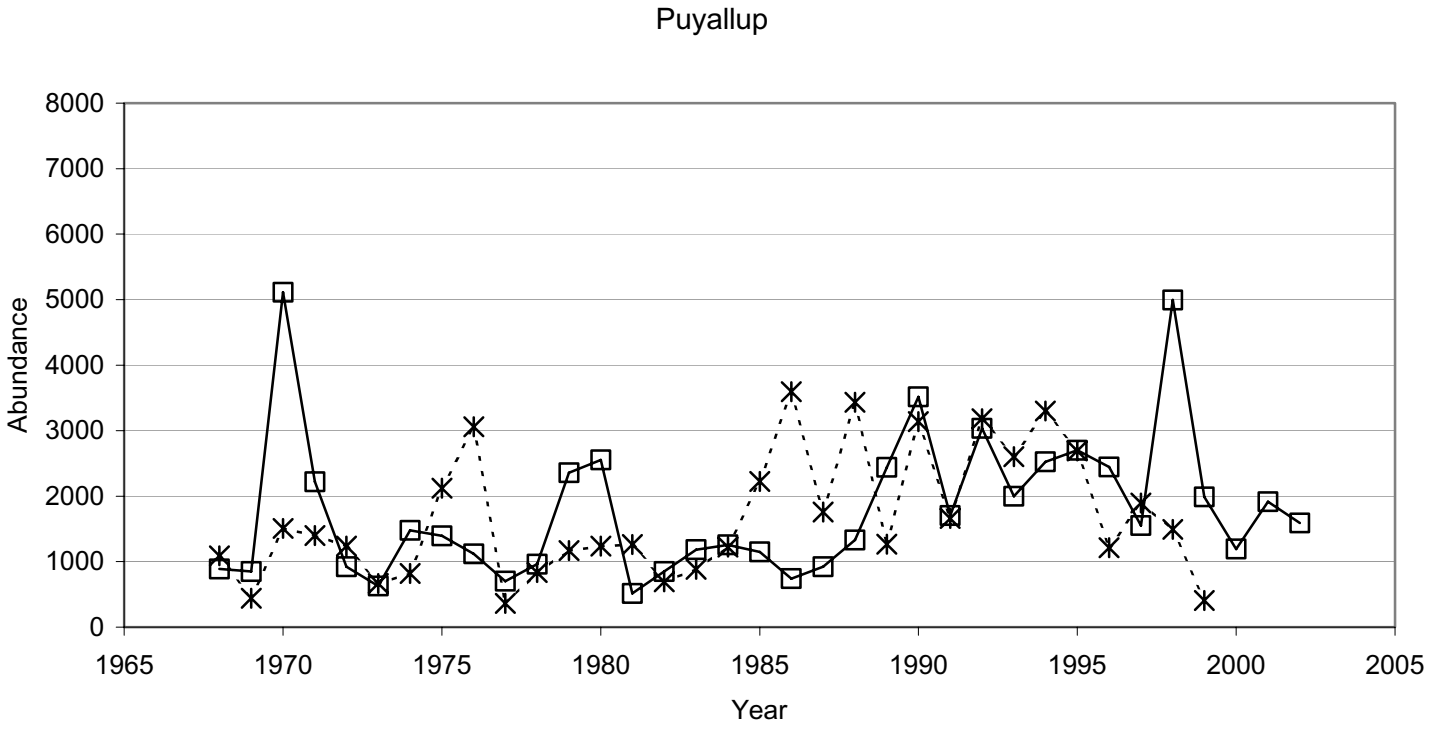
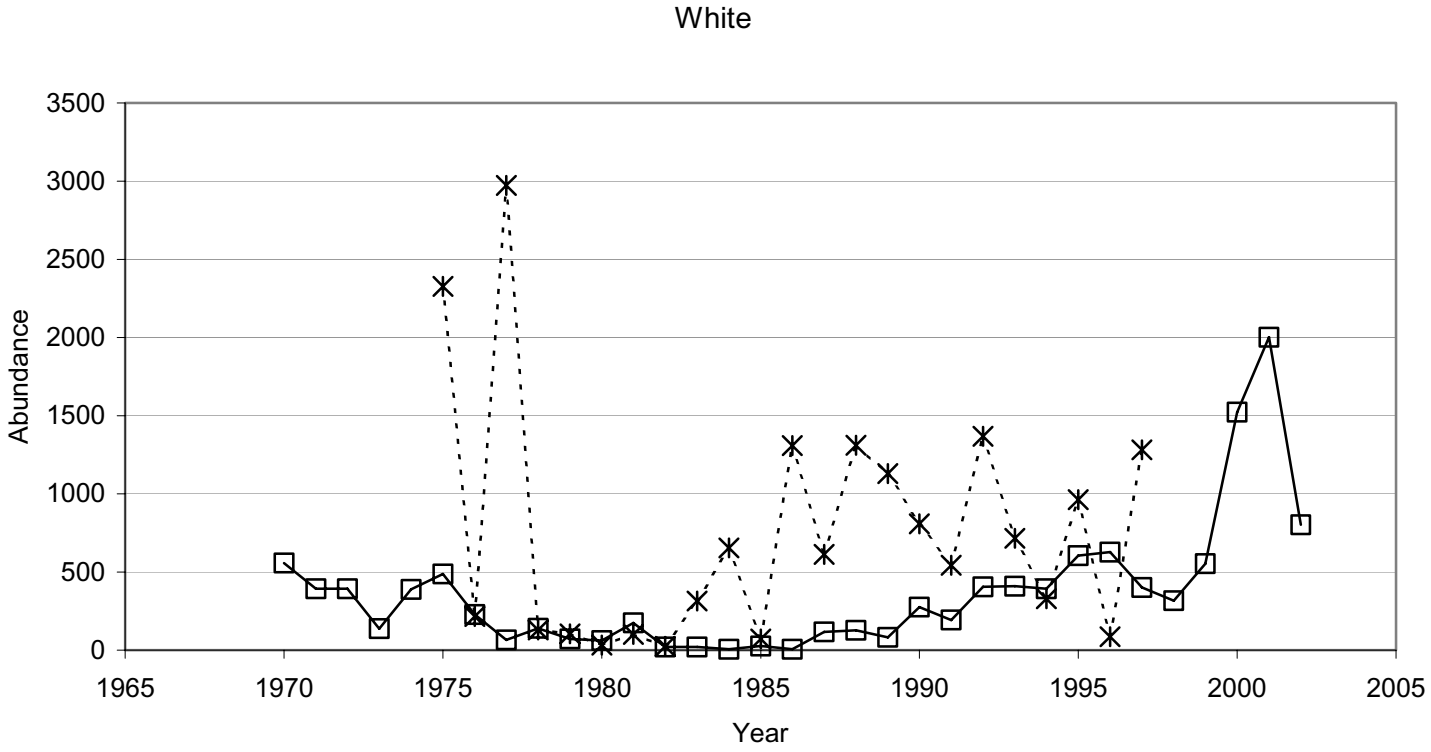


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



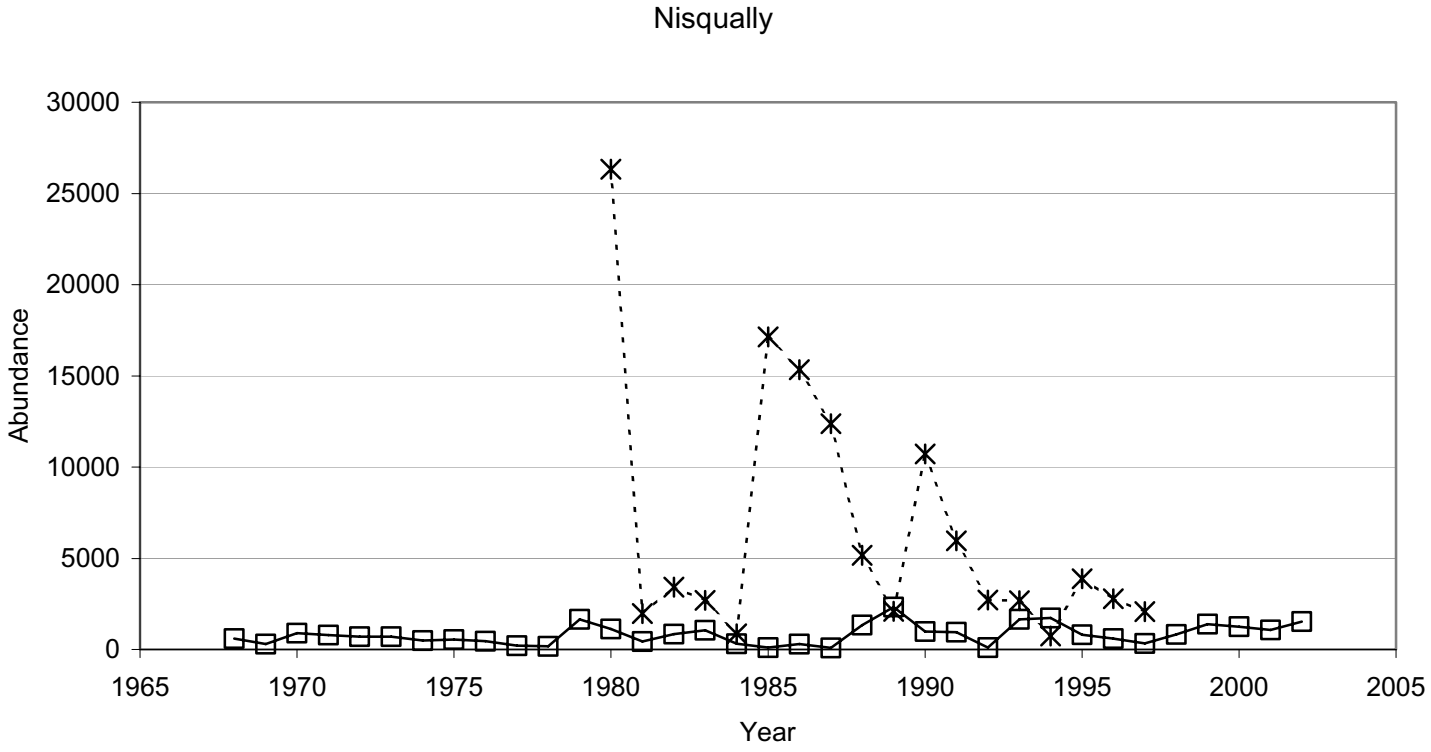
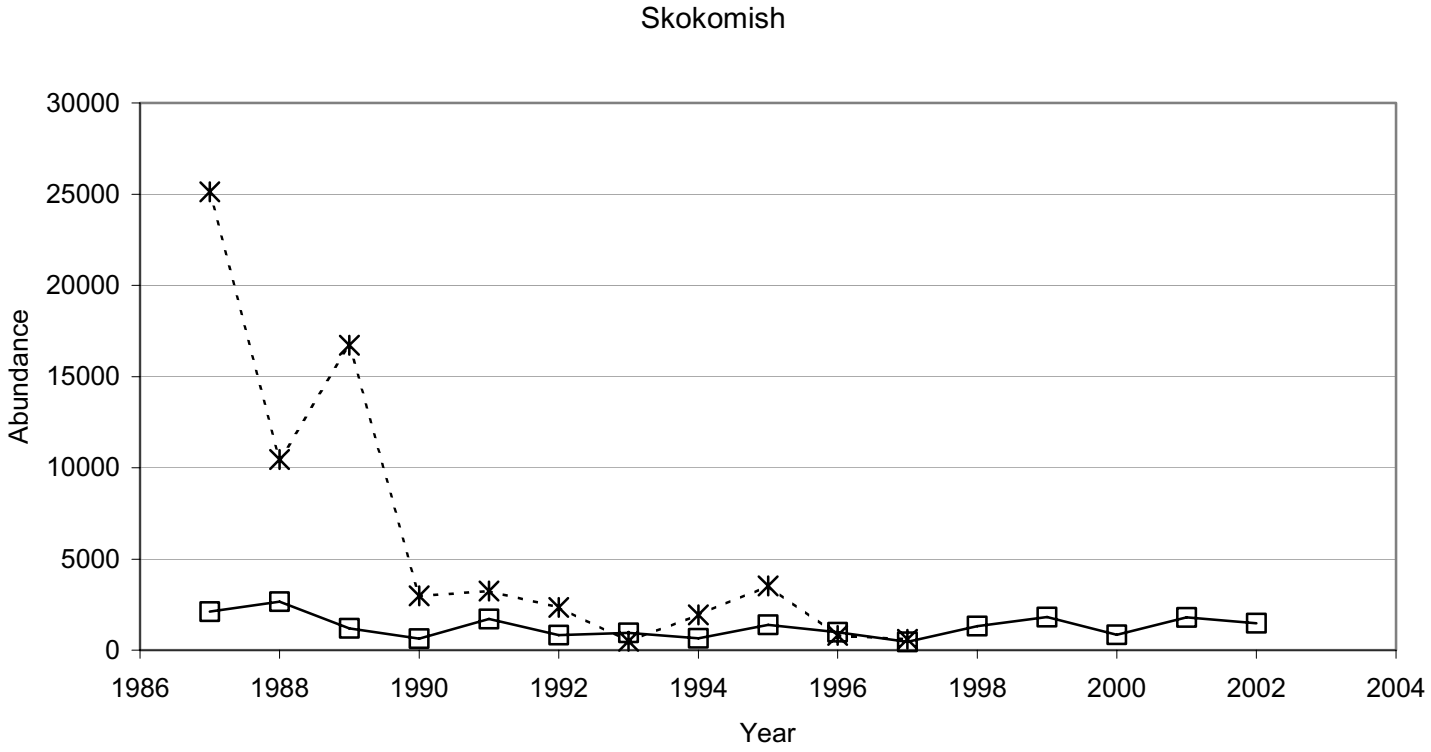


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)



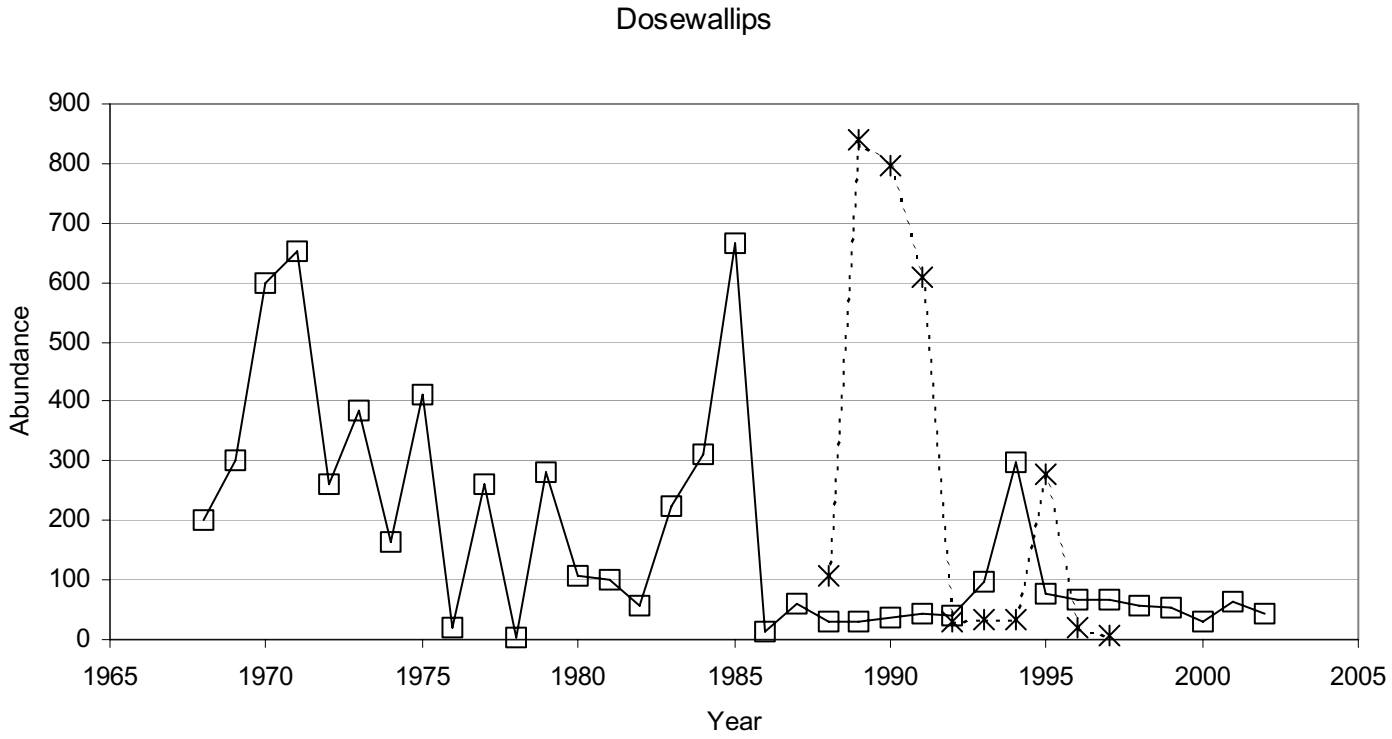
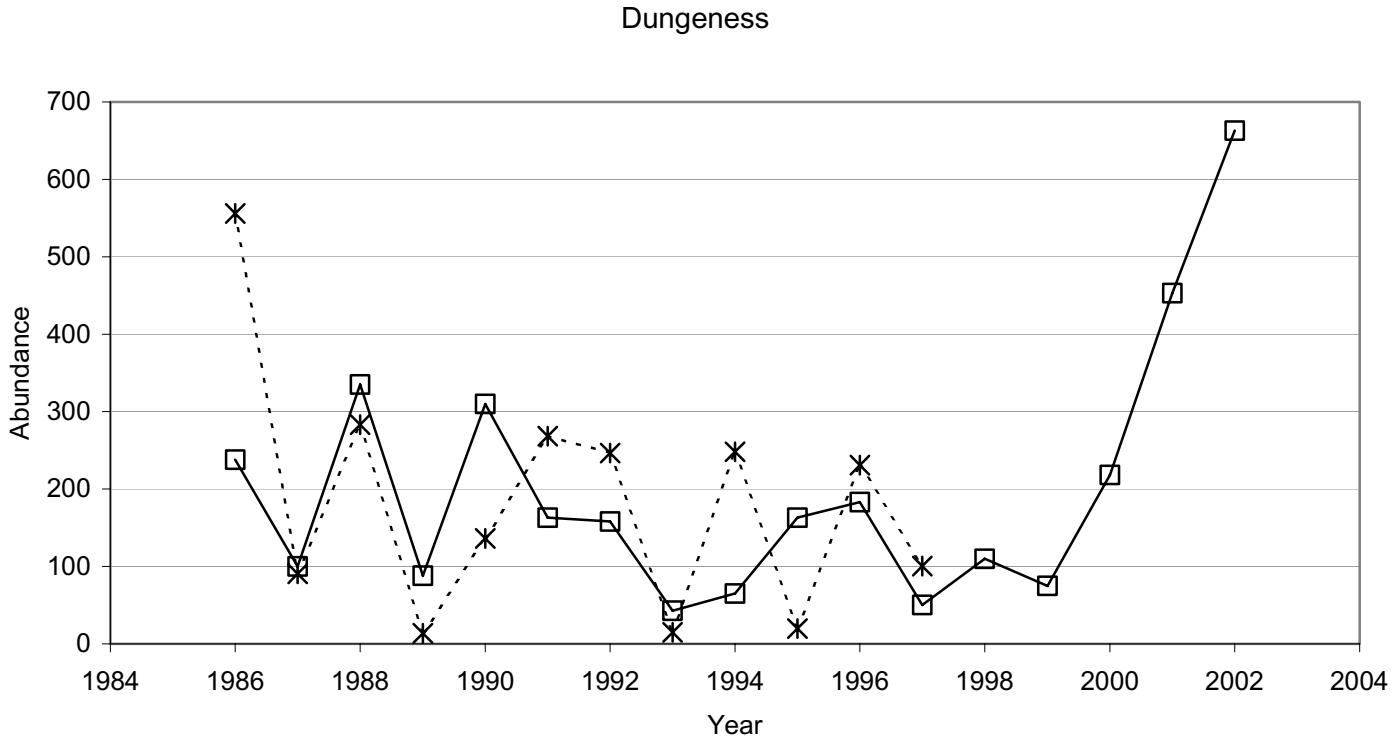
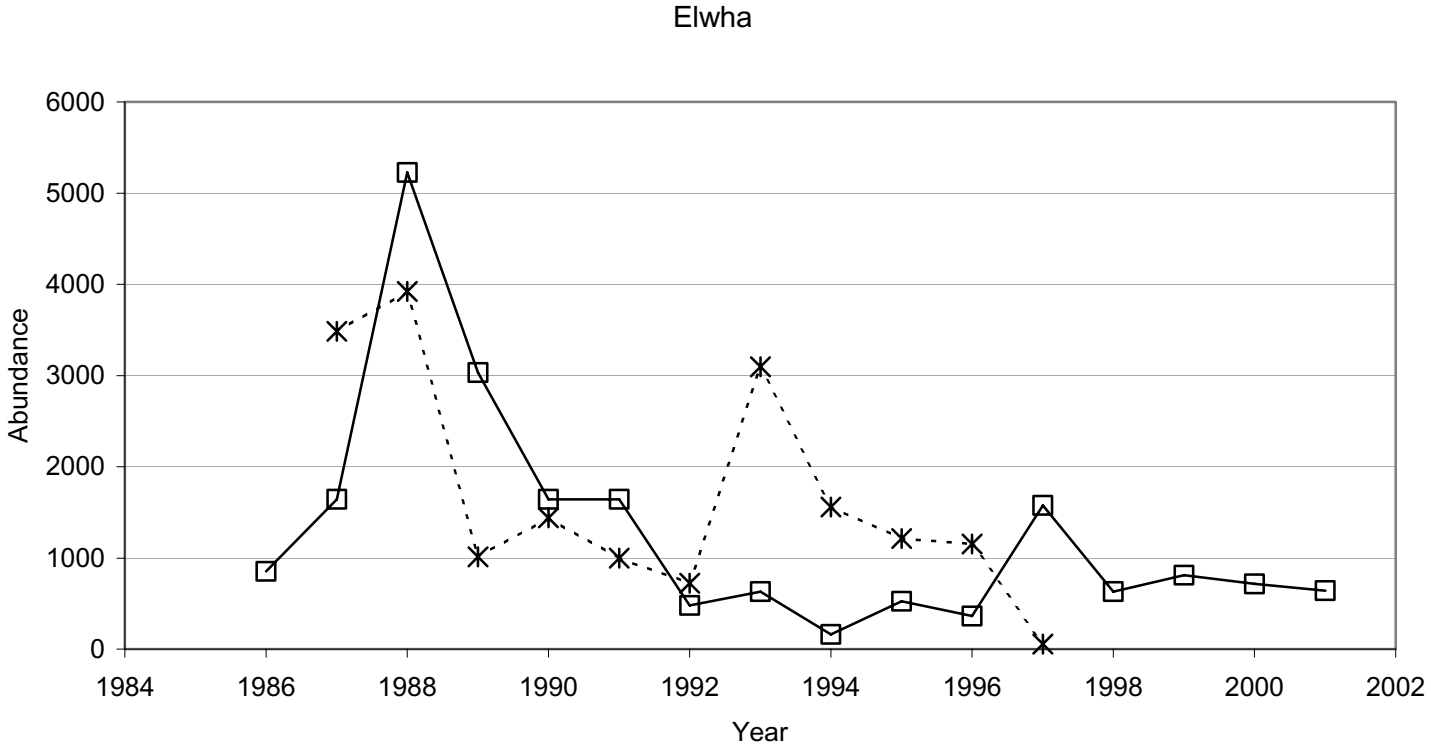


Figure A.2.4.2 Puget Sound Chinook pre-harvest recruits and spawners (cont.)





A.2.5 LOWER COLUMBIA RIVER CHINOOK SALMON

A.2.5.1 Summary of Previous BRT Conclusions

The status of Lower Columbia River chinook was initially reviewed by NMFS in 1998 (Myers et al. 1998) and updated in that same year (NMFS 1998). In the 1998 update, the Biological Review Team (BRT) noted several concerns for this ESU. The 1998 BRT was concerned that there were very few naturally self-sustaining populations of native chinook salmon remaining in the Lower Columbia River ESU. Naturally reproducing (but not necessarily self-sustaining) populations identified by the 1998 BRT were the Lewis and Sandy Rivers "bright" fall runs and the "tule" fall runs in the Clackamas, East Fork Lewis and Coweeman Rivers. These populations were identified as the only bright spots in the ESU. The few remaining populations of spring chinook salmon in the ESU were not considered by the previous BRT to be naturally self-sustaining because of either small size, extensive hatchery influence, or both. The previous BRT felt that the dramatic declines and losses of spring-run chinook salmon populations in the Lower Columbia River ESU represented a serious reduction in life-history diversity in the region. The previous BRT felt that the presence of hatchery chinook salmon in this ESU posed an important threat to the persistence of the ESU and also obscured trends in abundance of native fish. The previous BRT noted that habitat degradation and loss due to extensive hydropower development projects, urbanization, logging and agriculture threatened the chinook salmon spawning and rearing habitat in the lower Columbia River. A majority of the previous (1998) BRT concluded that the Lower Columbia River ESU was likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.

Current Listing Status: threatened

A.2.5.2. New Data and Updated Analyses

New data acquired for this report includes spawner abundance estimates through 2001, new estimates of the fraction of hatchery spawners and harvest estimates. In addition, estimates of historical abundance have been provided by WDFW. Information on recent hatchery releases was also obtained. New analyses include the designation of relatively demographically independent populations, recalculation of previous BRT metrics with additional years data, estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish, and estimates of current and historically available kilometers of stream.

Historical population structure—As part of its effort to develop viability criteria for LCR chinook, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 20 fall-run populations ("tules"), two late fall-run populations ("brights") and nine spring-run populations for a total of 31 populations (Figures A.2.5.1 and A.2.5.2). The populations identified in Myers et al. are used as the units for the new analyses in this report.

The WLC-TRT partitioned LCR Chinook populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2003). The WLC-TRT concludes that a viable ESU would need multiple viable populations in each of these strata. The strata and associated populations are identified in Table A.2.5.1.

Table A.2.5.1. Historical population structure and abundance statistics for Lower Columbia River chinook populations. The populations are partitioned into ecological zones and major life history types. The ecological zones are based on ecological community and hydro-dynamic patterns and life history types are based on traits related to run timing. Time series used for the summary statistics are referenced in Appendix A.5.2. Natural-origin spawners had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery.

Life History	Eco-logical Zone	Population	Years for Recent Means	Total Spawners		Natural-origin Spawners		Recent Average Hatchery-origin Spawners (%)
				Recent Geometric Mean	Recent Arithmetic Mean	Recent Geometric Mean	Recent Arithmetic Mean	
Fall Run	Coastal	Youngs Bay Fall Run	No Data					
		Grays River Fall Run	1997-2001	99	152	59	89	38
		Big Creek Fall	No Data					
		Elochoman River Fall	1997-2001	676	1074	186	289	68
		Clatskanie River Fall	No Data					
		Mill, Aber., Germany Fall	1997-2001	734	1197	362	626	47
		Scappoose Creek Fall	No Data					
	Cascade	Coweeman Fall	1997-2001	274	469	274	469	0
		Lower Cowlitz Fall	1996-2000	1,562	1,626	463	634	62
		Upper Cowlitz Fall	2001	5,682				No Data (assumed high)
		Toutle River Fall	No Data					
		Kalama River Fall	1997-2001	2,931	3,138	655	1,214	67
		Salmon Crk/ Lewis Fall	1997-2001 (East Fork Data only	256	294	256	294	0

Life History	Eco-logical Zone	Population	Years for Recent Means	Total Spawners		Natural-origin Spawners		Recent Average Hatchery-origin Spawners (%)
				Recent Geometric Mean	Recent Arithmetic Mean	Recent Geometric Mean	Recent Arithmetic Mean	
		Clackamas River Fall	1998-2001	40	56	No Data		
		Washougal River Fall	1997-2001	3,254	3,364	1,130	1,277	58
		Sandy River Fall	1997-2001	183	216	No Data		
	Gorge	Lower Gorge Trib. Fall	No Data					
		Upper Gorge Trib. Fall	1997-2001 (Wind River Data only)	136	216	109	198	13
		Hood River Fall	1994-1998	18	21	No Data		
		Big White Salmon Fall	1997-2001	334	602	218	462	21
Late Fall (bright)	Cascade	Sandy Late Fall	1997-2001	504	773	778	750	3
		N.F. Lewis Late Fall (bright)	1997-2001	7,841	8,834	6,818	7,828	13
Spring Run	Cascade	Upper Cowlitz Spring	2001	1,787		No Data		
		Cispus River Spring						
		Tilton River Spring						
		Toutle River Spring	No Data					
		Kalama River Spring	1997-2001	98	185	No Data		
		Lewis River Spring	1997-2001	347	363	No Data		
		Sandy River Spring	No Data					
	gorge	Big White Salmon Spring	No Data (No fish?)					
		Hood River Spring	1994-1998	51	61	No data		

Abundance and trends

Data sources for abundance time series and related data are in Appendix A.5.2. The recent abundance of both total and natural-origin spawners, and recent fraction of hatchery-origin spawners for LoCR Chinook populations are summarized in Table A.2.5.1. Natural-origin fish had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery. The abundances of natural-origin spawners range from near extirpation for most of the spring run populations to over 7,841 for the Lewis River bright population. The majority of the fall-run tule populations have a substantial fraction of hatchery-origin spawners in the spawning areas and may be sustained largely by hatchery production. Exceptions are the Coweeman population and the East Fork Lewis portion of the Lewis River/Salmon Creek population, which have few hatchery fish spawning on the natural spawning areas. These two populations have recent geometric mean natural-origin abundance estimates of 274 and 256 spawners respectively. Although quantitative information is not yet available, preliminary examination of scales indicates that almost all current spring run spawners in the Washington part of this ESU are of hatchery origin (Rawding, pers. comm.) The majority of the spring run populations have been extirpated largely as the result of dams blocking access to their high elevation habitat. The two bright chinook populations (i.e., Lewis and Sandy) have relatively high abundances, particularly the Lewis.

Access to the habitat of the historical Upper Cowlitz, Cispus, and Tilton Rivers populations is blocked by the Mayfield, Mossy Rock and Cowlitz Falls dams. A relatively large number of both spring and fall Chinook are currently released as part of a reintroduction program to establish chinook above Cowlitz Falls dam (Serl and Morrill 2002). The adults for the reintroduction program are collected at the Cowlitz Salmon hatchery and the vast majority of the chinook trucked above Cowlitz Falls are believed to be of hatchery origin, though marking of hatchery fish is not complete and a quantitative assessment has not been undertaken. Downstream survival of juvenile chinook though the dams and reservoirs is considered negligible, so juveniles are collected at Cowlitz Falls and trucked downstream. The current collection efficiency of juveniles at Cowlitz Falls is considered too low for the reintroduction to be self-sustaining (Rawding 2003 pers. comm.).

Where data are available, the abundance time series information for each of the populations is presented in Figures A.2.5.3-A.2.5.30. Three types of time series figures are presented. The first type of figure plots abundance against time (Figures A.2.5.3, A.2.5.4, A.2.5.5, A.2.5.6, A.2.5.8, A.2.5.10, A.2.5.12, A.2.5.14, A.2.5.16, A.2.5.18, A.2.5.20, A.2.5.21, A.2.5.22, A.2.5.24, A.2.5.25, A.2.5.26, and A.2.5.27). Where possible, two lines are presented on the abundance figure, where one line is the estimated total number of spawners and the other line is the estimated number of fish of natural origin. In many cases, data were not available to distinguish between natural- and hatchery-origin spawners, so only total spawner information is presented. This type of figure can give a sense of the levels of abundance, overall trend, patterns of variability, and the fraction of hatchery-origin spawners. A high fraction of hatchery-origin spawners indicates that the population may potentially be sustained by hatchery production and not the natural environment. It is important to note that estimates of the fraction of hatchery-origin fish are highly uncertain since the hatchery marking rate for LCR fall chinook is generally only a few percent and expansion to population hatchery fraction is based on only a handful of

recovered marked fish (unpublished analysis, McElhany, Rawding, and Sydor). The second type of time series figure displays fish per mile data. For three populations of fall run chinook in Oregon watersheds, total abundance estimates are not available, but fish per mile time series exists (Figures A.2.5.28-A.2.5.30). There are no estimates of the fraction of hatchery-origin spawners in these fish/mile time series, but the percentage may be high given the large number of hatchery fish released and the high fraction of hatchery-origin spawners estimated in Washington watersheds directly across the Columbia River. The lack of information on hatchery fraction reduces the value of these time series for evaluating extinction risk.

The third type of time series figure presents the total number of spawners (natural and hatchery origin) and the estimated number of preharvest recruits produced by those spawners against time (Figures A.2.5.7, A.2.5.7.9, A.2.5.7.11, A.2.5.13, A.2.5.15, A.2.5.17, A.2.5.19, A.2.5.23). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner for the broodyear. Spawner are taken as the sum of hatchery and natural-origin spawners. This type of figure requires harvest and age structure information and therefore could be produced for only a limited number of populations. This type of figure can indicate whether there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest.

Summary statistics on population trends and growth rate are presented in Tables A.2.5.2-A.2.5.4. The methods for estimating trends and growth rate (λ) are described in the general method section. Trends are calculated on total spawners, both hatchery and natural origin. The λ estimate is calculated under two different assumptions about the reproductive success of hatchery-origin spawners. In one analysis, hatchery-origin spawner are assumed to have zero reproductive success and in the other analysis, hatchery-origin spawners are assumed to have a reproductive success equal to that of natural-origin spawners. Because λ is only calculated for time series where the fraction of hatchery-origin spawners is known, most of the long-term trend estimates use data starting in 1980, even though the abundance time series of total spawners may extend earlier than 1980. The majority of populations have a long-term trend less than one, indicating the population is in decline. In addition, there is a high probability for most populations that the true trend/growth rate is less than one (Table A.2.5.4). However, in general there is a great deal of uncertainty about the growth rate, as indicated by the large confidence intervals. The uncertainly about growth rate is generally higher for chinook than for other LCR anadromous salmonids because of the high variability observed in the time series. A negative long-term growth rate is indicated for all of the populations except the Coweeman fall run when analyzed under the assumption that hatchery-origin fish have a reproductive success equal to natural-origin fish. The Coweeman fall run had very few hatchery-origin spawners (Table A.2.5.2). The potential reasons for these declines have been cataloged in previous status reviews and include habitat degradation, overharvest, deleterious hatchery practices, and climate-driven changes in marine survival.

The Lewis River bright population is considered the healthiest in the ESU. The population is significantly larger than any other population in the ESU, and, in fact, it is larger than any population of salmon in the Columbia Basin except the Hanford Reach chinook. The

Lewis bright chinook harvest has been managed to an escapement target of 5,700 and this target has been met every year for which data are available except 1999 (Figure A.2.5.16). The preharvest recruits have exceeded spawners in all years for which data are available except two (Figure A.2.5.17). There has been a hatchery program for Lewis River brights, but hatchery-origin spawners have generally comprised less than 10% of the spawning population over the time series. These indicators all suggest a relatively healthy population. However, the long-term population trend estimate is negative (Figure A.2.5.30), and it is not clear the extent to which this reflects management decisions to harvest closer to the escapement goal as compared to declining productivity over the time series. The population is also geographically confined to a reach that is only a few kilometers in length and is immediately below Merwin Dam, where it is affected by the flow management of the hydrosystem. This limited spatial distribution is a potential risk factor.

Table A.2.5.2.. Long-term trend and growth rate for subset of Lower Columbia chinook populations for which adequate data are available (95% C.I. are in parentheses). The long-term analysis used the entire data set. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Long-term Trend**	**Long-term Trend of Total Spawners**	**Years for Long-term λ**	**Long-term Median Growth Rate (λ)**	
					Hatchery = 0	**Hatchery = Wild**
Fall	Grays River fall-run	1964-2001	0.965 (0.928-1.003)	1980-2001	0.944 (0.739-1.204)	0.844 (0.660-1.081)
	Elochoman River fall-run	1964-2001	1.019 (0.990-1.048)	1980-2001	1.037 (0.813-1.323)	0.800 (0.625-1.024)
	Mill, Abernathy, Germany Creekd fall-run	1980-2001	0.965 (0.909-1.024)	1980-2001	0.981 (0.769-1.252)	0.829 (0.648-1.006)
	Coweeman River fall-run	1964-2001	1.046 (1.018-1.075)	1980-2001	1.092 (0.855-1.393)	1.091 (0.852-1.396)
	Lower Cowlitz River fall-run	1964-2000	0.951 (0.933-0.968)	1980-2000	0.998 (0.776-1.282)	0.682 (0.529-0.879)
	Kalama River fall-run	1964-2001	0.994 (0.973-1.016)	1980-2001	0.973 (0.763-1.242)	0.818 (0.639-1.048)
	Salmon Creek/ Lewis River fall-run	1980-2001	0.981 (0.949-1.014)	1980-2001	0.984 (0.771-1.256)	0.979 (0.765-1.254)
	Clackamas River fall-run	1967-2001	0.937 (0.910-0.965)	No Hatchery Fraction Data		

	Washougal River fall-run	1964-2001	1.088 (1.002-1.115)	1980-2001	1.025 (0.803-1.308)	0.815 (0.637-1.045)
	Upper Gorge Tributaries fall-run	1964-2001 (Wind only)	0.935 (0.892-0.979)	1980-2001	0.959 (0.751-1.224)	0.955 (0.746-1.223)
	Big White Salmon River fall-run	1967-2001	0.941 (0.912-0.971)	1980-2001	0.963 (0.755-1.229)	0.945 (0.738-1.210)
Late Fall Run (brights)	Sandy River late fall-run	1984-2001	0.946 (0.880-1.014)	1984-2001	0.943 (0.715-1.243)	0.935 (0.706-1.237)
	North Fork Lewis River late fall-run	1964-2001	0.992 (0.980-1.008)	1980-2001	0.968 (0.756-1.204)	0.948 (0.741-1.214)
Spring Run	Upper Cowlitz River spring-run	1980-2001	0.994 (0.942-1.064)	No Hatchery Fraction Data (presumed high)		
	Kalama River spring-run	1980-2001	0.945 (0.840-1.064)	No Hatchery Fraction Data (presumed high)		
	Lewis River spring-run	1980-2001	0.935 (0.879-0.995)	No Hatchery Fraction Data (presumed high)		

Table A.2.5.3. Short-term trend and growth rate for subset of Lower Columbia chinook populations for which adequate data are available (95% C.I. are in parentheses). Short-term data sets include data from 1990 to the most recent available year. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Short-term Trend**	**Short-term Trend of Total Spawners**	**Years for Short-term λ**	**Short-term Median Growth Rate (λ)**	
					Hatchery = 0	**Hatchery = Wild**
Fall	Grays River fall-run	1990-2001	1.086 (0.840-1.405)	1990-2001	1.004 (0.787-1.282)	0.898 (0.701-1.150)
	Elochoman River fall-run	1990-2001	1.154 (0.988-1.347)	1990-2001	1.119 (0.877-1.428)	0.869 (0.679-1.113)
	Mill, Abernathy, Germany Creeks fall-run	1990-2001	0.974 (0.833-1.139)	1990-2001	0.993 (0.778-1.268)	0.823 (0.643-1.054)
	Coweeman River fall-run	1990-2001	0.985 (0.816-1.139)	1990-2001	0.977 (0.765-1.247)	0.977 (0.763-1.251)
	Lower Cowlitz River fall-run	1990-2000	1.031 (0.969-1.097)	1990-2000	1.231 (0.873-1.443)	0.782 (0.607-1.009)

	Kalama River fall-run	1990-2001	0.996 (0.898-1.104)	1990-2001	0.944 (0.740-1.205)	0.799 (0.624-1.022)
	Salmon Creek/ Lewis River fall-run	1990-2001	1.017 (0.929-1.114)	1990-2001	1.027 (0.805-1.311)	1.027 (0.802-1.315)
	Clackamas River fall-run	1990-2001	0.799 (0.677-0.945)	1990-2001	No Hatchery Fraction Data	
	Washougal River fall-run	1990-2001	1.009 (0.961-1.058)	1990-2001	0.985 (0.722-1.257)	0.769 (0.600-0.989)
	Upper Gorge Tributaries fall-run	1990-2001	1.291 (0.943-1.769)	1990-2001	1.246 (0.976-1.590)	1.235 (0.964-1.581)
	Big White Salmon River fall-run	1990-2001	1.106 (0.899-1.361)	1990-2001	1.057 (0.828-1.348)	1.013 (0.791-1.297)
Late Fall Run (brights)	Sandy River late fall-run	1990-2001	0.915 (0.796-1.052)	1990-2001	0.919 (0.697-1.212)	0.912 (0.689-1.207)
	North Fork Lewis River late fall-run	1990-2001	0.969 (0.889-1.056)	1990-2001	0.966 (0.754-1.236)	0.945 (0.738-1.210)
Spring Run	Upper Cowlitz River spring-run	1990-2001	1.011 (0.891-1.148)	1990-2001	No Hatchery Fraction Data	
	Kalama River spring-run	1990-2001	1.080 (0.880-1.326)	1990-2001	No Hatchery Fraction Data	
	Lewis River spring-run	1990-2001	0.857 (0.783-0.937)	1990-2001	No Hatchery Fraction Data	

Table A.2.5.4. Probability that the long-term abundance trend or growth rate of as subset of Lower Columbia River steelhead populations is less than one. In the "Hatchery = 0" columns, the hatchery-origin fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	**Population**	**Long –Term Analysis**			**Short-Term Analysis**		
		Prob. Trend <1	**Prob. λ <1**		**Prob. Trend <1**	**Prob. λ <1**	
			Hatchery =0	**Prob. Trend <1**		**Hatchery =0**	**Hatchery = Wild**
Fall Run	Grays River fall-run	0.965	0.715	0.947	0.245	0.491	0.710
	Elochoman River fall-run	0.099	0.373	0.967	0.033	0.270	0.765
	Mill, Abernathey, Germany Creeks fall-run	0.887	0.581	0.973	0.643	0.514	0.833
	Coweeman River fall-run	0.001	0.194	0.196	0.570	0.556	0.556
	Lower Cowlitz River fall-run	1.000	0.510	0.510	0.148	0.216	0.952

	Kalama River fall-run	0.710	0.612	0.612	0.536	0.704	0.962
	Salmon Creek/ Lewis River fall-run	0.876	0.663	0.663	0.340	0.331	0.331
	Clackamas River fall-run	1.000	No hatchery fraction data		0.993	No hatchery fraction data	
	Washougal River fall-run	0.000	0.323	0.323	0.350	0.556	0.989
	Upper Gorge Tributaries fall-run	0.997	0.612	0.612	0.050	0.137	0.148
	Big White Salmon River fall-run	1.000	0.623	0.623	0.151	0.405	0.476
Late Fall Run (brights)	Sandy River late fall-run	0.994	0.833	0.833	0.906	0.828	0.849
	North Fork Lewis River late fall-run	0.817	0.800	0.800	0.785	0.733	0.841
Spring Run	Upper Cowlitz River spring-run	0.591	No hatchery fraction data		0.423	No hatchery fraction data	
	Kalama River spring-run	0.834	No hatchery fraction data		0.210	No hatchery fraction data	
	Lewis River spring-run	0.993	No hatchery fraction data		0.998	No hatchery fraction data	

Ecosystem Diagnosis and Treatment (EDT) based estimates of historical abundance

The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of the Lower Columbia River chinook populations using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). The EDT model attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/ dungenesswc/EDT-primer.pdf). WDFW populated this model with estimates of historical habitat condition that produced the estimates of average historical abundance shown in Table A.2.5.5. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates that should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas are historically accessible but currently blocked by large dams are omitted from the analyses, and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Table A.2.5.5. Estimate of historical abundance based on EDT analysis by WDFW of equilibrium abundance under historical habitat conditions (Busack and Rawding 2003).

Population	EDT Estimate of Historical Abundance
Grays River fall-run	2,477
Coweeman River fall-run	4,971
Lower Cowlitz River fall--run	53,956
Toutle River fall-run	25,392
Kalama River fall-run	2,455
Lewis River fall-run (East Fork only)	4,220
Lewis River late fall-run (brights)	43,371
Washougal River fall-run	7,518
Upper Gorge Tributaries fall-run (Wind River only)	2,363
Toutle River spring-run	2,901
Kalama River spring-run	4,178

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the LCR (Table A.2.5.6). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream kilometers as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations (particularly spring run) the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table A.2.5.6.. Loss of habitat from barriers. The potential current habitat is the kilometers of stream with a gradient between 0.5% and 4% below all currently impassable barriers. The potential historical habitat is the kilometers of stream with a gradient of between 0.5% and 4% below historically impassable barriers. The current to historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat (km)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio (%)
Youngs Bay fall-run	178	195	91
Grays River fall-run	133	133	100
Big Creek fall-run	92	129	71
Elochoman River fall-run	85	116	74
Clatskanie River fall-run	159	159	100
Mill, Abernathy, Germany Creeks fall-run	117	123	96
Scappoose Creek fall-run	122	157	78
Coweeman River fall-run	61	71	86
Lower Cowlitz River fall-run	418	919	45
Upper Cowlitz River fall-run			
Toutle River fall-run	217	313	69

Kalama River fall-run	78	83	94
Salmon Creek/Lewis River fall-run	438	598	73
Clackamas River fall-run	568	613	93
Washougal River fall-run	84	164	51
Sandy River fall-run	227	286	79
Lower Gorge Tributaries fall-run	34	35	99
Upper Gorge Tributaries fall-run	23	27	84
Hood River fall-run	35	35	100
Big White Salmon River fall-run	0	71	0
Sandy River late fall-run	217	225	96
North Fork Lewis River late fall-run (brights)	87	166	52
Upper Cowlitz spring-run	4	276	1
Cispus River spring-run	0	76	0
Tilton River spring-run	0	93	0
Toutle River spring-run	217	313	69
Kalama River spring-run	78	83	94
Lewis River spring-run	87	365	24
Sandy River spring-run	167	218	77
Big White Salmon River spring-run	0	232	0
Hood River spring-run	150	150	99
Total	4,075	6,421	63

A.2.5.4 New Hatchery Information

Recent Hatchery Releases

Updated information on chinook hatchery releases in the ESU is provided in Appendix A.5.3. These data indicate a high level of chinook hatchery production in the LCR. Categorizations of Lower Columbia River hatchery stocks (SSHAG 2003) can be found in Appendix A.5.1.

A.2.5.5 Comparison with Previous Data

ESU Summary

The ESU exhibits three major life history types: fall run ("tules"), late fall run ("brights"), and spring run. The ESU spans three ecological zones: Coastal (rain driven hydrograph), Western Cascade (snow or glacial driven hydrograph), and Gorge (transitioning to drier interior Columbia ecological zones). The fall chinook populations are currently dominated by large scale hatchery production, relatively high harvest and extensive habitat degradation (discussed in previous status reviews). The Lewis River late fall chinook population is the healthiest in the ESU and has a reasonable probability of being self-sustaining. The spring-run populations are largely extirpated as the result of dams which block access to their high elevation habitat. Abundances have largely declined since the last status review update (1998) and trend indicators for most populations are negative, especially if hatchery fish are assumed to have a reproductive success equivalent to that of natural-origin fish. However, 2001 abundance estimates increased

for most LCR chinook populations over the previous few years and preliminary indications are that 2002 abundance also increased (Rawding, WDFW pers. com.). Many salmon populations in the Northwest have shown increases in abundance over the last few years and the relationship of these increases to potential changes in marine survival are discussed in the introduction to this report.

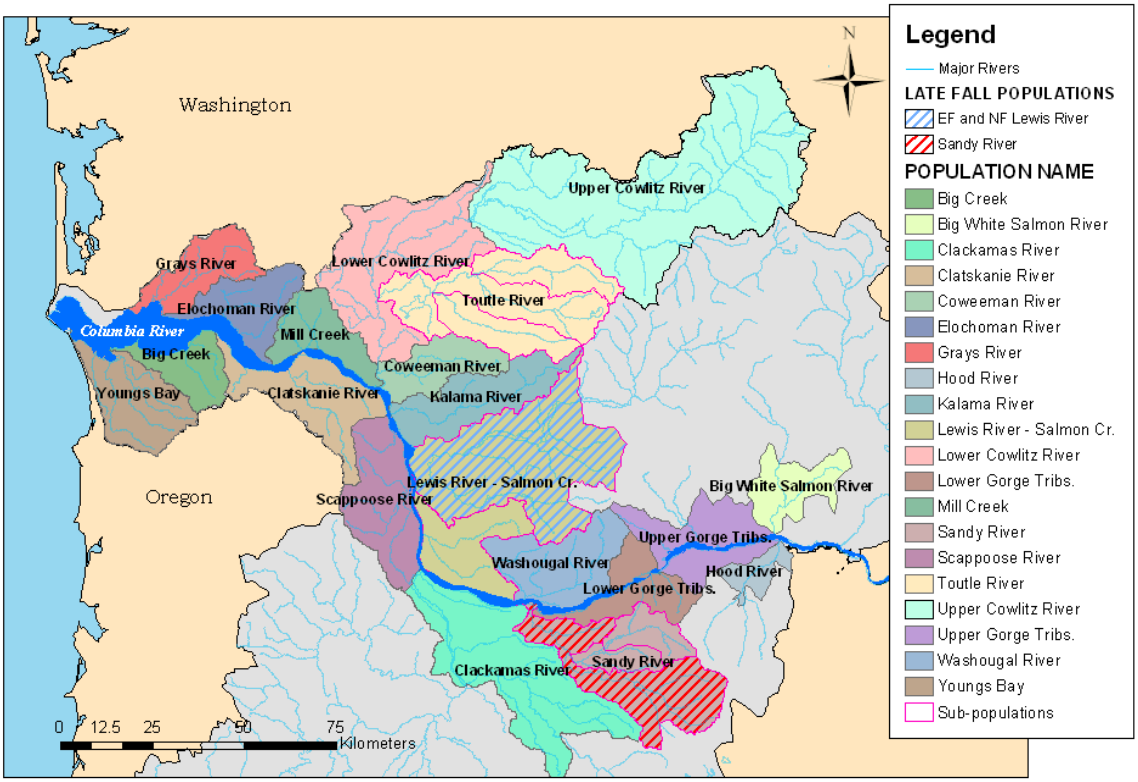


Figure A.2.5.1. Historical independent LCR early and late fall Chinook populations (Myers et al. 2002).

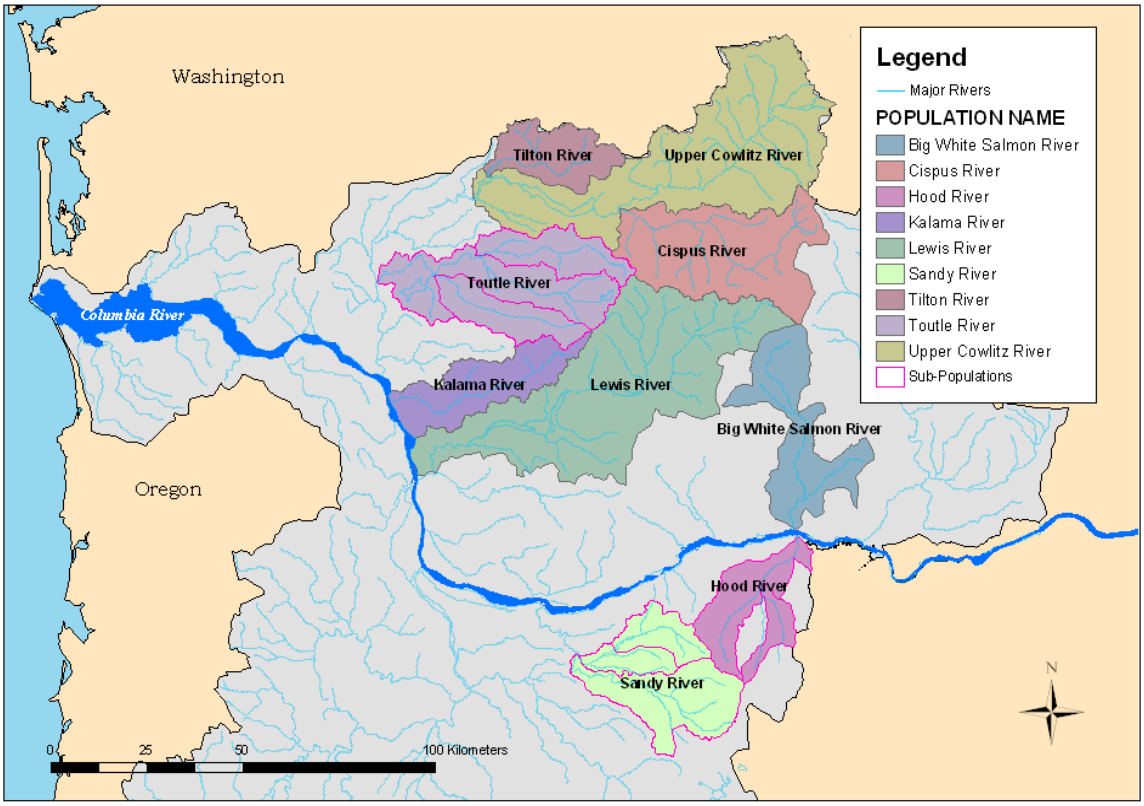


Figure A.2.5.2. Historical independent LCR spring Chinook populations (Myers et al. 2002).

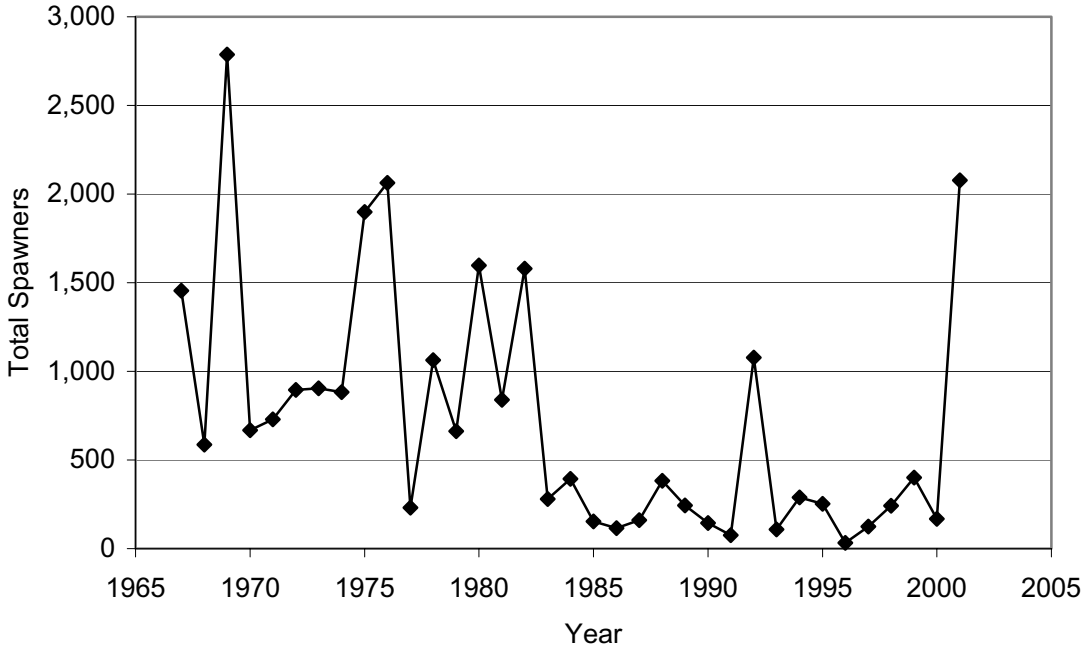


Figure A.2.5.3. Big White Salmon River fall-run chinook spawner abundance (hatchery and natural-origin).

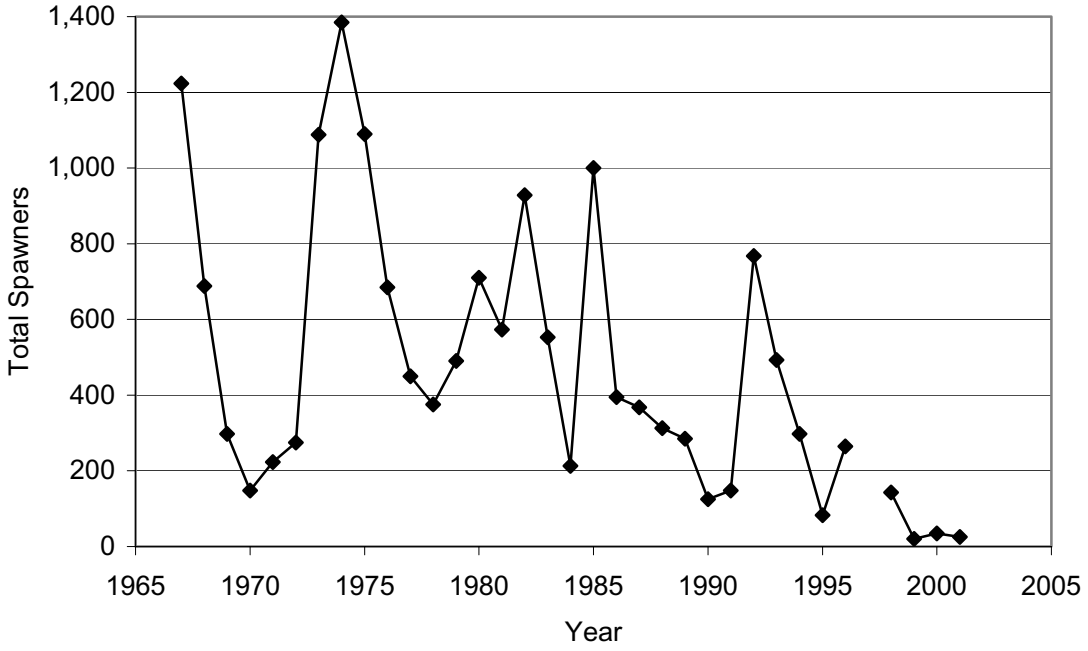


Figure A.2.5.4. Clackamas River fall-run chinook spawner abundance (hatchery and natural origin).

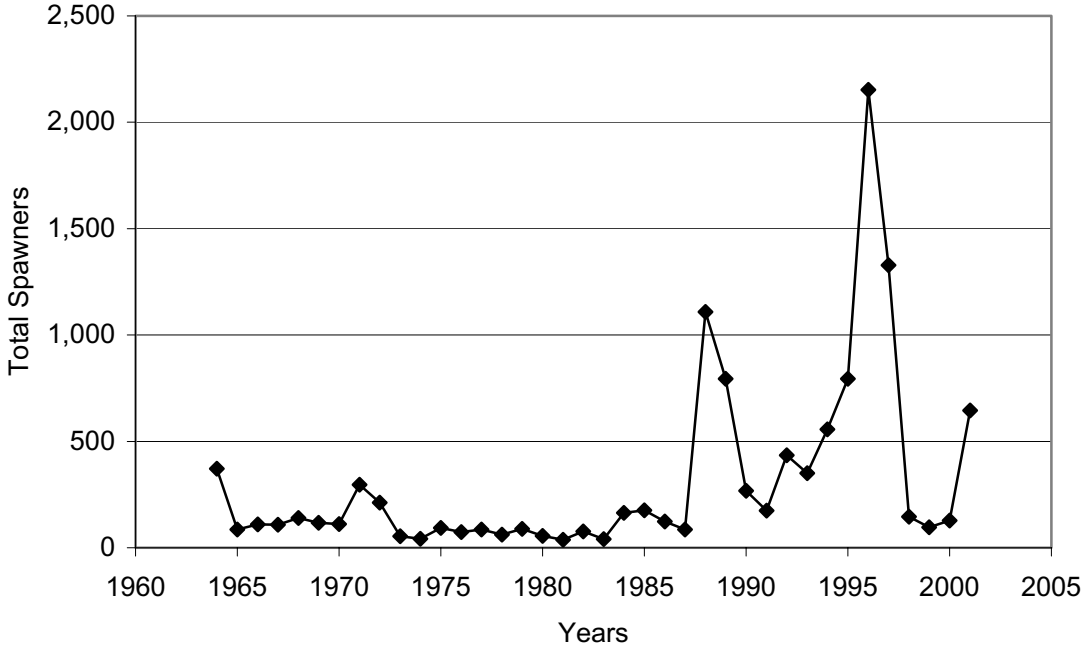


Figure A.2.5.5. Coweeman River fall-run chinook spawner abundance (almost all spawners are of natural origin).

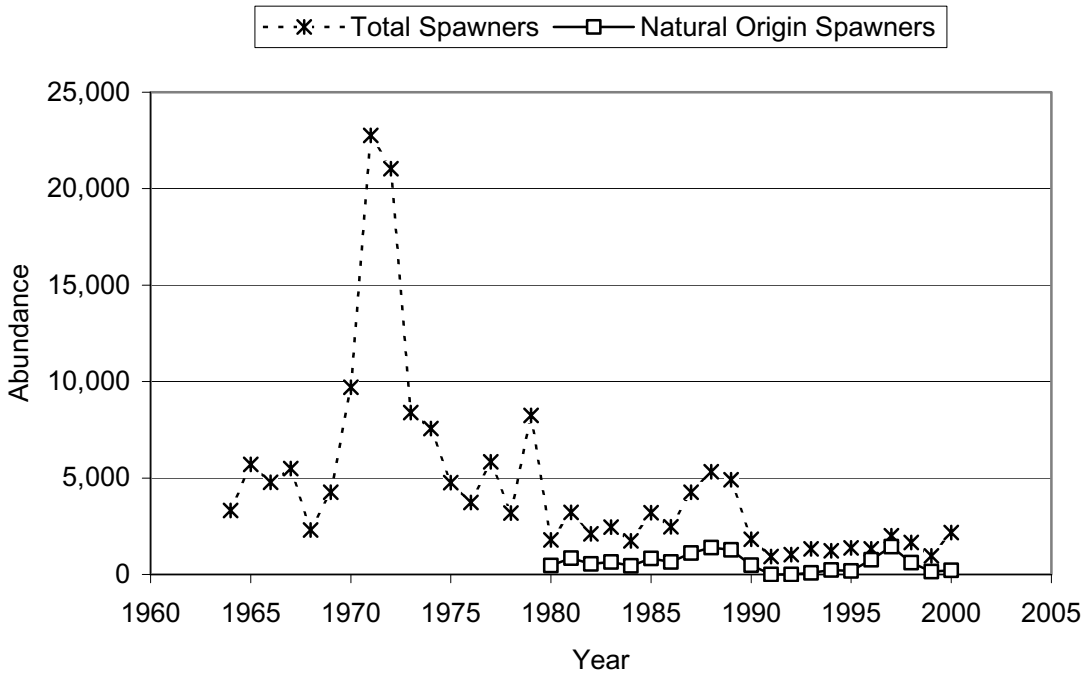


Figure A.2.5.6. Lower Cowlitz River fall-run chinook spawner abundance.

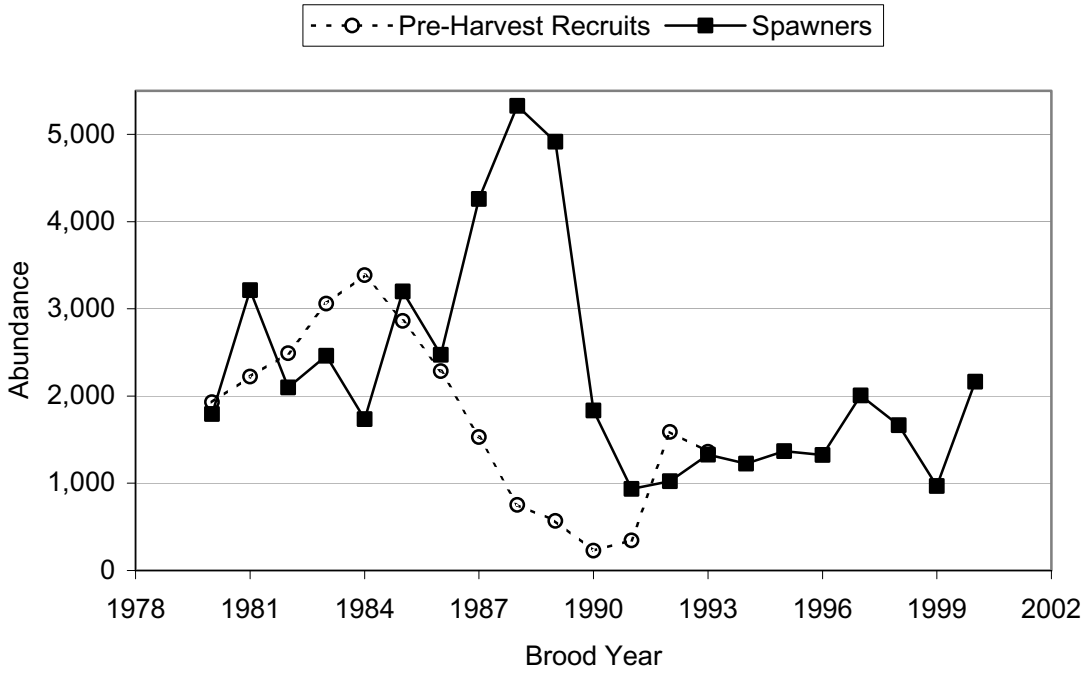


Figure A.2.5.7. Estimate of fall-run chinook pre-harvest recruits and spawners in the Cowlitz River.

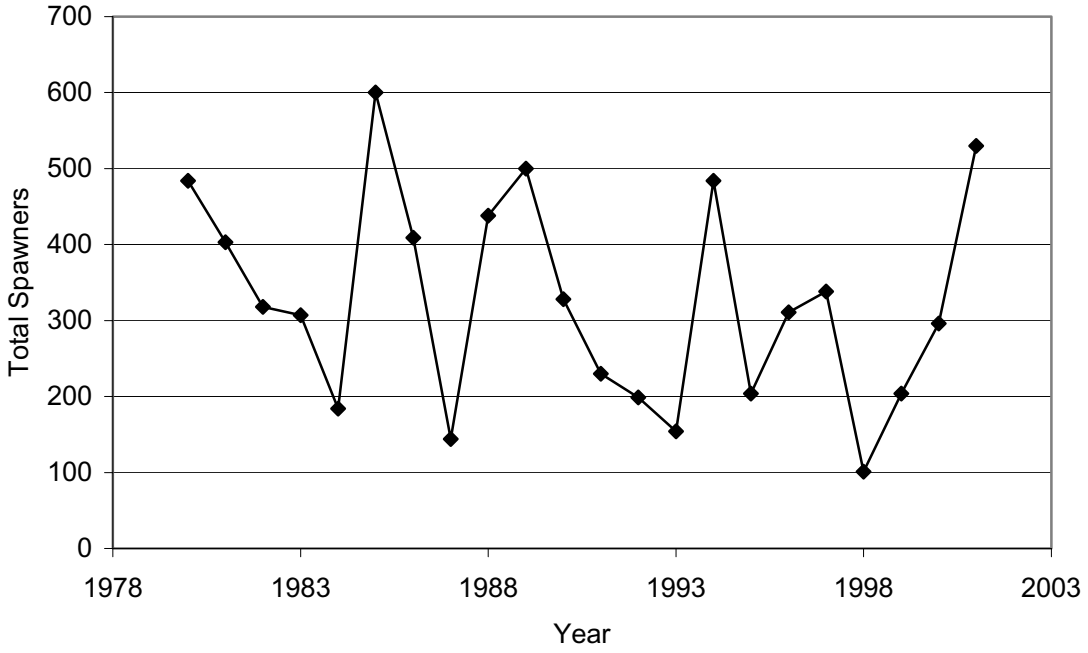


Figure A.2.5.8. East Fork Lewis River fall-run chinook total spawner abundance (almost all spawners are of natural origin).

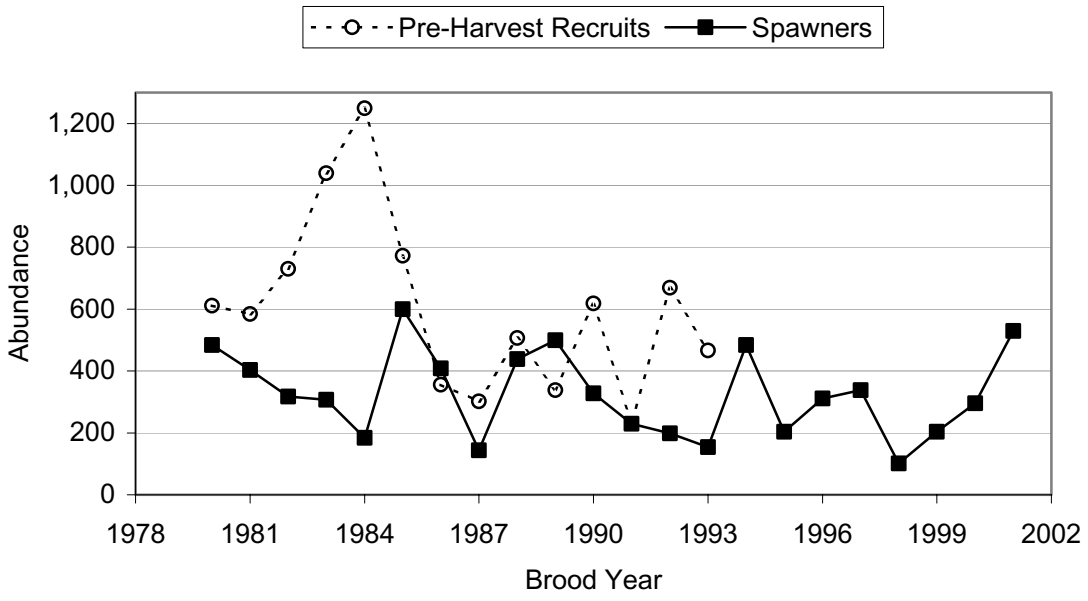


Figure A.2.5.9. Estimate of fall-run chinook preharvest recruits and spawners in the East Fork Lewis River.

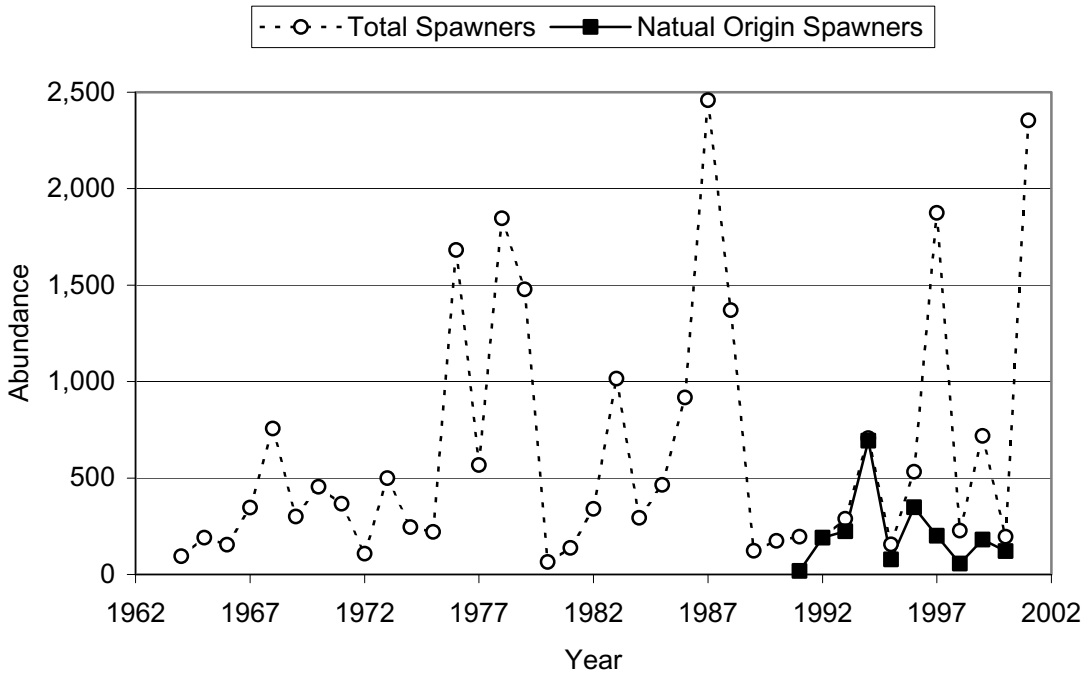


Figure A.2.5.10. Elochoman River fall-run chinook spawner abundance.

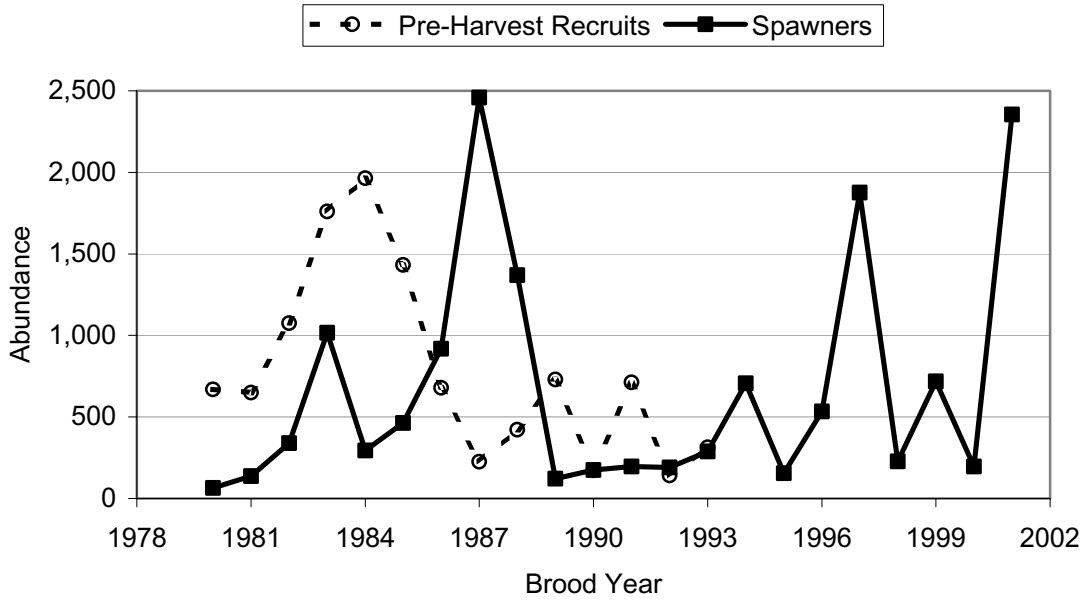


Figure A.2.5.11. Estimate of fall-run chinook pre-harvest recruits and spawners in the Elochoman River.

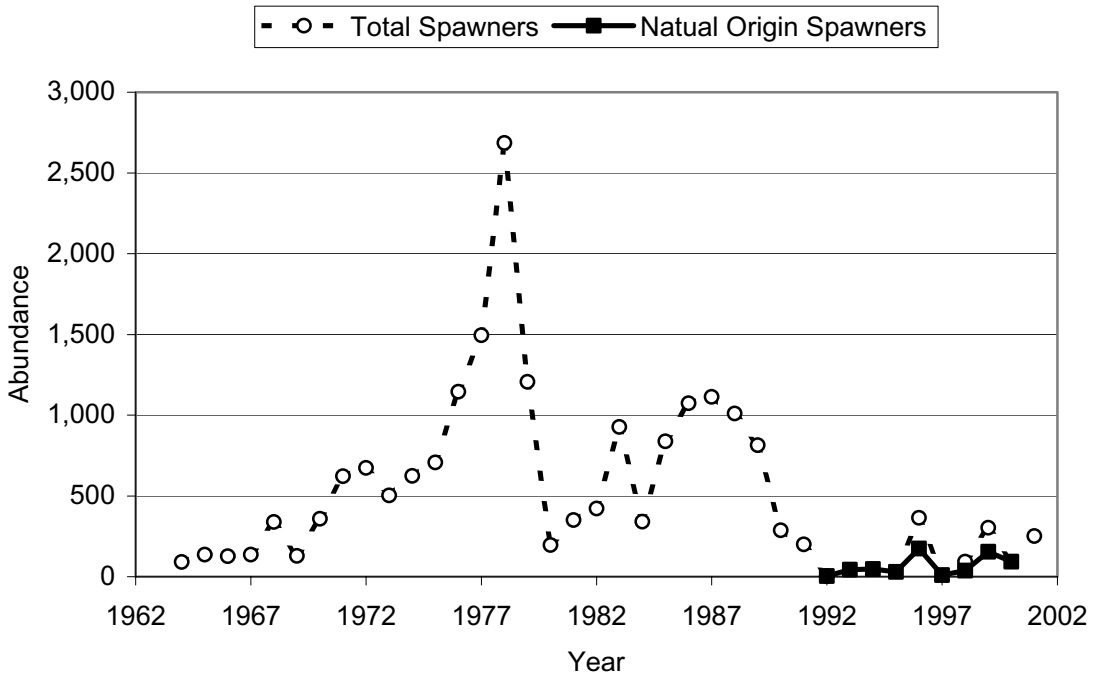


Figure A.2.5.12. Grays River fall-run chinook spawner abundance.

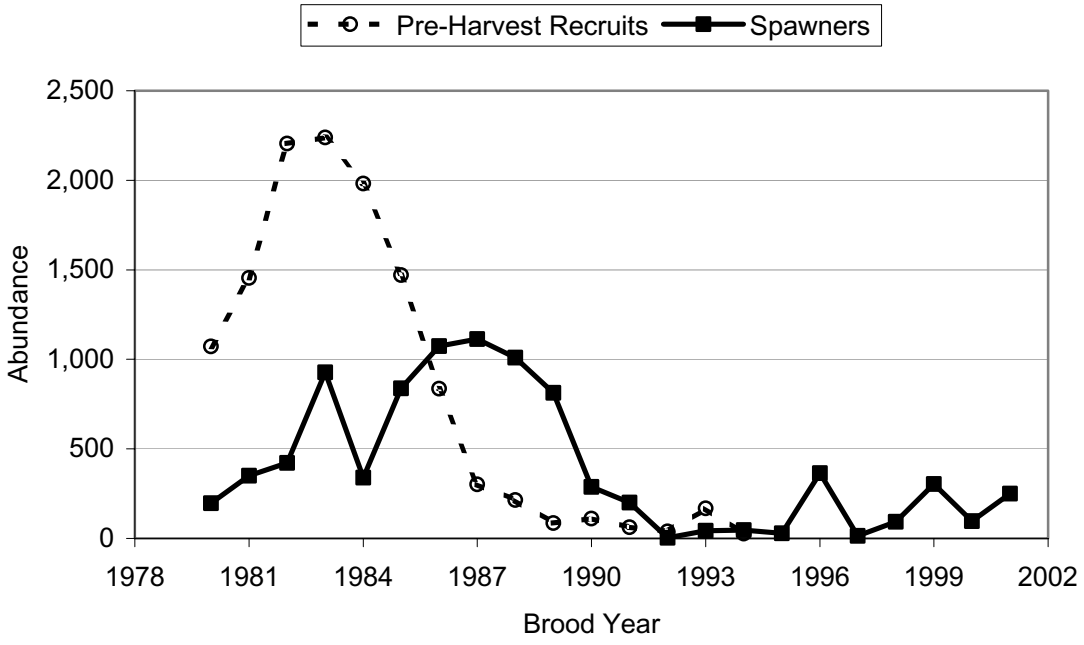


Figure A.2.5.13. Estimate of Grays River fall-run chinook pre-harvest recruits and spawners.

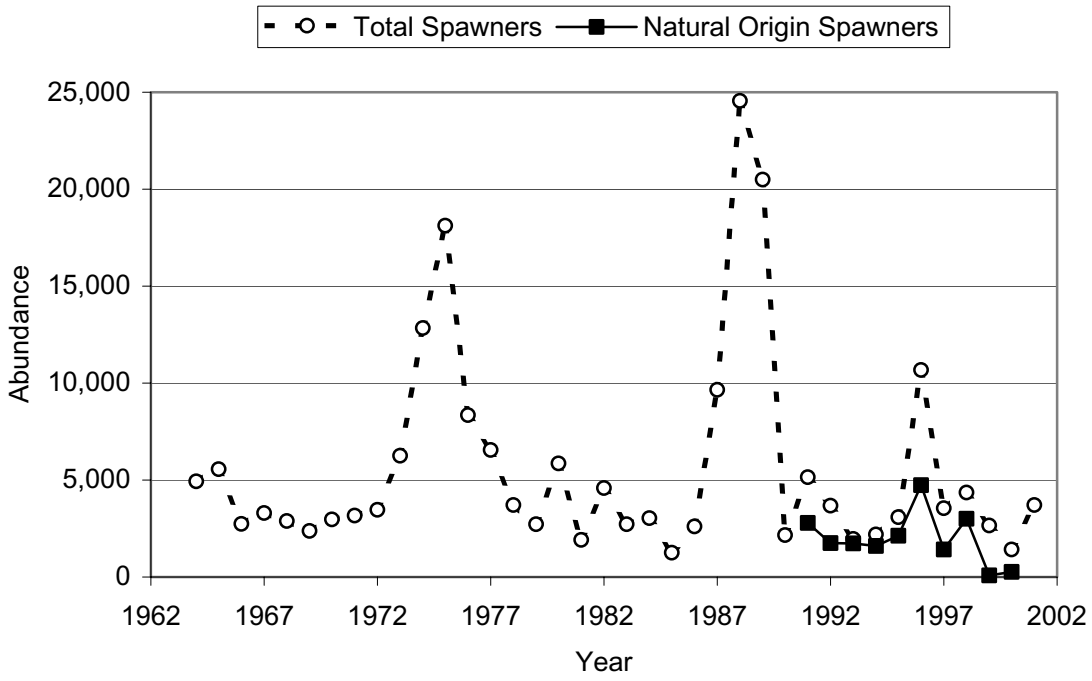


Figure A.2.5.14. Kalama River fall-run chinook spawner abundance.

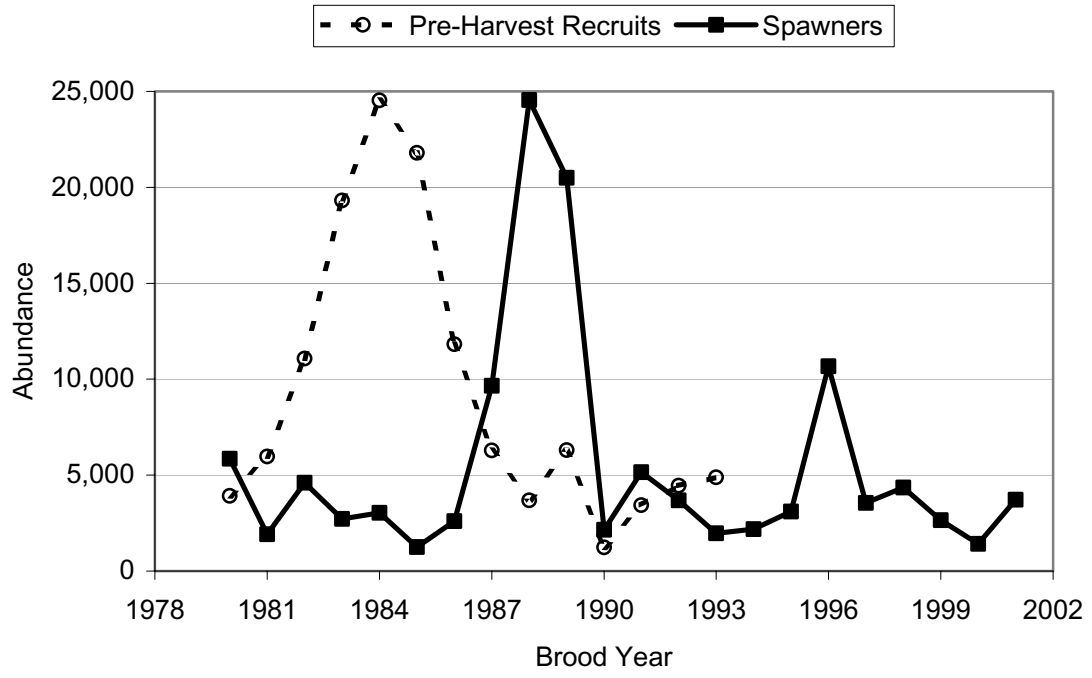


Figure A.2.5.15. Estimate of Kalama River fall-run chinook pre-harvest recruits and spawners.

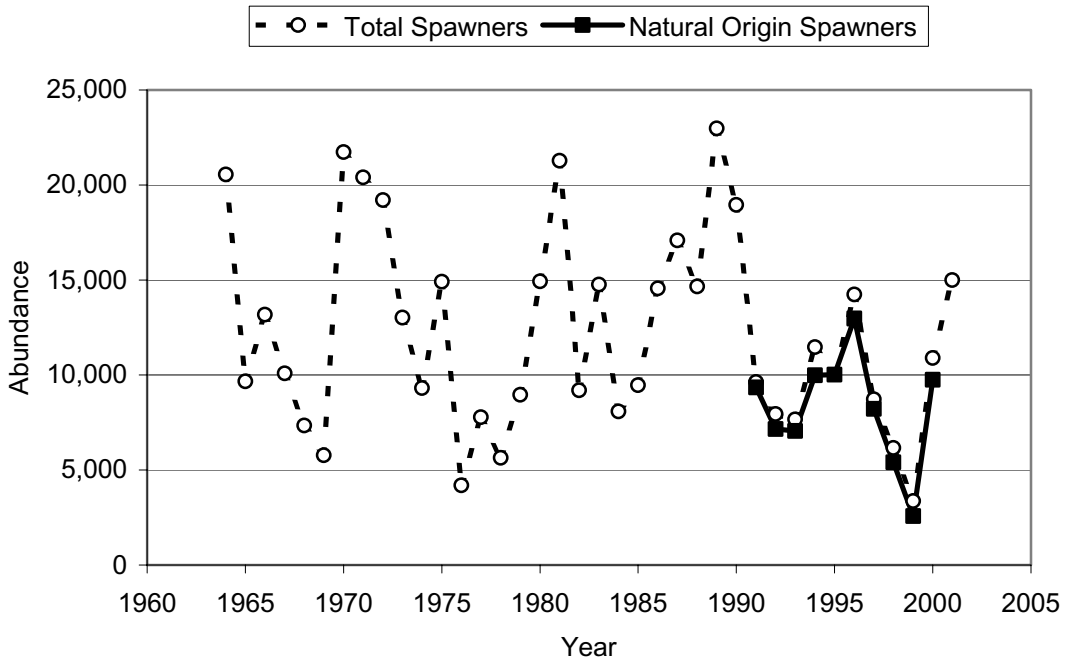


Figure A.2.5.16. Lewis River late fall-run (bright) chinook spawner abundance.

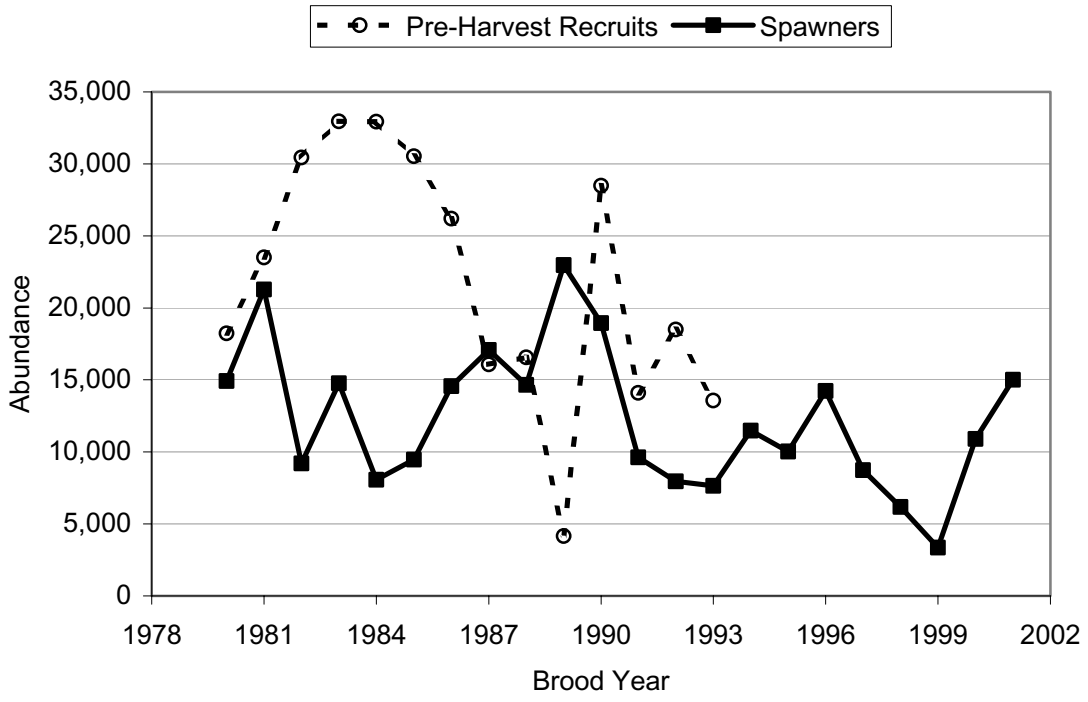


Figure A.2.5.17. Estimate of Lewis River late fall-run (bright) chinook pre-harvest recruits and spawners.

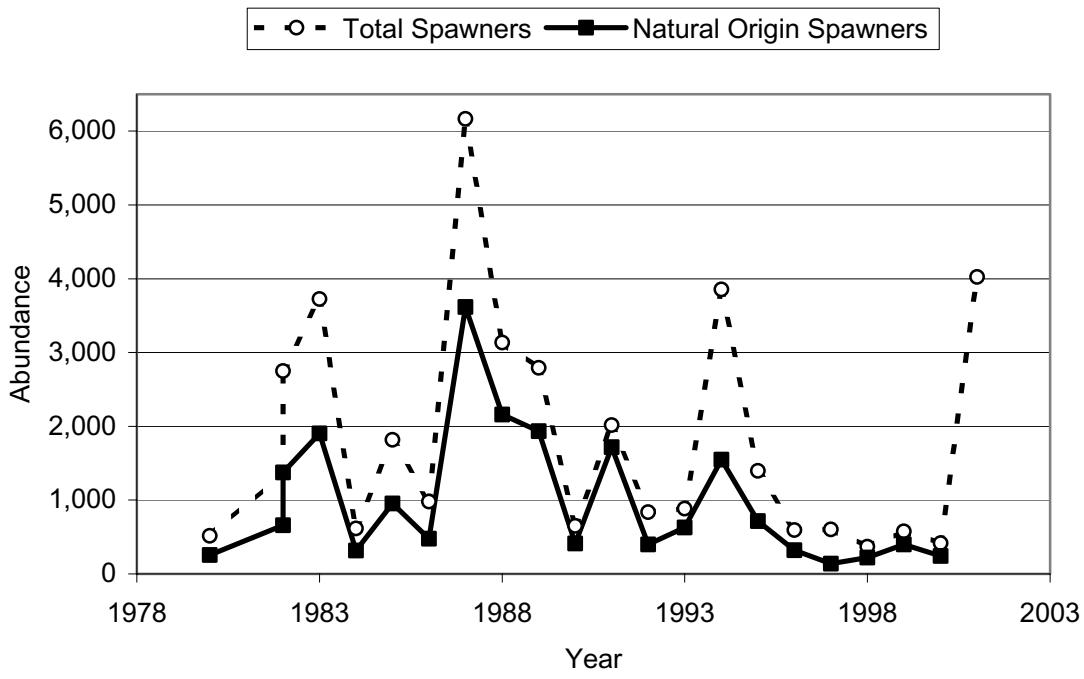


Figure A.2.5.18. Mill/Germany/Abernathy Creeks fall-run chinook spawner abundance.

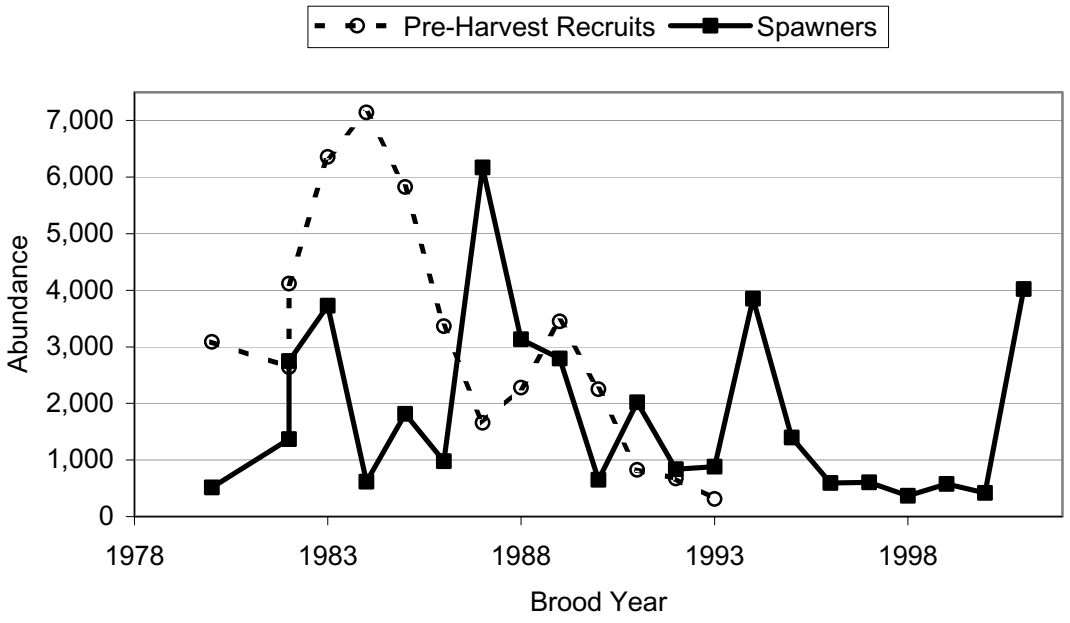


Figure A.2.5.19. Estimate of Mill/Germany/Abernathy Creeks fall-run chinook pre-harvest recruits and spawners.

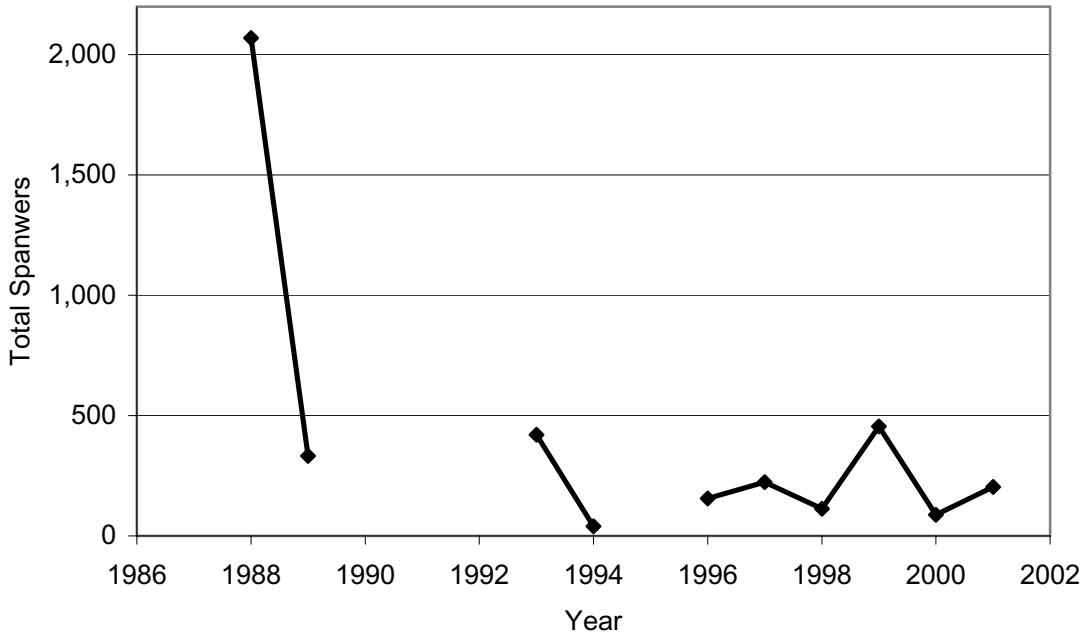


Figure A.2.5.20. Sandy River fall-run chinook spawner abundance.

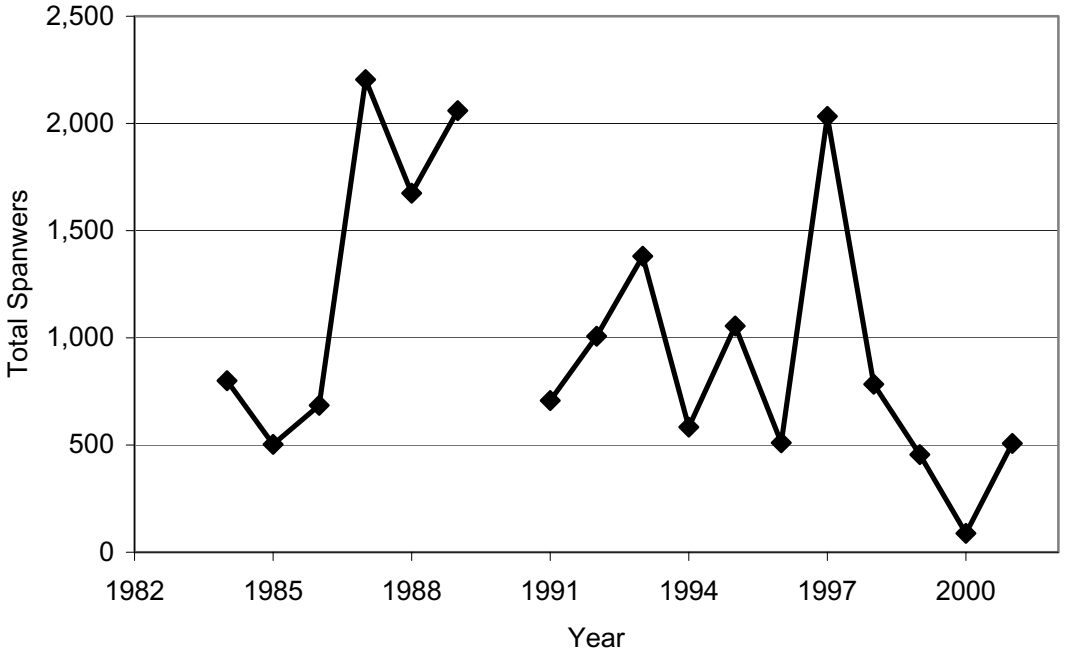


Figure A.2.5.21. Sandy River late fall-run (bright) chinook spawner abundance.

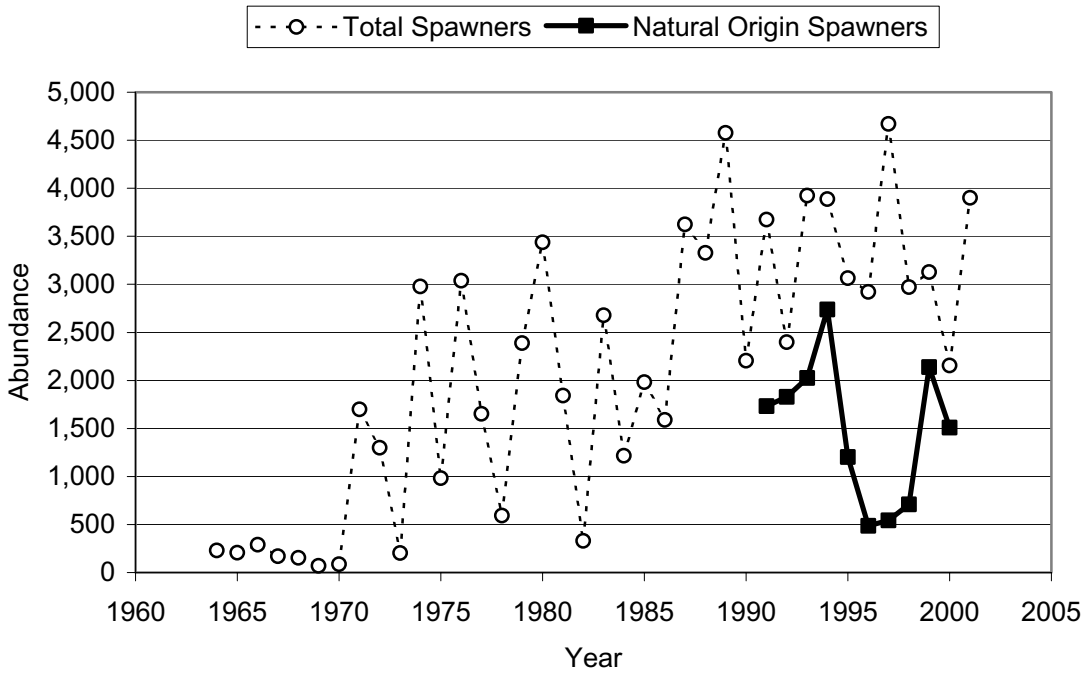


Figure A.2.5.22. Washougal River fall-run chinook spawner abundance.

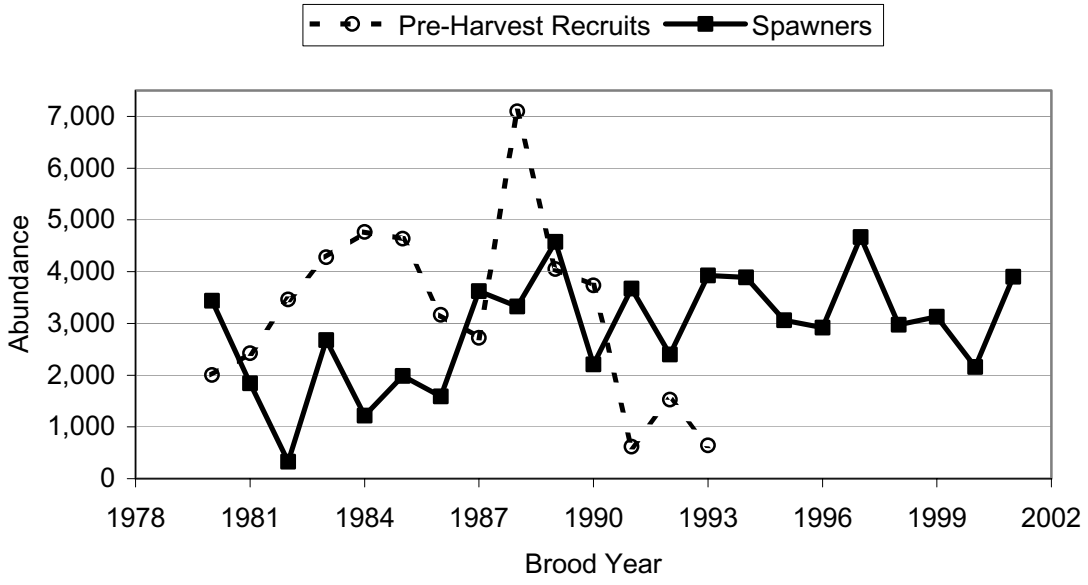


Figure A.2.5.23. Estimate of Washougal River fall-run chinook pre-harvest recruits and spawners.

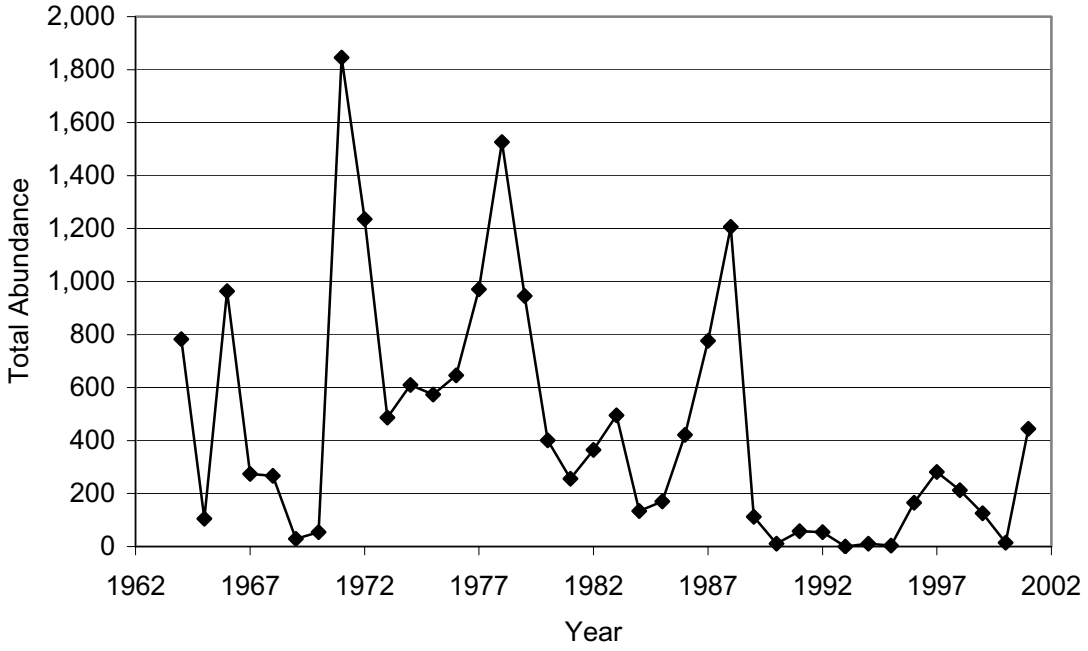


Figure A.2.5.24. Wind River fall-run chinook total spawner abundance (hatchery and natural origin).

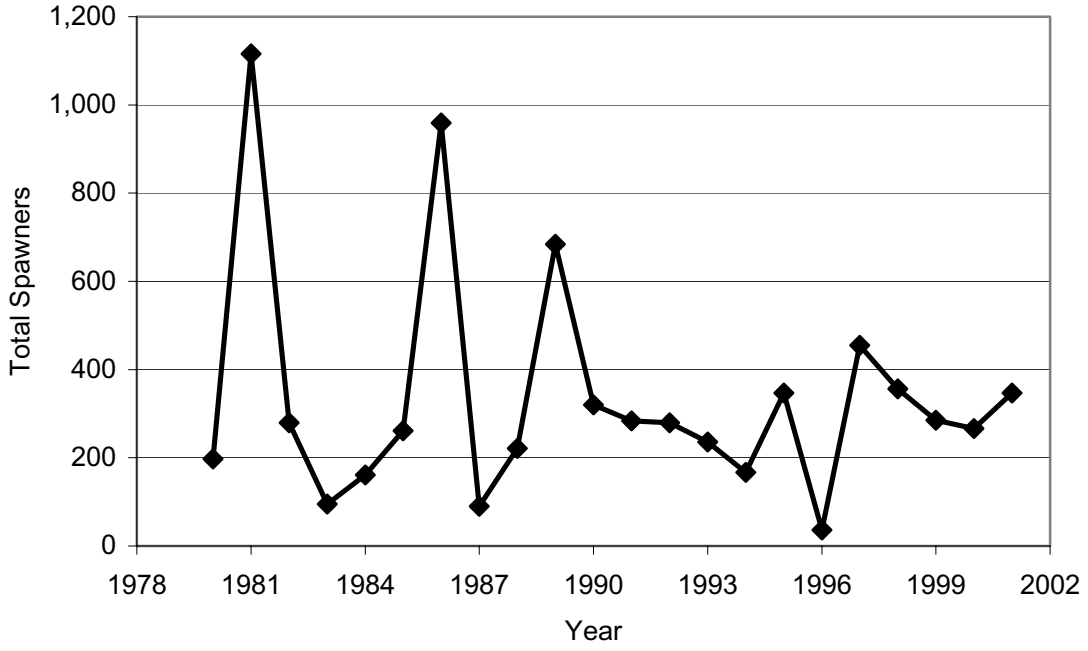


Figure A.2.5.25. Cowlitz River spring-run chinook total spawner abundance below Mayfield Dam (the majority of spawners are of hatchery origin).

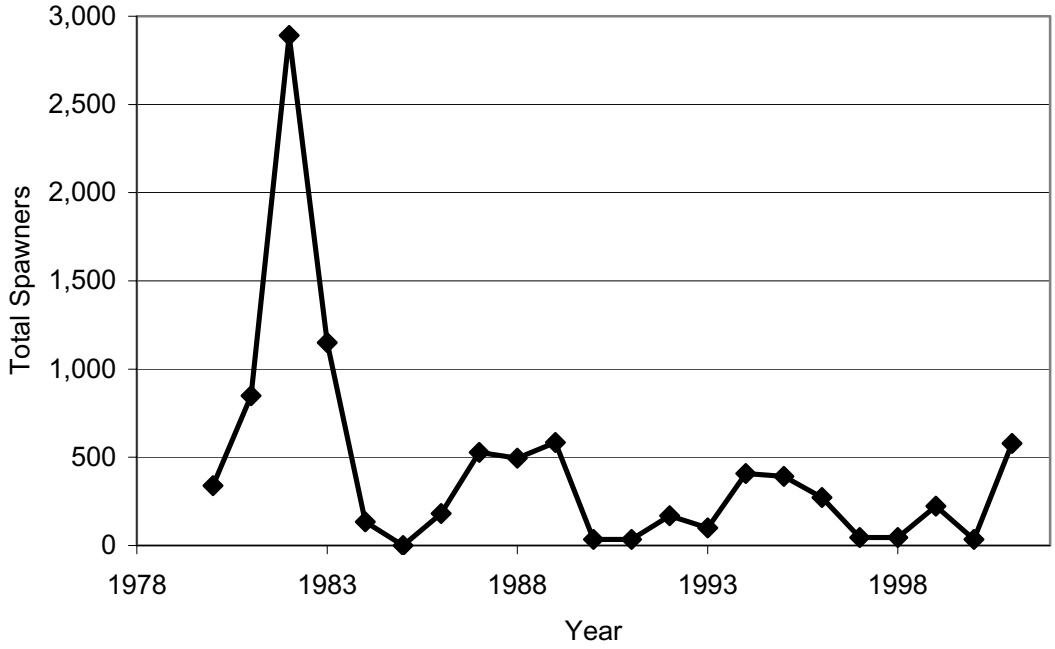


Figure A.2.5.26. Kalama River spring-run chinook total spawner (the majority of spawners are of hatchery origin).

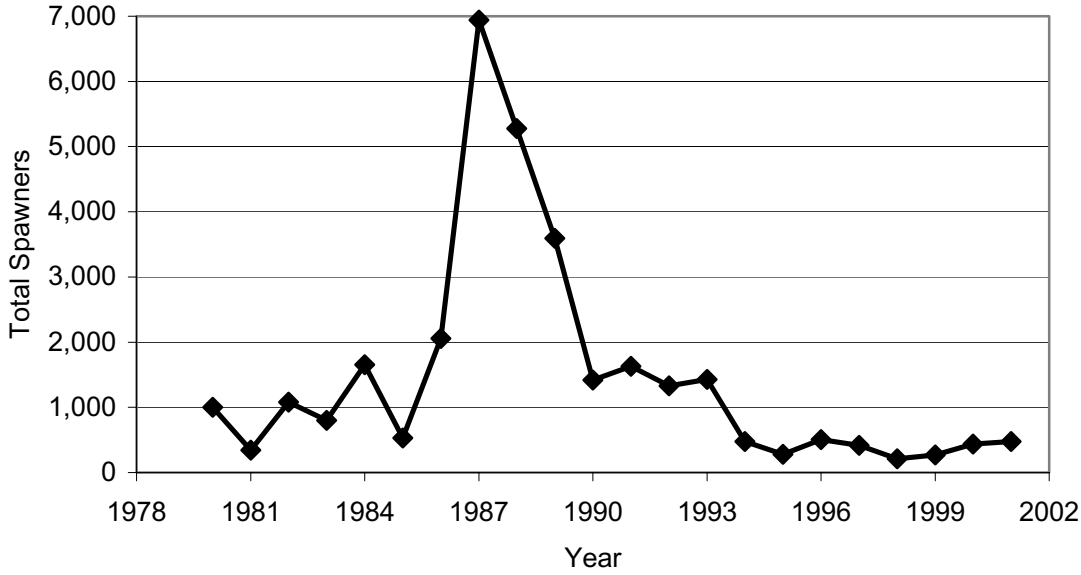


Figure A.2.5.27. Lewis River spring-run chinook total spawner abundance below Merwin Dam (the majority of spawners are of hatchery origin).

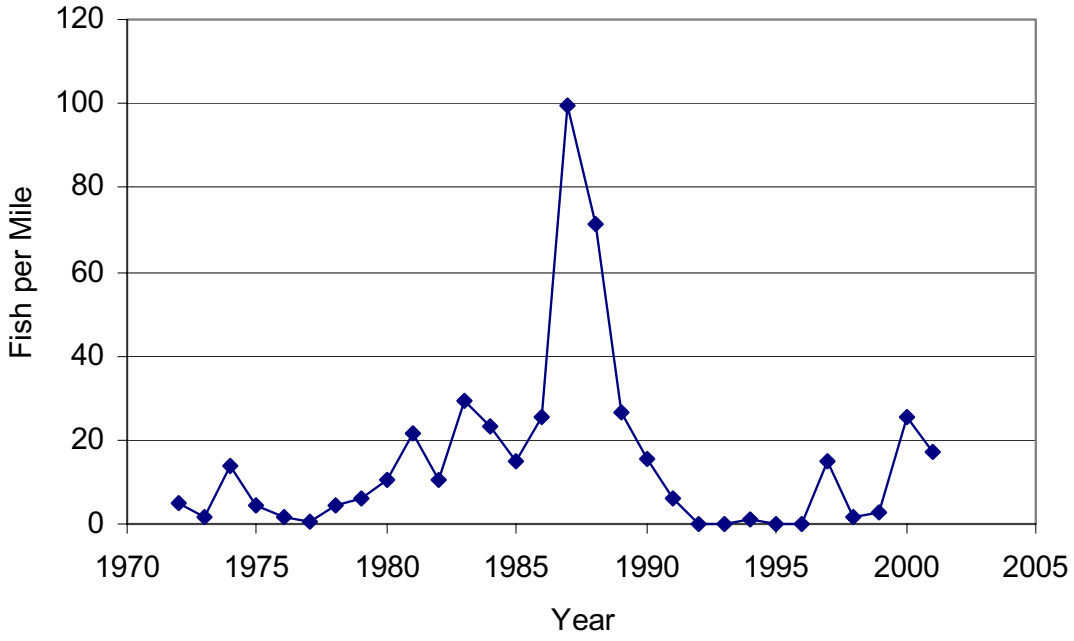


Figure A.2.5.28. Youngs Bay chinook fish-per-mile.

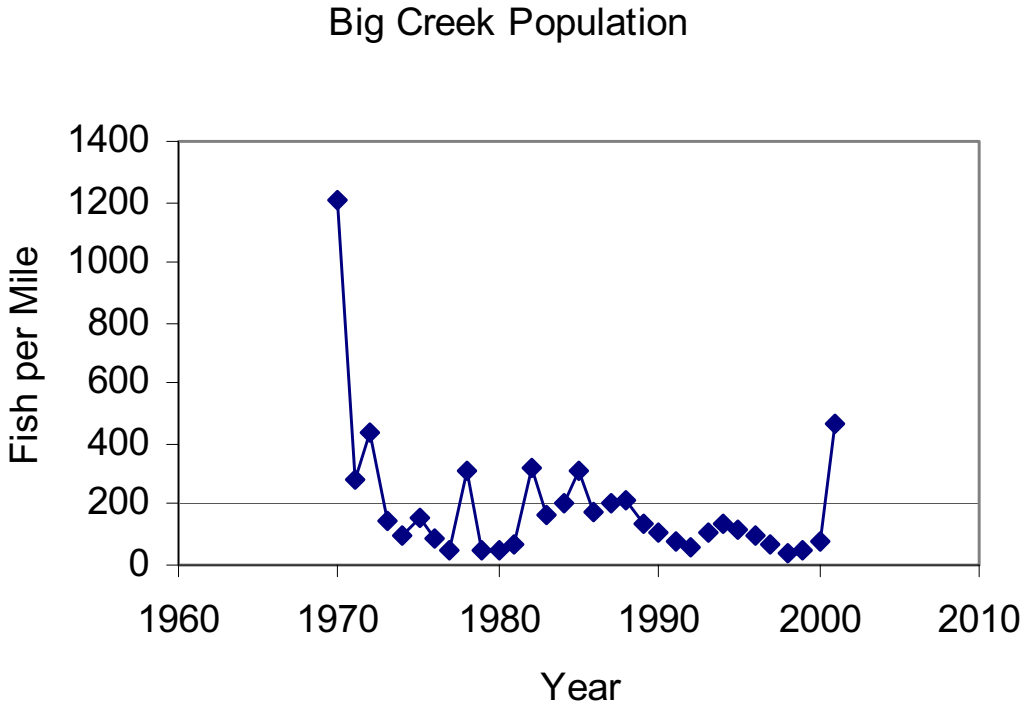


Figure A.2.5.29. Big Creek chinook fish-per-mile.

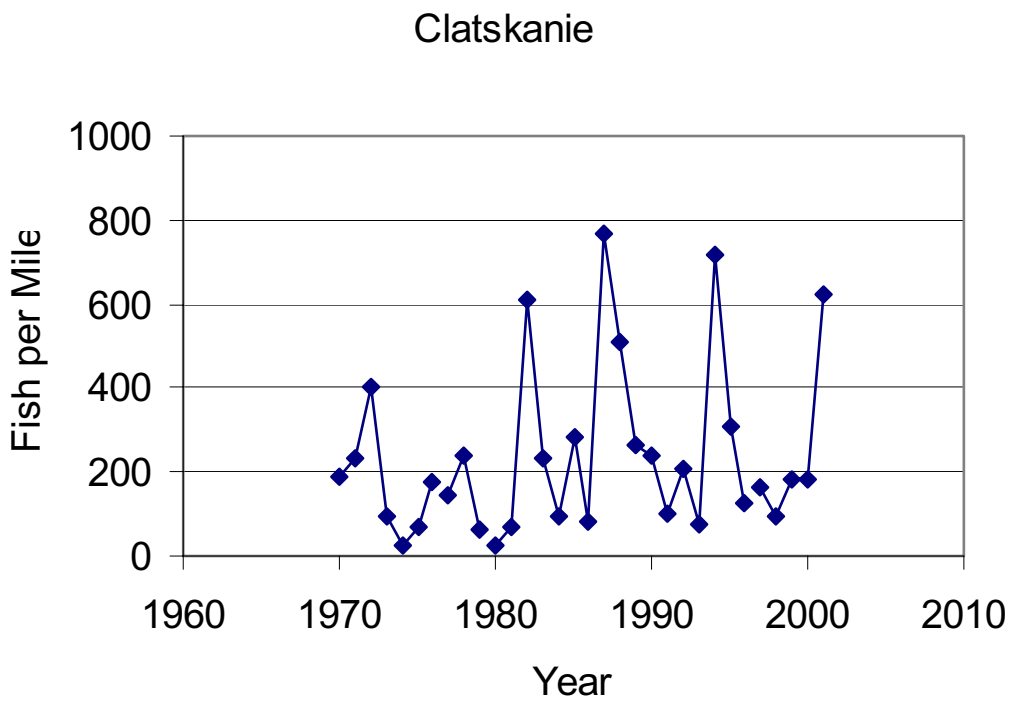


Figure A.2.5.30. Clatskanie River chinook fish-per-mile.

A.2.6 UPPER WILLAMETTE RIVER CHINOOK SALMON

A.2.6.1 Summary of Previous BRT Conclusions

The status of Upper Willamette River chinook was initially reviewed by NMFS in 1998 (Myers et al.1998) and updated in that same year (NMFS 1998). In the 1998 update, the BRT noted several concerns for this ESU. The previous BRT was concerned about the few remaining populations of spring chinook salmon in the Upper Willamette River ESU, and the high proportion of hatchery fish in the remaining runs. The BRT noted with concern that ODFW was able to identify only one remaining naturally-reproducing population in this ESU–the spring chinook salmon in the McKenzie River. The previous BRT was concerned about severe declines in short-term abundance that occurred throughout the ESU, and the McKenzie River population had declined precipitously, indicating that it may not be self-sustaining. The 1998 BRT also noted the potential for interactions between native spring-run and introduced fall-run chinook salmon had increased relative to historical times due to fall-run chinook salmon hatchery programs and the laddering of Willamette Falls. The previous BRT partially attributed the declines in spring chinook salmon in the Upper Willamette River ESU to the extensive habitat blockages caused by dam construction. The previous BRT was encouraged by efforts to reduce harvest pressure on naturally-produced spring chinook salmon in Upper Willamette River tributaries, and the increased focus on selective marking of hatchery fish should help managers targeting specific populations of wild or hatchery chinook salmon. A majority of the previous (1998) BRT concluded that the Lower Columbia River ESU was likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU were not presently in danger of extinction, nor were they likely to become so in the foreseeable future.

Current Listing Status: threatened

A.2.6.2 New Data and Updated Analyses

New data for this update include spawner abundance through 2002 in Clackamas, 2001 in McKenzie and 2001 at Willamette Falls. In addition, new data include updated redd surveys in the basin, new estimates of the fraction of hatchery-origin spawners in McKenzie and North Santiam from an otolith marking study, the first estimate of hatchery fraction in the Clackamas (2002 data), and information on recent hatchery releases. New analyses for this update include: the designation of relatively demographically independent populations, recalculation of previous BRT metrics in the McKenzie with additional years of data, estimates of current and historically available kilometers of stream, and updates on current hatchery releases.

Historical population structure—As part of its effort to develop viability criteria for UW chinook, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. (2002) hypothesized that the ESU historically consisted of 7 spring run populations (Figure A.2.6.1). The populations identified in Myers et al. (2002) are used as the units for the new analyses in this report.

Abundance and trends

References for abundance time series and related data are in Appendix A.5.3. Recent abundance of natural-origin spawners, recent fraction of hatchery-origin spawners, and recent harvest rates for UW Chinook populations are summarized in Table A.2.6.1. The total number of spring chinook spawners passing Willamette Falls from 1953 to 2001 is shown in Figure A.2.6.2. All spring chinook in the ESU, except those entering the Clackamas River, must pass Willamette Falls. There is no assessment of the ratio of hatchery-origin to natural-origin chinook passing the falls, but the majority of fish are undoubtedly of hatchery origin. (Natural-origin fish are defined has having had parents that spawned in the wild as opposed to hatchery -origin fish whose parents spawned in a hatchery.) The status of individual populations is discussed below.

Clackamas—The count of spring chinook passing the North Fork dam on the Clackamas from 1958 to 2002 are shown in Figure A.2.6.3 (Cramer 2002). The total number of chinook passing above the dam has exceeded 1,000 in most years since 1980 and the last several year show large increases. However, the majority of these fish are likely of hatchery origin. The only year for which hatchery-origin estimates are available is 2002 and the estimate is 64% of hatchery origin. Although the majority of spring chinook spawning habitat is above North Fork Dam, spawning is observed below the dam. The majority of spawning below the dam is also considered to be by hatchery-origin spawners. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Molalla—A 2002 survey of 16.3 miles of stream in the Molalla found 52 redds. However, 93% of the carcasses recovered in the Molalla in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners (Schroeder et al. 2002), so the true fraction is likely in excess of 93 % (i.e. near 100%). The Molalla natural spring chinook population is believed to be extirpated, or nearly so.

North Santiam—Survey estimates of redds per mile in the North Santiam are shown in Figure A.2.6.4 (from Schroeder et al 2002). The number of stream miles surveyed varies between 26.8 and 43.5. The total redds counted in a year varies between 116 and 310. Schroeder et al. (2002) estimate an escapement of 94 natural-origin spawners above Bennett Dam in 2000 and 151 in 2001. These natural-origin spawners were greatly outnumbered by hatchery-origin spawners (2,192 and 6,635 in 2000 and 2001 respectively). This resulted in estimated 94% hatchery-origin spawners in 2000 and 98% in 2001. This population is not considered self-sustaining.

South Santiam—A 2002 survey of 50.8 miles of stream in the South Santiam River below Foster dam found 982 redds. However, 84% of the carcasses recovered in the South Santiam in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners (Schroeder et al 2002), so the true fraction is likely in excess of 84 %. This population is not considered self-sustaining.

Calapooia—A 2002 survey of 11.1 miles of stream in the Calapooia above Brownsville found 16 redds (Schroeder et al 2002). The carcasses recovered in the Calapooia in 2002 were too

decomposed to determine the presence or absence of fin clips. However, it was assumed that all the fish were surplus hatchery fish outplanted from the South Santiam hatchery (Schroeder et al. 2002). The Calapooia natural spring chinook population is believed to be extirpated, or nearly so.

McKenzie—The time series of total spring chinook counts and natural-origin fish passing Leaburg Dam on the McKenzie is shown in Figure A.2.6.5. The average fraction of hatchery-origin fish passed above the dam from 1998 to 2001 was estimated at 26%. Redds are observed below Leaburg Dam, but the fraction of hatchery-origin fish is higher (Schroeder et al 2002). The fraction of fin-clipped spring chinook carcasses recovered below Leaburg was 72% in 2000 and 67% in 2001. Again, fin clip recoveries tend to underestimate the fraction of hatchery-origin spawners. The spring chinook population above Leaburg Dam in the McKenzie is considered the best in the ESU, but with over 20% of the fish of hatchery origin, it is difficult to determine if this population would be naturally self-sustaining. The population has shown substantial increases in total abundance (mixed hatchery and natural origin) in the last couple of years.

Middle Fork Willamette—A 2002 survey of 17 miles of the mainstem Middle Fork found 64 redds. However, 77% of the carcasses recovered in the Middle Fork in 2002 were fin-clipped and of hatchery origin (Schroeder et al 2002). In Fall Creek, a tributary of the Middle Fork, 171 redds in 13.3 miles were found in 2002. The 2002 carcass survey found 39% of fish fin-clipped. Fin-clip recovery fractions for spring chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners. This population is not considered self-sustaining.

No formal trend analyses were conducted on any of the UW chinook populations. The two populations with long time series of abundance (Clackamas and McKenzie) have insufficient information on the fraction of hatchery-origin spawners to permit a meaningful analysis.

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the UW (Table A.2.6.1). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will overestimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is significantly reduced from the historical condition.

Table A.2.6.1. Historical populations of Upper Willamette spring-run chinook salmon. For the McKenzie River population, hatchery fraction is the average percent of spawners of hatchery origin over the last four years. For the Clackamas River population, only one year of hatchery fraction estimate is available (2002). Hatchery fraction in the Molalla, South Santiam and Middle Fork are minimum estimates based on the ratio of adipose marked verses unmarked fish recovered in 2001 (Schroeder et al. 2002). The current and historical habitat estimates are based on analysis by Steel and Sheer (2002).

Population	Hatchery Fraction (%)	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio (%)
Clackamas River	64	369	475	78
Molalla River	>93	432	688	63
North Santiam River	97	173	269	64
South Santiam River	>84	445	658	68
Calapooia River	Estimated @ 100%	163	253	65
McKenzie River	26	283	382	74
Middle Fork Willamette River	>77	197	425	46
Total		2,063	3,150	65

Hatchery releases

A large number of spring chinook are released in the Upper Willamette as mitigation for the loss of habitat above federal hydroprojects (Table A.2.6.2). This hatchery production is considered a potential risk, because it masks the productivity of the natural population, interbreeding of hatchery and natural fish poses potential genetic risks and the incidental take from the fishery promoted by the hatchery production can increase adult mortality. Harvest retention is only allowed for hatchery marked fish, but take from hooking mortality and non-compliance is still a potential issue.

Fall chinook are not native to the upper Willamette and are not part of the Upper Willamette chinook ESU. Fall chinook hatchery fish are no longer released into the upper Willamette, though there have been substantial releases in the past (Figure A.2.6.6).

A.2.6.3 ESU Summary

The updated information provided in this report, the information contained in previous UW chinook status reviews, and preliminary analysis by the WLC-TRT, indicate that most natural spring chinook populations are likely extirpated or nearly so. The only population considered potentially self-sustaining is the McKenzie. However, its abundance has been relatively low (low thousands) with a substantial number of these fish being of hatchery origin. The population has shown a substantial increase in the last couple of years, hypothesized to be a result of increase ocean survival. It is unknown what ocean survivals will be in the future and the long-term sustainability of this population in uncertain.

Table A.2.6.2. Upper Willamette spring-run chinook hatchery releases (compiled by Waknitz 2002).

Watershed	Years	Hatchery	Stock	Release Site	Total
Willamette R	1994	Dexter Pd	McKenzie	L Willamette R	73,028
	1995	Dexter Pd	Willamette	L Willamette R	137,573
	1995	Lone Star	Clackamas	L Willamette R	59,654
	1995	Marion Forks	N Santiam	L Willamette R	40,320
	1993, 1994	McKenzie	McKenzie	L Willamette R	344,089
	1992, 1993	Step	Clackamas	L Willamette R	70,193
	1993, 1994	Step	McKenzie	L Willamette R	331,446
	1993-1995	McKenzie	Clackamas	L Willamette R	125,585
	1996-1999	Willamette	McKenzie	L Willamette R	225,122
	1995-1996	Willamette	N Santiam	L Willamette R	81,513
	1995-1999	McKenzie	McKenzie	L Willamette R	574,117
Clackamas R	1991-1994	Clackamas	Clackamas	Clackamas R	4,358,092
	1995-2002	Clackamas	Clackamas	Clackamas R	9,182,916
	1996-2001	McKenzie	McKenzie	Clackamas R	1,332,542
	1991	Eagle Creek NFH	Clackamas	Eagle Cr	556,814

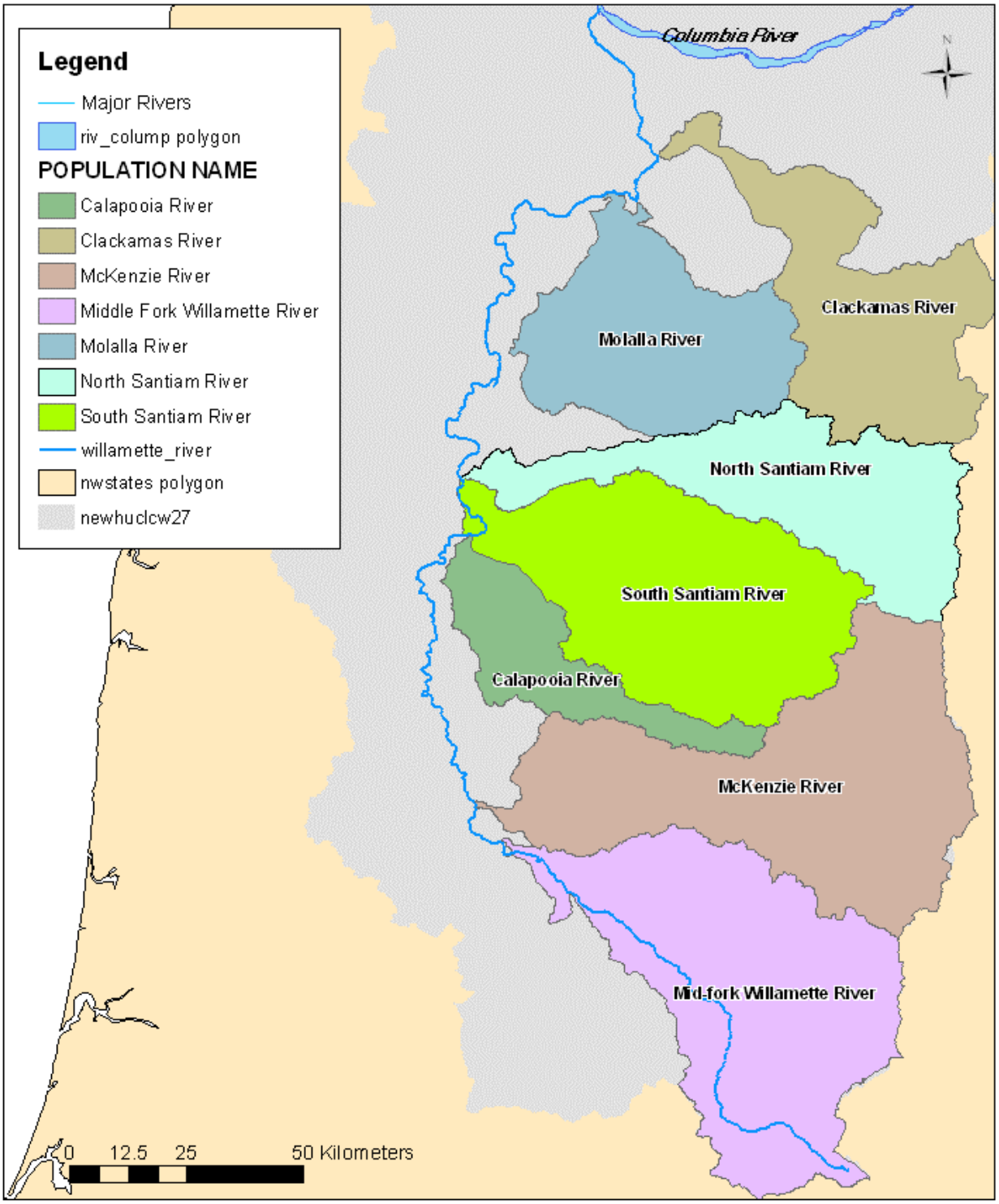


Figure A.2.6.1. Historical populations of spring-run chinook in the Willamette ESU (Myers et al. 2002).

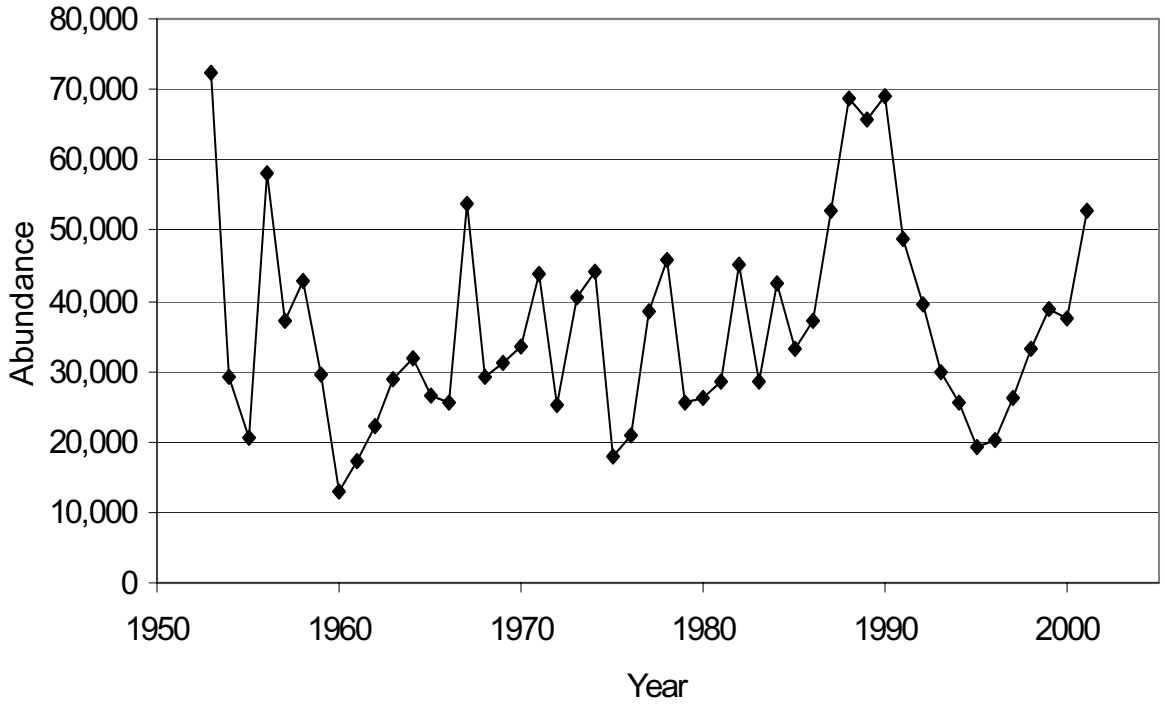


Figure A.2.6.2. Counts of spring-run chinook passing Willamette Falls. The count is of mixed natural and hatchery origin, with the majority of fish likely of hatchery origin.

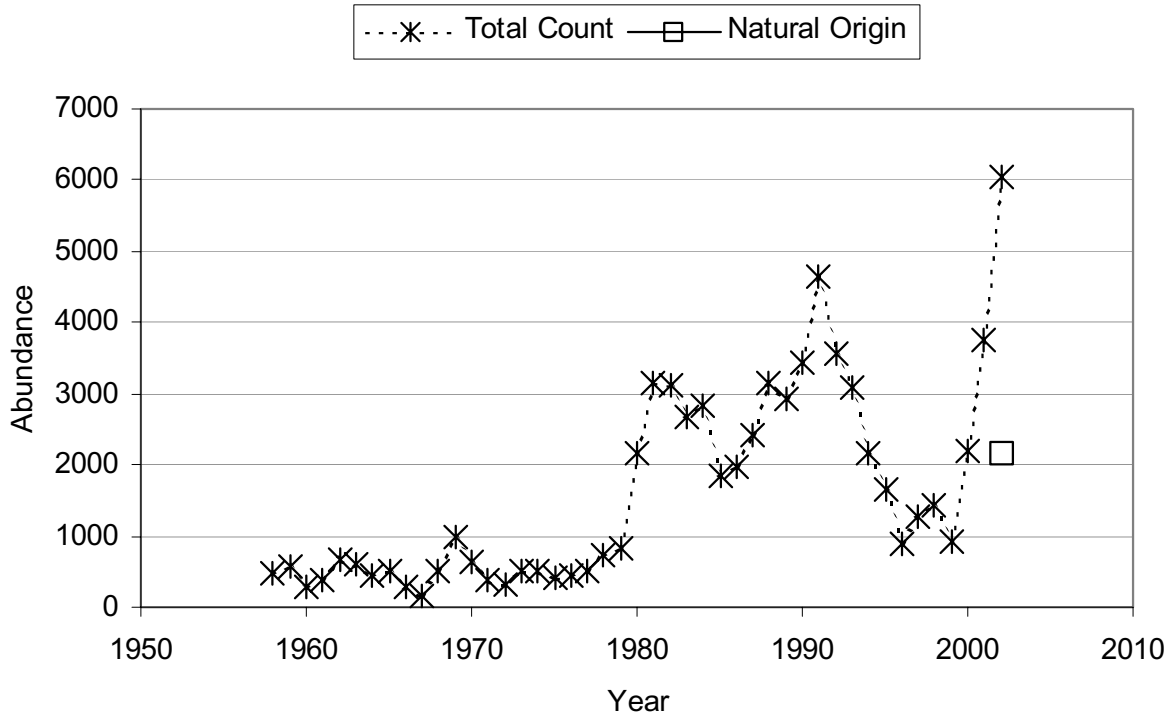


Figure A.2.6.3. Counts of spring-run chinook passing North Fork Dam on the Clackamas River (Cramer 2002). The total count is all fish passing above the dam. There is only one estimate (in 2002) of the number of fish passing above the dam that are of natural origin.

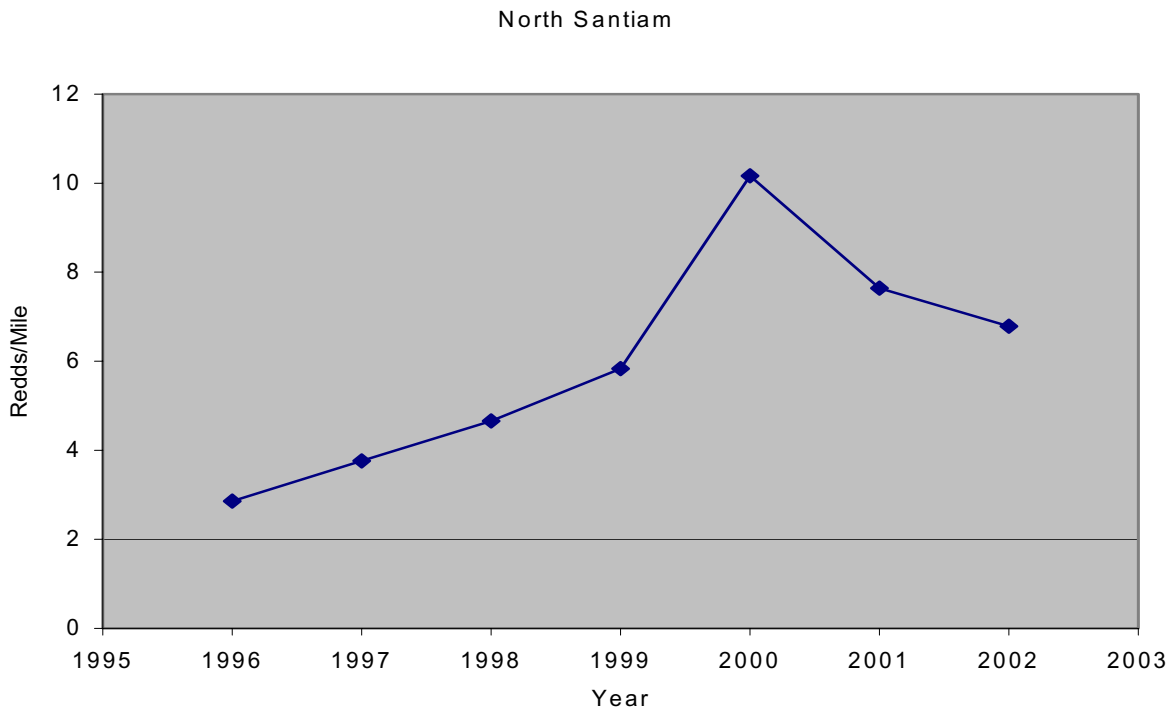


Figure A.2.6.4. North Santiam redds per mile (data from Schroeder et al. 2002). The number of stream miles surveyed varies between 26.8 and 43.5 miles. The total redds counted in a year varies between 116 and 310. Over 95% of the spawners are estimated of hatchery origin

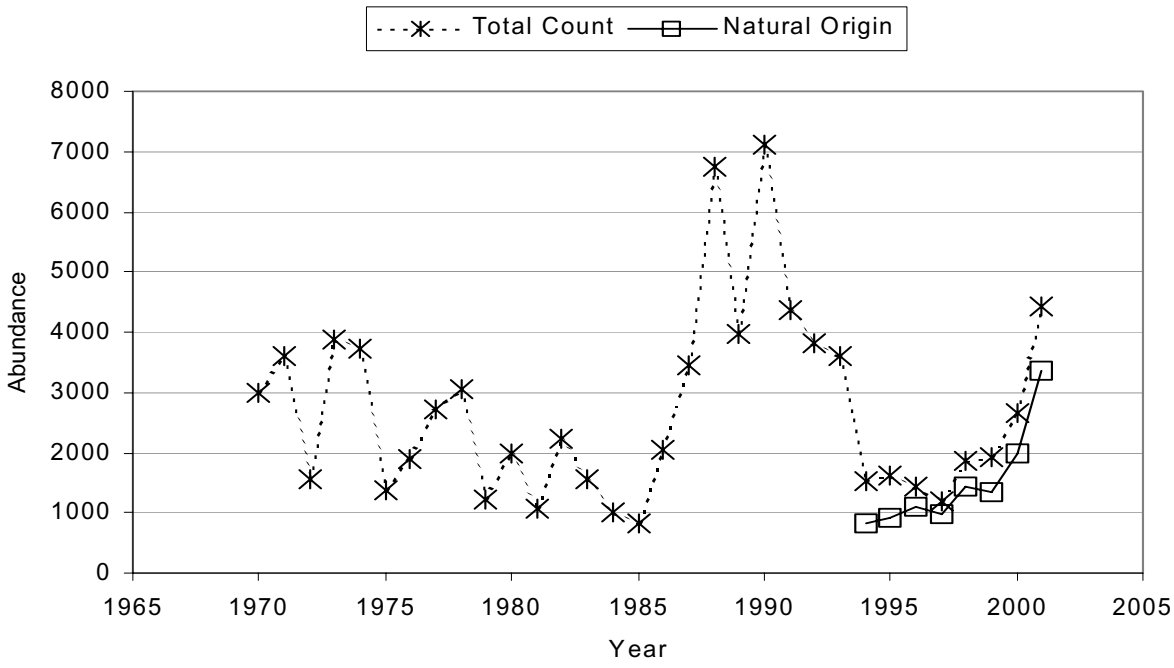


Figure A.2.6.5. Counts of McKenzie River spring-run chinook at Leaburg Dam.

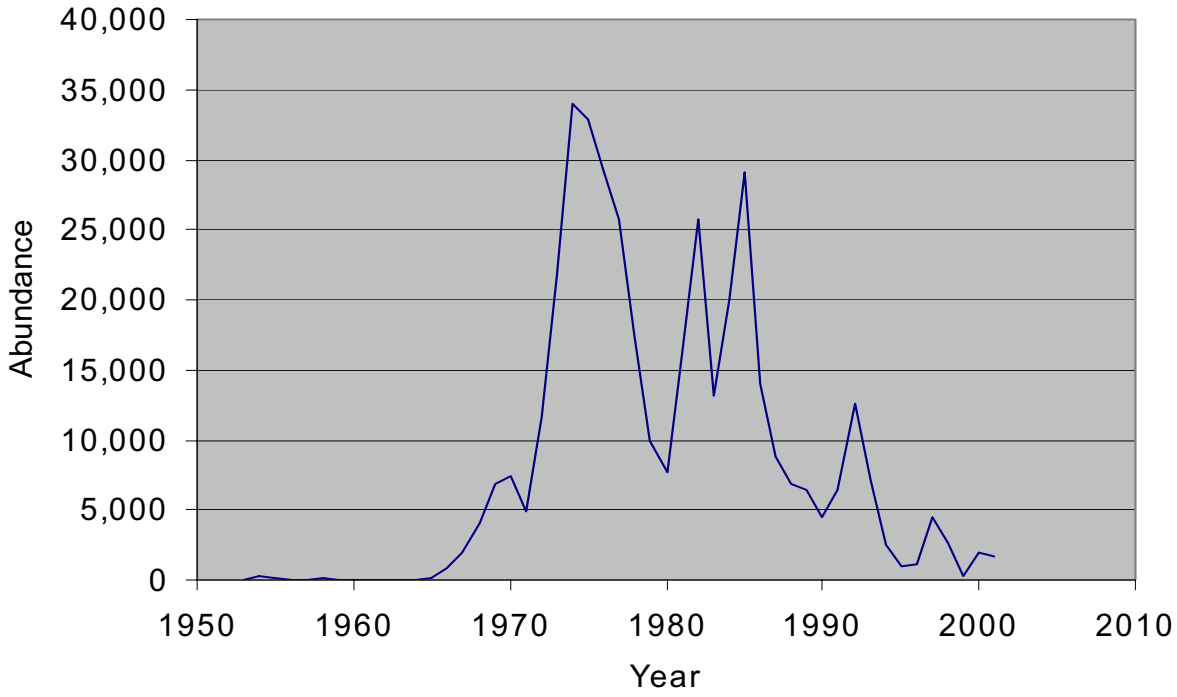


Figure A.2.6.6. Counts of fall-run chinook at Willamette Falls. Fall-run chinook are not native in the Upper Willamette River and are not in the in the Upper Willamette chinook salmon ESU.

A.2.7 CALIFORNIA COASTAL CHINOOK SALMON

Primary contributor: Eric P. Bjorkstedt (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.7.1 Summary of Previous BRT Conclusions

The status of chinook salmon throughout California and the Pacific Northwest was formally assessed in 1998 (Myers et al. 1998). Substantial scientific disagreement about the biological data and its interpretation persisted for some Evolutionarily Significant Units (ESUs); these ESUs were reconsidered in a subsequent status review update (NMFS 1999). Information from those reviews regarding ESU structure, analysis of extinction risk, risk factors, and hatchery influences is summarized in the following sections.

ESU structure

The initial status review proposed a single ESU of chinook salmon inhabiting coastal basins south of Cape Blanco and the tributaries to the Klamath River downstream of its confluence with the Trinity River (Myers et al. 1998). Subsequent review of an augmented genetic data set and further consideration of ecological and environmental information led to the division of the originally proposed ESU into the Southern Oregon and Northern California Coastal Chinook Salmon ESU and the California Coastal Chinook Salmon ESU (NMFS 1999). The California Coastal Chinook Salmon ESU currently includes chinook salmon from Redwood Creek to the Russian River (inclusive).

Summary of risk factors and status

The California Coastal Chinook Salmon ESU is listed as Threatened. Primary causes for concern were low abundance, reduced distribution (particularly in the southern portion of the ESU's range), and generally negative trends in abundance; all of these concerns were especially strong for spring-run chinook salmon in this ESU (Myers et al. 1998). Data for this ESU are sparse and, in general of limited quality, which contributes to substantial uncertainty in estimates of abundance and distribution. Degradation of the genetic integrity of the ESU was considered to be of minor concern and to present less risk for this ESU than for other ESUs.

Previous reviews of conservation status for chinook salmon in this area exist. Nehlsen et al. (1991) identified three putative populations (Humboldt Bay Tributaries, Mattole River, and Russian River) as being at high risk of extinction and three other populations (Redwood Creek, Mad River, and Lower Eel River) as being at moderate risk of extinction. Higgins et al. (1992) identified seven "stocks of concern," of which two populations (tributaries to Humboldt Bay and the Mattole River) were considered to be at high risk of extinction. Some reviewers indicate that chinook salmon native to the Russian River have been extirpated.

Historical estimates of escapement are presented in Table A.2.7.1. These estimates are based on professional opinion and evaluation of habitat conditions, and thus do not represent rigorous estimates based on field sampling. Historical time series of counts of upstream migrating adults are available for Benbow Dam (South Fork Eel River 1938-1975), Sweasy Dam (Mad River 1938-1964), and Cape Horn Dam (Van Arsdale Fish Station, Eel River); the latter represent a small, unknown and presumably variable fraction of the total run to the Eel River. Data from cursory, nonsystematic stream surveys of two tributaries to the Eel River (Tomki and Sprowl Creeks) and one tributary to the Mad River (Canon Creek) were also available; these data provide crude indices of abundance.

Previous status reviews considered the following to pose significant risks to the California Coastal Chinook Salmon ESU: degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, mining, and severe recent flood events (exacerbated by land use practices). Special concern was noted regarding the more precipitous declines in distribution and abundance in spring-run chinook salmon. Many of these factors are particularly acute in the southern portion of the ESU range and were compounded by uncertainty stemming from the general lack of population monitoring in California (Myers et al. 1998).

In previous status reviews, the effects of hatcheries and transplants on the genetic integrity of the ESU elicited less concern than other risk factors for this ESU, and were less of a concern for this ESU in comparison to other ESUs.

Listing status

The California Coastal Chinook Salmon ESU is currently listed as "Threatened."

Table A.2.7.1. Historical estimates of abundance of chinook salmon in the California Coastal Chinook Salmon ESU.

Selected Watersheds	**CDFG 1965**	**Wahle & Pearson 1987**
Redwood Creek	5,000	1,000
Mad River	5,000	1,000
Eel River	55,000	17,000
Mainstem Eel[a]	13,000	
Van Duzen Rivera[a]	2,500	
Middle Fork Eel[a]	13,000	
South Fork Eel[a]	27,000	
Bear River		100
Small Humboldt County Rivers	1,500	
Miscellaneous Rivers North of Mattole		600
Mattole River	5,000	1,000
Noyo River	50	
Russian River	500	50
Total	72,550	20,750

[a]Entries for subbasins of the Eel River Basin are not included separately in the total.

A.2.7.2 New Data and Updated Analysis

The TRT for the North-Central California Coast Recovery Domain has proposed a set of plausible hypotheses, based largely on geography, regarding the population structure of the California Coast Chinook Salmon ESU (Table A.2.7.2), but has concluded that insufficient information exists to discriminate among these hypotheses (NCCC-TRT, *in preparation*). Data are not available for all of the potential populations; only those for which data are available are considered below.

New or updated time series for chinook salmon in this ESU include 1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River; 2) cursory, quasi-systematic spawner surveys on Canon Creek (tributary to the Mad River), Tomki Creek (tributary to the Eel River), and Sprowl Creek (tributary to the Eel River); 3) counts of returning spawners at a weir on Freshwater Creek (tributary to Humboldt Bay). None of these time series is especially suitable for analysis of trends or estimation of population growth rates.

Table A.2.7.2. Plausible hypotheses for independent populations considered by the North Central California Coast TRT. This information is summarized from a working draft report and should be considered as preliminary and subject to revision.

"Lumped"	**"Split"**
Redwood Creek	
Mad River	
Humboldt Bay Tributaries	
Eel River[a]	
	South Fork Eel River
	Van Duzen River
	Middle Fork Eel River
	North Fork Eel River
	Upper Eel River
Bear River	
Mattole River	
Tenmile to Gualala[b]	
Russian River	

[a]Plausible hypotheses regarding the population structure of chinook salmon in the Eel River basin include scenarios ranging from five independent populations (South Fork Eel River, Van Duzen River, Upper Eel River, Middle Fork Eel River, and North Fork Eel River) to a single, strongly structured independent population.
[b]This stretch of the coast comprises numerous smaller basins that drain directly into the Pacific Ocean, some of which appear sufficiently large to support independent populations of chinook salmon. The following hypotheses span much of the range of plausible scenarios: (1) independent populations exist in all basins that exceed a minimum size; (2) independent populations exist only in basins between the Tenmile River and Big River, inclusive, that exceed a minimum size; (3) chinook salmon inhabiting basins along this stretch of coastline exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins, and possibly from larger basins to the north and south; and (4) chinook salmon inhabiting basins between the Tenmile River and Big River, inclusive, exhibit patchy population or metapopulation dynamics in which the occupancy of any given basin is dependent on migrants from other basins in this region and possibly to the north, while other basins to the south only sporadically harbor chinook salmon.

Table A.2.7.3. Geometric means, estimated lambda, and long- and short-term trends for abundance time series in the California Coastal Chinook Salmon ESU.

	5 year Geometric Mean			Trend	
	Rec	**Min**	**Max**	**Long**	**Short**
Freshwater Creek	22	13	22	0.137 (-0.405, 0.678)	0.137 (-0.405, 0.678)
Mad River					
Canon Creek	73	19	103	0.0102 (-0.106, 0.127)	0.155 (-0.069, 0.379)
Eel River					
Sprowl Creek	43	43	497	-0.096 (-0.157, -0.034)	-0.183 (-0.356, -0.010)
Tomki Creek	61	13	2,233	-0.199 (-0.351, -0.046)	0.294 (0.055, 0.533)

Freshwater Creek—Counts of chinook salmon passing the weir near the mouth of Freshwater Creek, a tributary to Humboldt Bay, provide a proper census of a small (N ~ 20) population of naturally and hatchery-spawned chinook salmon (Figure A.2.7.1). Chinook salmon occupying this watershed may be part of a larger "population" that uses tributaries of Humboldt Bay (NCCC-TRT, *in preparation*). The time series comprises only 8 years of observations, which is too few to draw strong inferences regarding trends. Clearly, the trend is positive, although the role of hatchery production in producing this signal may be significant (Table A.2.7.3; Figure A.2.7.1).

Mad River—Data for naturally spawning fish are available from spawner surveys on Canon Creek, and to a lesser extent on the North Fork Mad River. Only the counts from Canon Creek extend continuously to the present (Figure A.2.7.2a). Due to high variability in these counts, short-term and long-term trends do not differ significantly from zero, although the tendency is toward a positive trend. Due to a hypothesized, but unquantified, effect of interannual variation in water availability on distribution of spawners in the basin, it is not clear whether these data provide any useful information for the population as a whole; however, more sporadic counts from the mainstem Mad River suggest that the estimates from Canon Creek capture gross signals, and support the hypothesis of a recent positive trend in abundance (Figure A.2.7.2b).

Eel River—The Eel River plausibly harbors anywhere from one to five independent populations (NCCC-TRT, *in prep.*, Table A.2.7.2). Three current time series provide information for the population(s) that occupy this basin: 1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River (Figure A.2.7.3a); 2) spawner surveys on Sprowl Creek (tributary to the Eel River) (Figure A.2.7.3b); and 3) spawner surveys on Tomki Creek (tributary to the Eel River) (Figure A.2.7.3c). These data are not especially suited to rigorous analysis of population status for a number of reasons, and sophisticated analyses were not pursued.

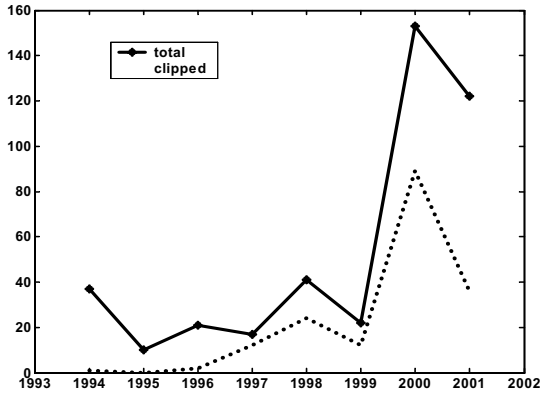
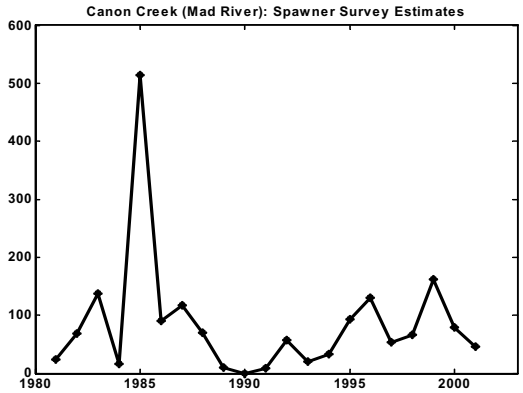


Figure A.2.7.1. Counts of chinook salmon at the weir on Freshwater Creek.

a



b

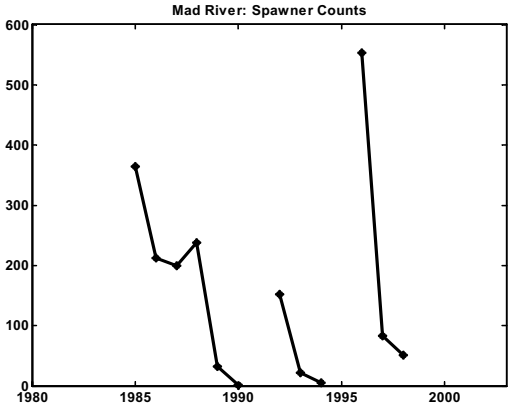


Figure A.2.7.2. Abundance time series for chinook salmon in portions of the Mad River basin. (a) spawner counts on Canon Creek; and (b) spawner counts on portions of the mainstem Mad River.

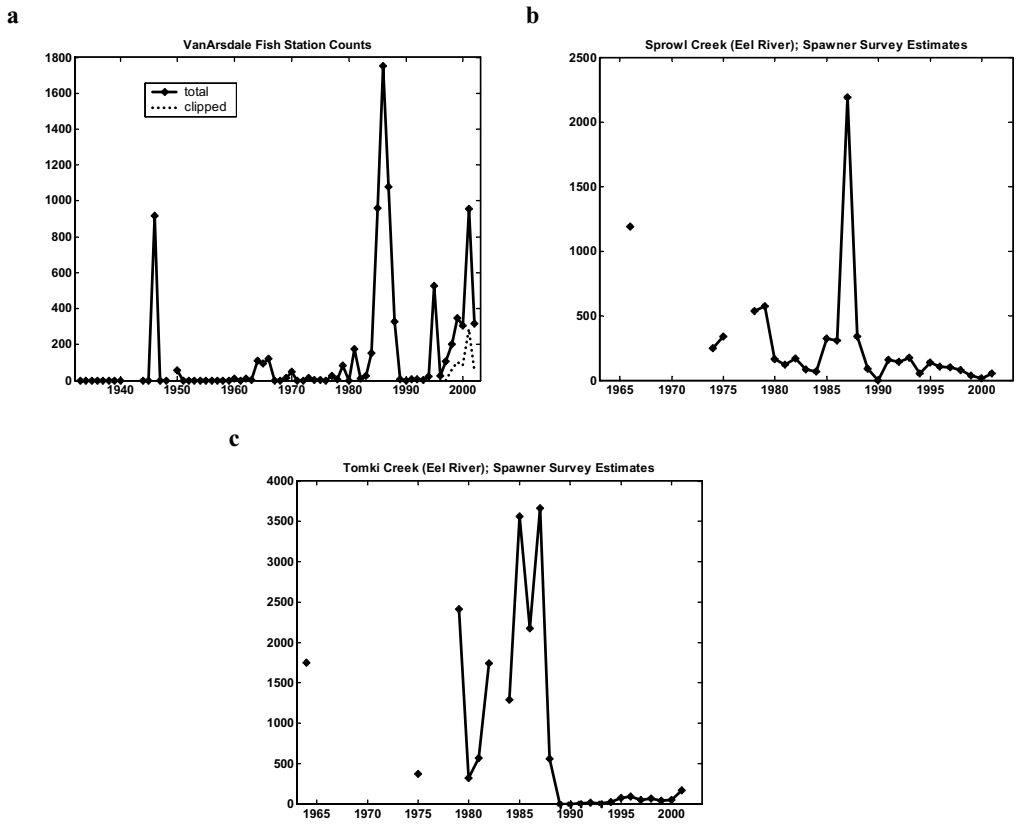


Figure A.2.7.3. Abundance time series for chinook salmon in portions of the Eel River basin. (a) counts of chinook salmon at Van Arsdale Fish Station at the upstream terminus of anadromous access on the mainstem Eel River; (b) estimates of spawner abundance based on spawner surveys and additional data from Sprowl Creek; and (c) estimates of spawner abundance based on spawner surveys and additional data from Tomki Creek.

Inferences regarding population status drawn from the time series of counts of adult chinook salmon reaching Van Arsdale Fish Station (VAFS) are weakened by two characteristics of the data. First, adult salmon reaching VAFS include both naturally and hatchery-spawned fish, yet the long-term contribution of hatchery production to the spawner population is unknown and may be quite variable due to sporadic operation of the egg take-and-release programs since the mid-1970s. Second, and perhaps more importantly, it is not clear what counts of natural spawners at VAFS indicate about the population or populations of chinook salmon in the Eel River. As a weir count, measurement error is expected to be small for these counts. However, very little spawning habitat exists above VAFS, which sits just below the Cape Horn dam on the Eel River, which suggests that counts made at VAFS represent the upper edge of the spawners' distribution in the Upper Eel River. Spawner access to VAFS and other headwater habitats in the Eel River basin is likely to depend strongly on the timing and persistence of suitable river flow, which suggests that a substantial component of the process error in these counts is not due to population dynamics. For these reasons, no statistical analysis of these data was pursued.

Additional data for the Eel River population or populations are available from spawner surveys from Tomki and Sprowl Creeks, which yield estimates of abundance based on 1) quasi-systematic index site spawner surveys that incorporate mark-recapture of carcasses and 2) additional so-called "compatible" data from other surveys. Analysis for Sprowl Creek indicates negative long-term and short-term trends; similar analysis indicates a long-term decline and short-term increase for Tomki Creek (Table A.2.7.3). Caution in interpreting these results is warranted, particularly given the quasi-systematic collection of these data, and the likelihood that these data include unquantified variability due to flow-related changes in spawners' use of mainstem and tributary habitats. In particular, inferences regarding population status based on extrapolations from these data to basin-wide estimates of abundance are expected to be weak and perhaps not warranted.

Mattole River—Recent spawner and redd surveys on the Mattole River and tributaries have been conducted by the Mattole Salmon Group since 1994. The surveys provide useful information on the distribution of salmon and spawning activity throughout the basin. Local experts have used these and ancillary data to develop rough "index" estimates of spawner escapement to the Mattole; however, the intensity and coverage of these surveys has not been consistent, and the resulting data are not suitable for rigorous estimation of abundance (e.g., through area-under-the-curve analysis).

Russian River—No long-term, continuous time series are available for sites in the Russian River Basin, but sporadic estimates based on spawner surveys are available for some tributaries. Video-based counts of upstream migrating adult chinook salmon passing a temporary dam near Mirabel on the Russian River are available for 2000-2002. Counts are incomplete, due to technical difficulties with the video apparatus, occasional periods of poor water clarity, occasional overwhelming numbers of fish, and disparities between counting and migration periods; thus, these data represent a minimum count of adult chinook salmon. Counts have

exceeded 1,300 fish in each of the last three years (5,465 in 2002); and a rigorous mark-recapture estimate of outmigrant abundance in 2002 exceeded 200,000 (Shawn Chase, Sonoma County Water Agency, *personal communication*). Since chinook salmon have not been produced at the Don Clausen Hatchery since 1997, these counts represent natural production or straying from other systems. No data were available to assess the genetic relationship of these fish to others in this or other ESUs.

Summary—Historical and current information indicates that abundance in putatively independent populations of chinook salmon is depressed in many of those basins where they have been monitored. The relevance of recent strong returns to the Russian River to ESU status are not clear as the genetic composition of these fish is unknown. Reduction in geographic distribution, particularly for spring-run chinook salmon and for basins in the southern portion of the range, continues to present substantial risk. Genetic concerns are reviewed below (Hatchery Information). As for previous status reviews, uncertainty continues to contribute substantially to assessments of risk facing this ESU.

A.2.7.3 Hatchery Information

Hatchery stocks that are being considered for inclusion in this ESU are: 1) Mad River Hatchery; 2) hatchery activities of the Humboldt Fish Action Council on Freshwater Creek; 3) Yager Creek Hatchery operated by Pacific Lumber Company; 4) Redwood Creek Hatchery; 5) Hollow Tree Creek Hatchery; 6) Van Arsdale Fish Station; and 6) hatchery activities of the Mattole Salmon Group. Chinook salmon are no longer produced at the Don Clausen hatchery on Warm Springs Creek (Russian River). In general, hatchery programs in this ESU are not oriented toward large-scale production, but rather are small-scale operations oriented at supplementing depressed populations.

Freshwater Creek—This hatchery is operated by Humboldt Fish Action Council and CDFG to supplement and restore natural production in Freshwater Creek. All spawners are from Freshwater Creek; juveniles are marked and hatchery fish are excluded from use as broodstock. Weir counts provide good estimates of the proportion of hatchery- and naturally produced fish returning to Freshwater Creek (30%-70% hatchery from 1997-2001); the contribution of HFAC production to spawning runs in other streams tributary to Humboldt Bay is unknown.

Mad River—Recent production from this hatchery has been based on small numbers of spawners returning to the hatchery. There are no estimates of naturally spawning chinook salmon abundance available for the Mad River to determine the contribution of hatchery production to chinook salmon in the basin as a whole. Broodstock has generally been drawn from chinook salmon returning to the Mad River; however, releases in the 1970s and 1980s have included substantial releases of fish from out-of-basin (Freshwater Creek) and out-of-ESU (Klamath-Trinity and Puget Sound).

Eel River—Four hatcheries, none of which are major production hatcheries, contribute to production of chinook salmon in the Eel River Basin: hatcheries on Yager Creek (recent effort: ~12 females spawned per year), Redwood Creek (~12 females), Hollow Tree Creek, and the Van Arsdale Fish Station (VAFS) (~60 males and females spawned). At the first three hatcheries, broodstock is selected from adults of non-hatchery origin; at VAFS, broodstock includes both

natural and hatchery-origin fish. In all cases, however, insufficient data on naturally spawning chinook salmon are available to estimate the effect of hatchery fish on production or other characteristics of naturally spawning chinook salmon in the Eel River Basin. Since 1996, all fish released from VAFS have been marked. Subsequent returns indicate that approximately 30% of the adult chinook salmon trapped at VAFS are of hatchery origin. It is not clear what these numbers indicate about hatchery contributions to the population of fish spawning below VAFS.

Mattole River—The Mattole Salmon Group has operated a small hatchbox program since 1980 (current effort: ~40,000 eggs from ~10 females) to supplement and restore chinook salmon and other salmonids in the Mattole River. All fish are marked, but no rigorous estimate of hatchery contributions to adult escapement is possible. Hatchery-produced outmigrants comprised approximately 17.3% (weighted average) of outmigrants trapped during 1997, 1998, and 2000 (Mattole Salmon Group 2000, Five Year Management Plan for Salmon Stock Rescue Operations 2000-2001 through 2004-2005 Seasons). Trapping efforts did not fully span the period of natural outmigration, so this figure may overerestimate the contribution of hatchbox production to total production in the basin.

Russian River—Production of chinook salmon at the Don Clausen (Warm Springs Hatchery) ceased in 1997 and had been largely ineffective for a number of years prior to that. Recent returns of chinook salmon to the Russian River stem from natural production, and possibly from fish straying from other basins, including perhaps Central Valley stocks.

Summary

Artificial propagation of chinook salmon in this ESU remains at relatively low levels. No putatively independent populations of chinook salmon in this ESU appear to be entirely dominated by hatchery production, although proportions of hatchery fish can be quite high where natural escapement is small and hatchery production appears to be successful (e.g., Freshwater Creek). It is not clear whether current hatcheries pose a risk or offer a benefit to naturally spawning populations. Extant hatchery programs are operated under guidelines designed to minimize genetic risks associated with artificial propagation, and save for historical inputs to the Mad River Hatchery stock, do not appear to be at substantial risk of incorporating out-of-basin or out-of-ESU fish. Thus, it is likely that artificial propagation and degradation of genetic integrity continue to not represent a substantial conservation risk to the ESU. Categorizations of hatchery stocks in the California Coastal chinook salmon ESU (SSHAG 2003) can be found in Appendix A.5.1.

A.2.7.4 Comparison with Previous Data

Few new data, and few new datasets were available for consideration, and none of the recent data contradict the conclusions of previous status reviews. Chinook salmon in the Coastal California ESU continue to exhibit depressed population sizes relative to historical abundances; this is particularly true for spring-run chinook salmon, which may no longer be extant anywhere within the range of the ESU. Evaluation of the significance of recent potential increases in abundance of chinook salmon in the Russian River must weigh the substantial uncertainty regarding the genetic relatedness of these fish to others in the northern part of the ESU.

Harvest rates are not explicitly estimated for this ESU; however, it is likely that current restrictions on harvest of Klamath River fall-run chinook salmon maintain low ocean harvest of chinook salmon from the California Coastal ESU (PFMC 2002a, b). Potential changes in age-structure of chinook salmon populations (e.g., Hankin et al. 1993) and associated risk has not been evaluated for this ESU.

No information exists to suggest new risk factors, or substantial effective amelioration of risk factors noted in the previous status reviews save for recent changes in ocean conditions. Recent favorable ocean conditions have contributed to apparent increases in abundance and distribution for a number of anadromous salmonids, but the expected persistence of this trend is unclear.

A.2.8 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

Primary contributor: Steven T. Lindley (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.8.1 Summary of Previous BRT Conclusions

The status of chinook salmon coastwide was formally assessed in 1998 (Myers et al. 1998); however, NMFS had previously recognized Sacramento River winter-run chinook as a "distinct population segment" under the ESA (NMFS 1987).

Summary of major risk factors and status indicators

Historically, winter-run chinook salmon were dependent on access to spring-fed tributaries to the upper Sacramento River that stayed cool during the summer and early fall. Adults enter freshwater in early winter and spawn in the spring and summer. Juveniles rear near the spawning location until at least the fall, when water temperatures in lower reaches are suitable for migration. Winter-run chinook salmon were abundant and comprised populations in the McCloud, Pit, and Little Sacramento, with perhaps smaller populations in Battle Creek and the Calaveras River. On the basis of commercial fishery landings in the 1870s, Fisher (1994) estimated that the total run size of winter-run chinook salmon may have been 200,000 fish.

The most obvious challenge to winter-run chinook salmon was the construction of Shasta Dam, which blocked access to the entire historic spawning habitat. It was not expected that winter-run chinook salmon would survive this habitat alteration (Moffett 1949). Cold-water releases from Shasta, however, created conditions suitable for winter-run chinook salmon for roughly 100 km downstream from the dam. Presumably, there were several independent populations of winter-run chinook salmon in the Pitt, McCloud, and Little Sacramento Rivers, and various tributaries to these rivers, such as Hat Creek and the Fall River. These populations merged to form the present single population. If there ever were populations in Battle Creek and the Calaveras River, they have been extirpated.

In addition to having only a single extant population dependent on artificially created conditions, winter-run chinook salmon face numerous other threats. Chief among these is small population size—escapement fell below 200 fish in the 1990s. Population size declined monotonically from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival. There are questions of genetic integrity due to winter-run chinook salmon having passed through several bottlenecks in the 20th century. Other threats include inadequately screened water diversions, predation at artificial structures and by non-native species, pollution from Iron Mountain Mine (among other sources), adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures (e.g., Red Bluff Diversion Dam), and vulnerability to drought.

Previous BRT conclusions

The chinook salmon BRT spent little time considering the status of winter-run chinook salmon, because winter-run chinook salmon were already listed as endangered at the time of previous BRT meetings.

Listing status

Winter-run chinook salmon were listed as Threatened in 1990 and reclassified as Endangered 1994.

A.2.8.2 New Data and Updated Analyses

Viability assessments

Two studies have been done on the population viability of Sacramento River winter-run chinook salmon. Botsford and Brittnacher (1998), in a paper that is part of the draft recovery plan, developed de-listing criteria using a simple age-structured, density-independent model of spawning escapement. They concluded, on the basis of the 1967-1995 data, that winter-run chinook salmon were certain to fall below the quasi-extinction threshold of three consecutive spawning runs with less than 50 females.

Lindley and Mohr (2003) developed a slightly more complex Bayesian model of winter-run chinook salmon spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures initiated in 1989. This model, due to its allowance for the growth rate change, its accounting for parameter uncertainty, and use of newer data (through 1998), suggested a lower but still biologically significant expected quasi-extinction probability of 28%.

Draft recovery plan

The draft recovery plan for winter-run chinook salmon (NMFS 1997) provides a comprehensive review of the status, life history, habitat requirements, and risk factors of winter-run chinook salmon. It also provides a recovery goal: an average of 10,000 females spawners per year and a $\lambda \geq 1.0$ calculated over 13 years of data (assuming a certain level of precision in spawning escapement estimates).

New abundance data

The winter-run chinook salmon spawning run has been counted at Red Bluff Diversion Dam (RBDD) fish ladders since 1967. Escapement has been estimated with a carcass survey since 1996. Through the mid-1980s, the RBDD counts were very reliable. At that time, changes to the dam operation were made to alleviate juvenile and adult passage problems. Now, only the tail end of the run (about 15% on average) is forced over the ladders, greatly reducing the accuracy of the RBDD counts. The carcass mark-recapture surveys were initiated to improve

escapement estimates. The two measures are in very rough agreement, and there are substantial problems with both estimates, making it difficult to choose one as more reliable than the other. One problem with the carcass-based estimate is the estimation of the probability of capturing carcasses—it appears that the probability of initial carcass recovery depends strongly on the sex of the fish, the size of the fish, and possibly on whether it has been previously recovered. In the winter-run chinook salmon carcass surveys, a high ratio of female to males is observed (e.g., Snider et al. 1999), and several studies of salmon carcass recovery have noted that females are recovered with a higher probability than males, presumably because of the different behavior of males and females (e.g., Shardlow et al. 1986 and references therein). In spite of these problems, both abundance measures suggest that the abundance of winter-run chinook salmon is increasing. Based on the RBDD counts, the winter-run chinook salmon population has been growing rapidly since the early 1990s (Figure A.2.8.1), with a short-term trend of 0.26 (Table A.2.8.1). On the population growth rate-population size space, the winter-run chinook salmon population has a somewhat low population growth and moderate size compared to other Central Valley salmonid populations (Figure A.2.8.2).

Table A.2.8.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals. Results for other populations are shown for comparison.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)
Sacramento River steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	NA

Winter-run chinook salmon may be responding to a number of factors, including wetter-than-normal winters, changes in ocean harvest regulations since 1995 significantly reducing harvest, changes in RBDD operation, improved temperature management on the Upper Sacramento (including installation of a cold-water release device on Shasta Dam), water quality improvements due to remediation of Iron Mountain Mine discharges, changes in operations of the state and federal water projects, and a variety of other habitat improvements. While the status of winter-run chinook salmon is improving, there is only one winter-run chinook salmon population and it is dependent on cold-water releases of Shasta Dam, which could be vulnerable to a prolonged drought. The recent 5-year geometric mean is only 3% of the maximum post-1967 5-year geometric mean.

The RBDD counts are suitable for modeling as a random-walk-with-drift (also known as the "Dennis model" [Dennis et al. 1991]). In the RWWD model, population growth is described by exponential growth or decline:

$$N_{t+1} = N_t \exp(\mu + \eta_t), \quad (1)$$

where N_t is the population size at time t, μ is the mean population growth rate, and η_t is a normal random variable with mean=0 and variance = σ^2_p.

Table A.2.8.2. Parameter estimates for the constant-growth and step-change models applied to winter-run chinook salmon. Numbers in parentheses indicate 90% confidence intervals.

	Model	
parameter	**constant μ**	**step change μ**
μ	-0.085	-0.214
	(-0.181, 0.016)	(-0.322, -0.113)
δ	NA	0.389
	NA	(0.210, 0.574)
σ^2_p	0.105	0.056
	(0.094, 0.122)	(0.046, 0.091)
σ^2_m	0.0025	0.011
	(2.45E-6, 0.0126)	(3.92E-6, 0.022)
P_{100}(ext)[a]	0.40	0.003
	(0.00, 0.99)	(0.0, 0.0)

[a] Probability of extinction (pop. size < 1 fish) within 100 years.

The RWWD model, as written in Equation 1, ignores measurement error. Observations (y_t) can be modeled separately,

$$y_t = N_t \exp(\varepsilon_t), \quad (2)$$

where ε_t is a normal random variable with mean = 0 and variance = σ^2_m. Equations 1 and 2 together define a state-space model that, after linearizing by taking logarithms, can be estimated using the Kalman filter (Lindley in press).

A recent analysis of the RBDD data (Lindley and Mohr 2003) indicated that the population growth since 1989 was higher than in the preceding period. For this reason, I fit two forms of the RWWD model—one with a fixed growth rate (constant-growth model) and another with a growth rate with a step-change in 1989, when conservation actions began (step-change model, $\mu_t = \mu$ for $t < 1989$, $\mu_t = \mu + \delta$ for $t \geq 1989$). In both cases, a 4-year running sum was applied to the spawning escapement data to form a total population estimate (Holmes 2001). Results of model fitting are shown in Table A.2.8.2. The constant-growth model satisfies all model diagnostics, although visual inspection of the residuals shows a strong tendency to under-predict abundance in the most recent 10 years. The residuals of the step-change model fail the Shapiro-Wilks test for normality; the residuals look truncated on the positive side, meaning that good years are not as extreme as bad years. Winter-run chinook salmon growth rate might be better modeled as a

mixture between a normal distribution and another distribution reflecting near-catastrophic population declines caused by episodic droughts.

According to Akaike's information criterion (AIC), the step-change model is a much better approximation to the data than the constant population growth rate model, with an AIC difference of 9.61 between the two models (indicating that the data provide almost no support for the constant-growth model). The step-change model suggests the winter-run chinook salmon population currently has a λ of 1.21, while for the constant population growth rate model, λ = 0.97[5]. The extinction risks predicted by the two models are extremely different: winter-run chinook salmon have almost no risk of extinction if the apparent recent increase in λ holds in the future, but are certain to go extinct if the population grows at its average rate, with a most likely time of extinction being 100 years. While it would be dangerous to assume that recent population growth will hold indefinitely, it does appear that the status of winter-run chinook salmon is improving.

Harvest impacts

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of winter-run chinook salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena, and that fish from the Central Valley are caught in Oregon fisheries. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon.. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and concurrent increases in other chinook salmon runs in the Central Valley.

Because they mature before the ocean fishing season, winter-run chinook salmon should have lower harvest rates than fall-run chinook salmon, if they have similar age-at-maturity. At the time of the last status review, the only information on the harvest rate of winter-run chinook salmon came from a study conducted in the 1970s. Hallock and Fisher (1985) reported that the average catch/(catch+escapement) for the 1969-71 broodyears was 0.40 for the ocean fishery. For the 1968-1975 period, freshwater sport fisheries caught an average of 10% of the winter chinook salmon run.

The recent release of significant numbers of ad-clipped winter-run chinook salmon provides new, but limited, information on the harvest of winter-run chinook salmon in coastal recreational and troll fisheries. The Pacific Fisheries Management Council's Sacramento River Winter and Spring Chinook salmon Workgroup (SRWSCW) conducted a cohort reconstruction of the 1998 broodyear (PFMC 2003). Winter-run chinook salmon are mainly vulnerable to ocean fisheries as 3-year olds. SRWSCW calculated, on the basis of 123 coded-wire-tag

[5]In this section of the document, λ is defined as $\exp(\mu + \sigma^2_p / 2)$, the *mean* annual population growth rate.

recoveries, that the ocean fishery impact rate on 3-year-olds was 0.23, and the in-river sport fishery impact rate was 0.24. These impacts combine to reduce escapement to 100*(1-0.23)*(1-0.24) = 59% of what it would have been in the absence of fisheries, assuming no natural mortality during the fishing season. The high estimated rate of harvest in the river sport fishery, which arises from the recovery of eight coded-wire tags, was a surprise because salmon fishing is closed from January 15 to July 31 to protect winter-run chinook salmon. The tags were recovered in late December/early January, at the tail end of the fishery for late-fall-run chinook salmon.. The estimate of river sport fishery impact is much less certain than the ocean fishery impact estimate because of the lower number of tag recoveries, less rigorous tag sampling, and larger expansion factors. The California Fish and Game Commission is moving forward with an emergency action to amend sport fishing regulations to ban retention of salmon caught in river sport fisheries on January 1 rather than January 15. Had such regulations been in place in 1999/2000, the freshwater harvest rate would have been 20% of that observed.

New hatchery information

Livingston Stone National Fish Hatchery (LSNFH) was constructed at the base of Shasta Dam in 1997, with the sole purpose of helping to restore natural production of winter-run chinook salmon. LSNFH was designed as a conservation hatchery with features intended to overcome the problems of CNFH (better summer water quality, natal water source). All production is ad-clipped. Each individual considered for use as broodstock is genotyped to ensure that it is a winter-run chinook salmon. No more than 10% of the broodstock is composed of hatchery-origin fish, and no more than 15% of the run is taken for broodstock, with a maximum of 120 fish. Figure 3 shows the number of winter-run chinook salmon released by CNFH/LSNFH; Figure 4 shows the number of winter-run chinook salmon spawners taken into the hatchery.

A.2.8.3 New Comments

The California State Water Contractors, the San Luis and Delta-Mendota Water Authority, and the Westlands Water District recommend that the listing status of winter-run chinook salmon be changed from Endangered to Threatened. They base this proposal on the recent upturn of adult abundance, recently initiated conservation actions (restoration of Battle Creek, ocean harvest reductions, screening of water diversions, remediation of Iron Mountain Mine, and improved temperature control), and a putative shift in ocean climate in 1999.

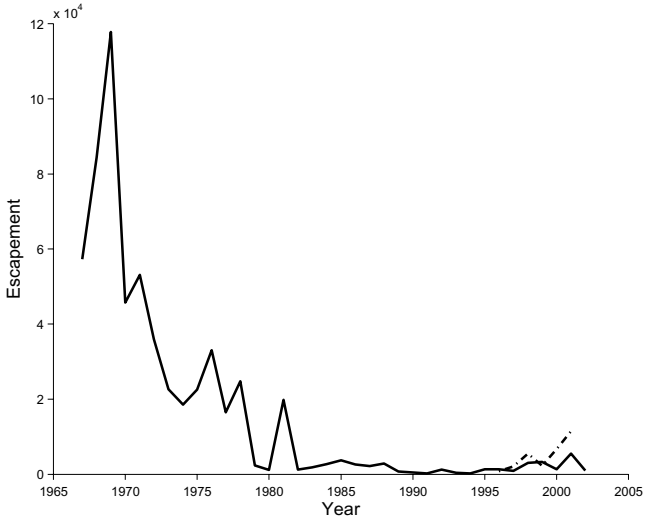


Figure A.2.8.1. Estimated winter-run chinook spawner abundance as determined by RBDD fish ladder (solid line) and carcass mark-recapture (dashed line).

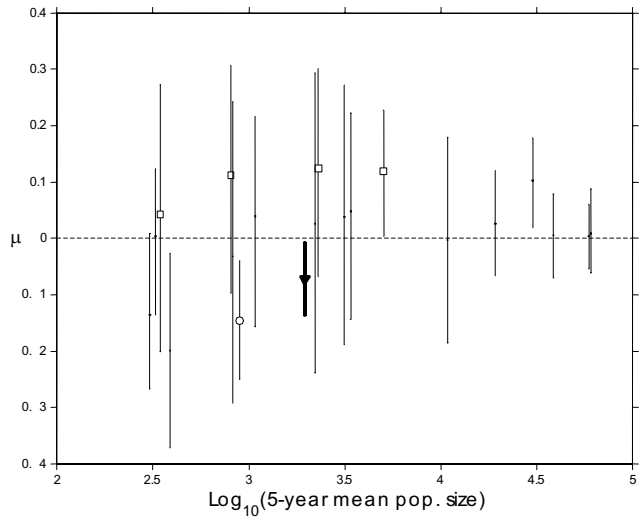


Figure A.2.8.2. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; open squares- spring chinook; filled triangle- winter-run chinook; small black dots- other chinook stocks. Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log(\lambda)$.)

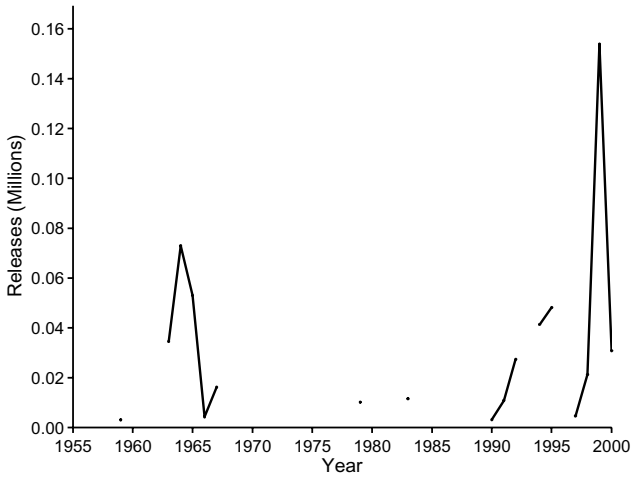


Figure A.2.8.3. Number of juvenile winter-run chinook released by Coleman and Livingston Stone National Fish Hatcheries.

Figure A.2.8.4. Number of adult winter-run chinook collected for broodstock by Coleman and Livingston Stone National Fish Hatcheries.

A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

Primary contributor: Steven T. Lindley (Southwest Fisheries Science Center – Santa Cruz Lab)

A.2.9.1. Summary of Previous BRT Conclusions

The status of Central Valley spring-run chinook salmon was formally assessed during a coastwide status review (Myers et al. 1998). In June 1999, a BRT convened to update the status of this ESU by summarizing information and comments received since the 1997 status review and presenting BRT conclusions concerning four deferred chinook salmon ESUs (NMFS 1999).

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring-run chinook salmon fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring-run chinook salmon program. Like most spring-run chinook salmon, CV spring-run chinook salmon require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500 m elevation, and most such habitat in the CV is now upstream of impassable dams (Figure A.2.9.1). Only three wild populations of spring-run chinook salmon with consistent spawning runs (on Mill, Deer and Butte Creeks, tributaries to the Lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on early gill-net fishery catches). The Upper Sacramento River supports a small spring-run population, but population status is poorly documented and the degree of hybridization with fall-run chinook salmon is unknown. Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain. The Feather River population is dependent on Feather River Hatchery (FRH) production, and may be hybridized with fall-run chinook salmon. Little is known about the status of the spring-run chinook salmon population on the Yuba River other than it appears to be small.

In addition to outright loss of habitat, CV spring-run chinook salmon must contend with the widespread habitat degradation and modification of their rearing and migration habitats in the natal stream, the Sacramento River, and the delta. The natal tributaries do not have large impassable dams like many Central Valley streams, but they do have many small hydropower dams and water diversions that, in some years, have greatly reduced or eliminated in-stream flows during spring-run migration periods. Problems in the migration corridor include unscreened or inadequately screened water diversions, predation by non-native species, and excessively high water temperatures.

The Feather and Yuba Rivers contain populations that are thought to be significantly influenced by the FRH spring-run chinook salmon stock. The FRH spring-run chinook salmon program releases its production far downstream of the hatchery[6], causing high rates of straying (CDFG 2001). There is concern that fall-run and spring-run chinook salmon have hybridized in the hatchery. The BRT viewed FRH as a major threat to the genetic integrity of the remaining wild spring-run chinook salmon populations.

[6] In 2003, CDFG plans to release half of its spring-run chinook production into the river, half into San Pablo Bay.

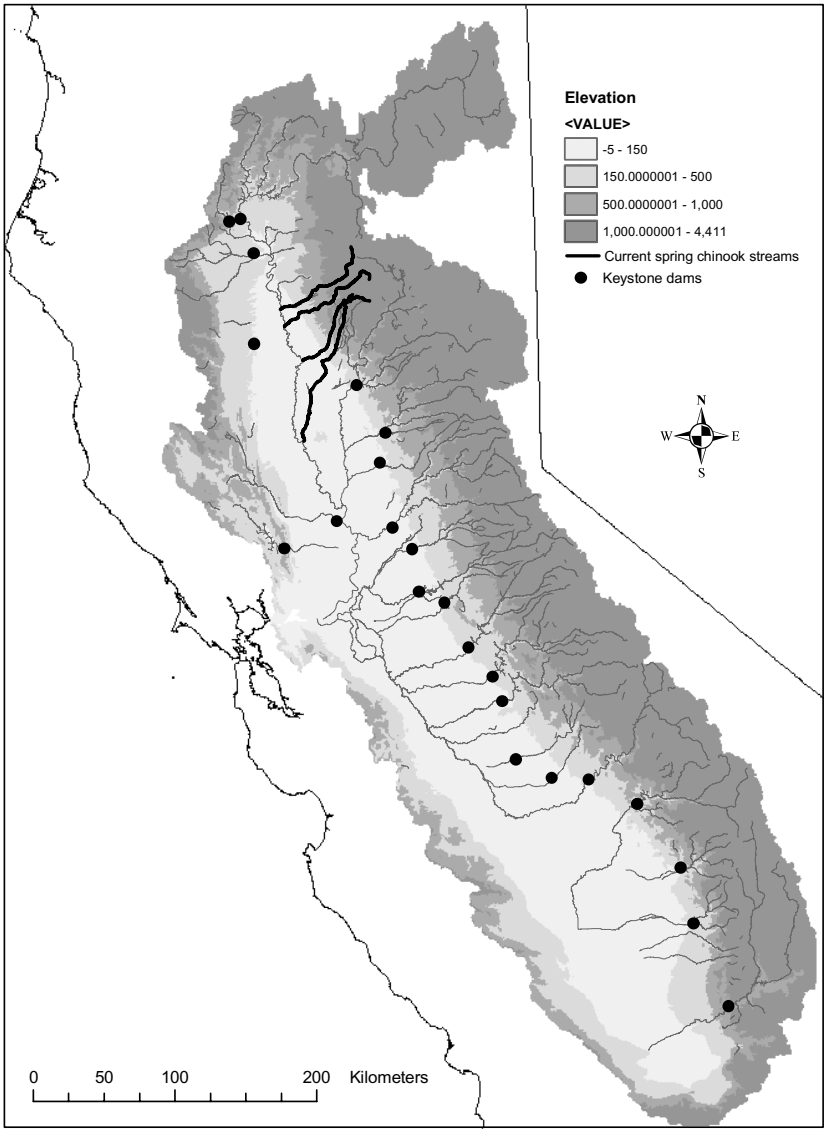


Figure A.2.9.1. Map of Central Valley showing the locations of spring-run chinook salmon populations with consistent runs, plus Big Chico Creek, which in recent years has had a small run. These populations are found in the only watersheds with substantial accessible habitat above 500 m elevation. Keystone dams are the lowest impassable dams on a river or stream.

Previous BRT conclusions

In the original chinook salmon status review, a majority of the BRT concluded that the CV spring-run chinook salmon ESU was in danger of extinction (Myers et al. 1998). Listing of this ESU was deferred, and in the status review update, the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (NMFS 1999). A major reason for this shift was data indicating that a large run of spring-run chinook salmon on Butte Creek in 1998 was naturally produced, rather than strays from FRH.

Listing status

Central Valley spring-run chinook salmon were listed as threatened in 1999. Naturally spawning spring-run chinook salmon in the Feather River were included in the listing, but the Feather River Hatchery stock of spring-run chinook salmon was excluded.

A.2.9.2 New Data and Updated Anlayses

Status assessments

In 1998, CDFG reviewed the status of spring-run chinook salmon in the Sacramento River drainage in response to a petition to list these fish under the California Endangered Species Act (CESA) (CDFG 1998). CDFG concluded that spring-run chinook salmon formed an interbreeding population segment distinct from other chinook salmon runs in the Central Valley. CDFG estimated that peak run sizes might have exceeded 600,000 fish in the 1880s, after substantial habitat degradation had already occurred. They blame the decline of spring-run chinook salmon on the early commercial gillnet fishery, water development that blocked access to headwater areas, and habitat degradation. Current risks to the remaining populations include continued habitat degradation related to water development and use, and the operation of FRH. CDFG recommended that Sacramento River spring-run chinook salmon be listed as threatened under the CESA.

Population structure

There are preliminary results for two studies of spring-run chinook salmon population structure. Two important insights are provided by these data sets. First, CV spring-run chinook salmon do not appear to be monophyletic, yet wild CV spring-run chinook salmon populations from different basins are more closely related to each other than to fall-run chinook salmon from the same basin. Second, neither Feather River natural (FR) or Feather River Hatchery (FRH) spring-run chinook salmon are closely related to any of the three wild populations although they are closely related to each other and to CV fall-run chinook salmon.

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring-run chinook salmon are not closely related to sympatric fall-run chinook salmon populations or the FRH spring-run chinook salmon stock (Figure A.2.9.2). FRH spring-run chinook salmon,

putative Feather River natural spring-run chinook salmon, and Yuba River spring-run chinook salmon fell into a large cluster composed mostly of natural and hatchery fall-run chinook salmon.

Dennis Hedgecock and colleagues, using 12 microsatellite markers, showed that there are two distinct populations of chinook salmon in the Feather River (Hedgecock 2002). One population is formed by early-running ("spring-run") chinook salmon, the other by late running fish ("fall-run"). Once run timing was accounted for, hatchery and naturally spawning fish appear to form a homogeneous population. The Feather River spring-run population is most closely related to FR fall-run (F_{st}=0.010) and to Central Valley fall-run chinook salmon (F_{st}=0.008), and is distinct from spring-run chinook salmon in Deer, Mill (F_{st}=0.016), and Butte (F_{st}=0.034) Creeks. Figure A.2.9.3 shows the neighbor-joining tree with Cavalli-Sforza and Edwards chord distances and unweighted pair-group method arithmetic averaging.

At least two hypotheses could explain the Feather River observations:

1. An ancestral Mill/Deer/Butte-type spring-run chinook salmon was forced to hybridize with the fall-run chinook salmon, producing an intermediate form.
2. The ancestral Feather River spring-run chinook salmon had a common ancestor with the Feather River fall-run chinook salmon, following the pattern seen in Klamath chinook salmon but different from the pattern seen in Deer, Butte, and Mill Creeks. The FR and FRH populations have merged.

Hedgecock argues against the first hypothesis. Feather River fish cluster well within Central Valley fall-run chinook salmon rather than between Mill/Deer/Butte spring-run chinook salmon and Central Valley fall-run chinook salmon, as would be expected under hypothesis 1. Furthermore, there is no evidence from linkage disequilibria that FR spring-run and FR fall-run populations are hybridizing, i.e., these populations are reproductively isolated. It is perhaps not surprising that Feather River spring-run chinook salmon might have a different ancestry than spring-run chinook salmon in Mill, Deer, and Butte Creeks, because the Feather River is in a different ecoregion.

Regardless of the cause of the genetic patterns described above, these new data do not support the current configuration of the CV spring-run chinook salmon ESU. Feather River spring-run chinook salmon do not appear to share a common ancestry or evolutionary trajectory with other spring-run chinook salmon populations in the Central Valley. They share the designation of "spring-run" chinook salmon, and indeed, the Feather River and FRH have a chinook salmon spawning run that starts much earlier than other Sacramento basin rivers. There is no longer a distinct bimodal distribution to run timing, however, and substantial fractions of fish released as FRH spring-run chinook salmon have returned during the fall-run chinook salmon period (and vice versa) (CDFG 1998). If FR and FRH spring-run chinook salmon are retained in the CV spring-run chinook salmon ESU, then the ESU configuration of the CV fall-late-fall-run chinook salmon ESU (among several others) should be reconsidered for the sake of consistency, because late-fall-run chinook salmon are more distinct genetically and arguably as distinct in terms of life history as FRH spring-run chinook salmon.

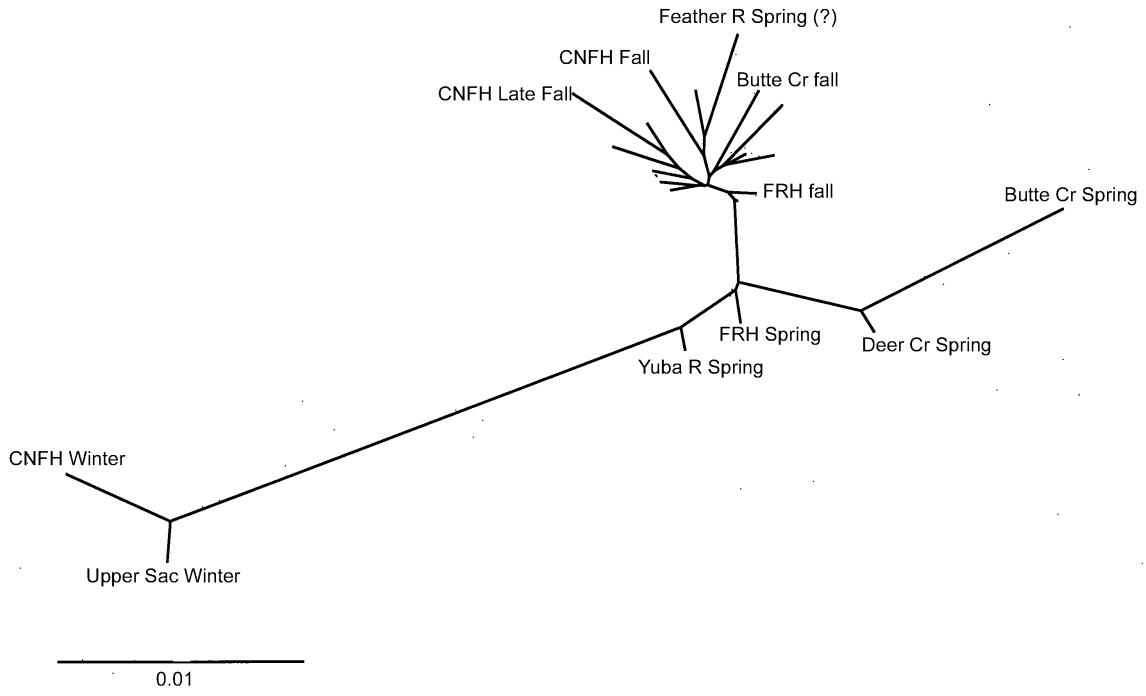


Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall-run chinook salmon populations. The "?" after Feather R Spring indicates that CDFG biologists are not certain that the fish collected for that sample are truly spring-run chinook salmon.

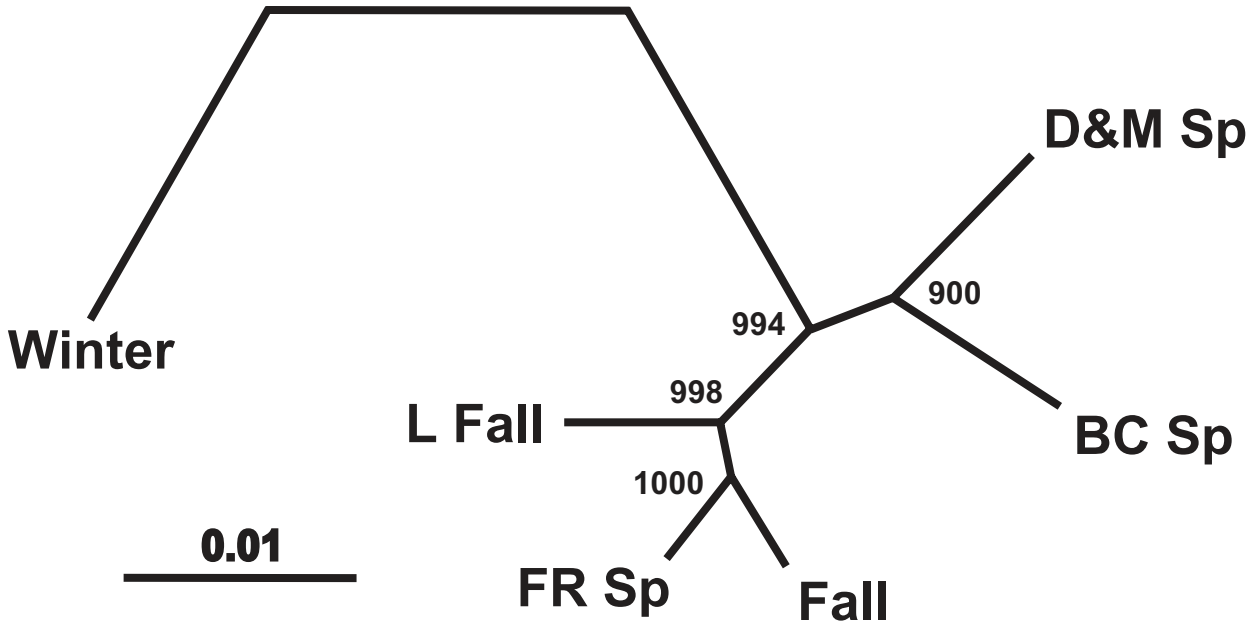


Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring-run chinook salmon; L Fall-run = late-fall-run chinook salmon; Winter = winter-run chinook salmon. The tree was constructed using Cavalli-Sforza and Edwards measure of genetic distance and the unweighted pair-group method arithmetic averaging. Figure from Hedgecock (2002).

Historic habitat loss

Yoshiyama and colleagues detailed the historic distribution of CV spring-run chinook salmon. Yoshiyama et al. (2001) estimated that 72% of salmon spawning and rearing habitat has been lost in the Central Valley. This figure is for fall-run as well as spring-run chinook salmon, so the amount of spring-run chinook salmon habitat lost is presumably higher because spring-run chinook salmon spawn and rear in higher elevations, areas more likely to be behind impassable dams. They deem the 95% loss estimate of CDFG (Reynolds et al. 1993) as "perhaps somewhat high but probably roughly accurate."

Life history

CDFG recently began intensive studies of Butte Creek spring-run chinook salmon (Ward et al. 2002). One of the more interesting observations is that while the great majority of spring-run chinook salmon leave Butte Creek as young-of-the-year, yearling outmigrants make up roughly 25% of the ocean catch of Butte Creek spring-run chinook salmon.

Harvest information

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of CV spring-run chinook

salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and recent increases in spring-run populations.

Coded-wire tagging of juvenile spring-run chinook salmon in Butte Creek provides some limited information on the ocean distribution of this population; there have not yet been enough tag recoveries for a full cohort reconstruction. Butte Creek spring-run chinook salmon have a more northerly distribution than winter-run chinook salmon (PFMC 2003), with recoveries off of Oregon and in the Klamath Management Zone and Fort Bragg areas. The majority of recoveries have been south of Point Arena.

Abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico Creek spring-run chinook salmon have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate.

The time series for Butte, Deer, and Mill Creeks are barely amenable to simple analysis with the random walk-wth-drift model (Homes 2001, Lindley in press). The data series are short, and inconsistent methods were used until 1992, when a consistent snorkel survey was initiated on Butte and Deer Creeks. The full records for these three systems are analyzed with the knowledge that there may be significant errors in pre-1992 observations. Table A.2.9.1 summarizes the analyses of these time series.

It appears that the three spring-run chinook salmon populations in the Central Valley are growing. The current 5-year geometric means for all three populations are also the maximum 5-year means. All three spring-run chinook salmon populations have long- and short-term $\lambda > 1$ (λ is defined as $\exp(\mu + \sigma^2_p / 2)$—the *mean* annual population growth rate in this document), with lower bounds of 90% confidence intervals generally > 1. Long- and short-term trends are also positive, although some confidence interval lower bounds are negative. CV spring-run chinook salmon have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run chinook salmon populations (Figure A.2.9.5).

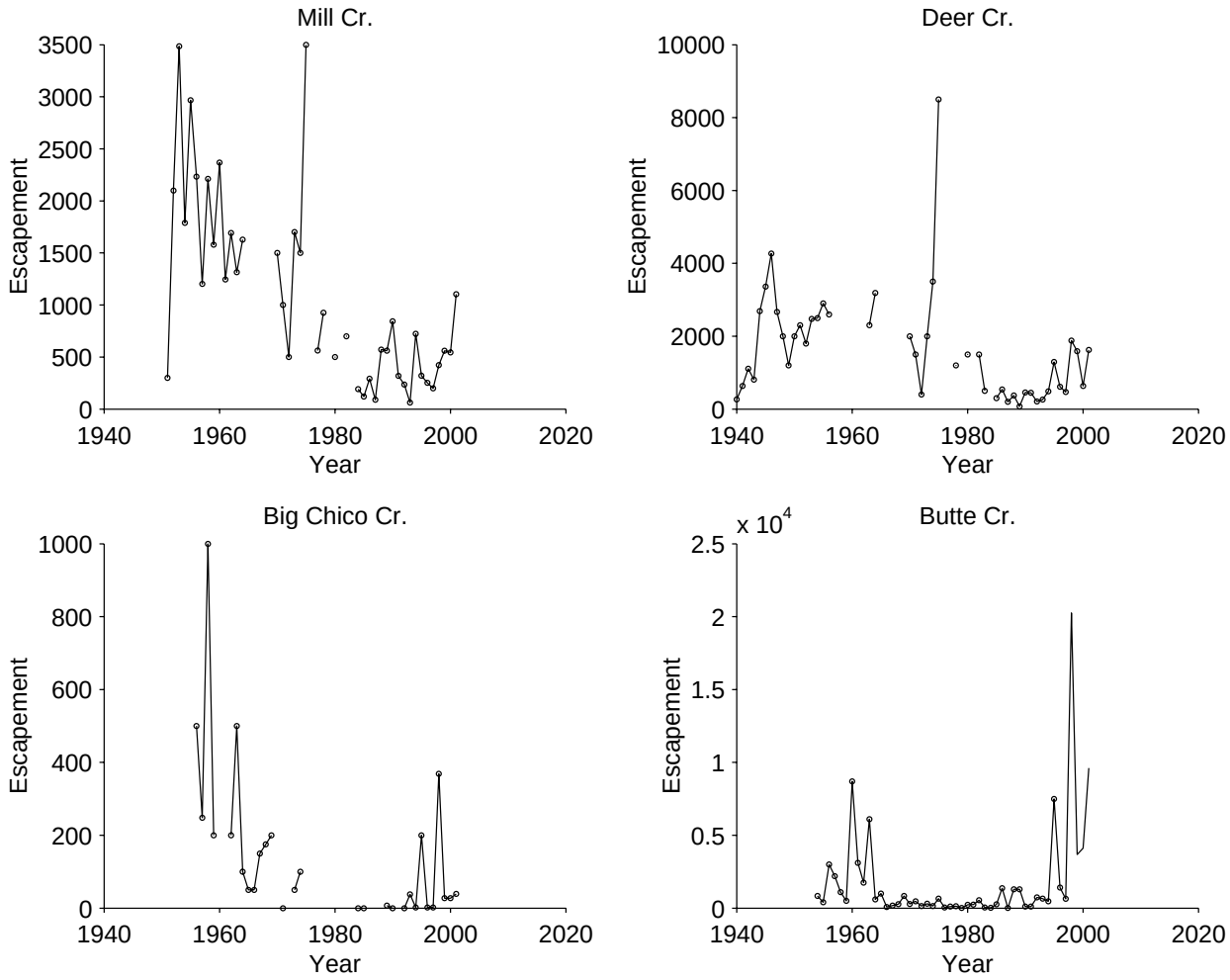


Figure A.2.4. Time series of population abundance for Central Valley spring-run chinook salmon.

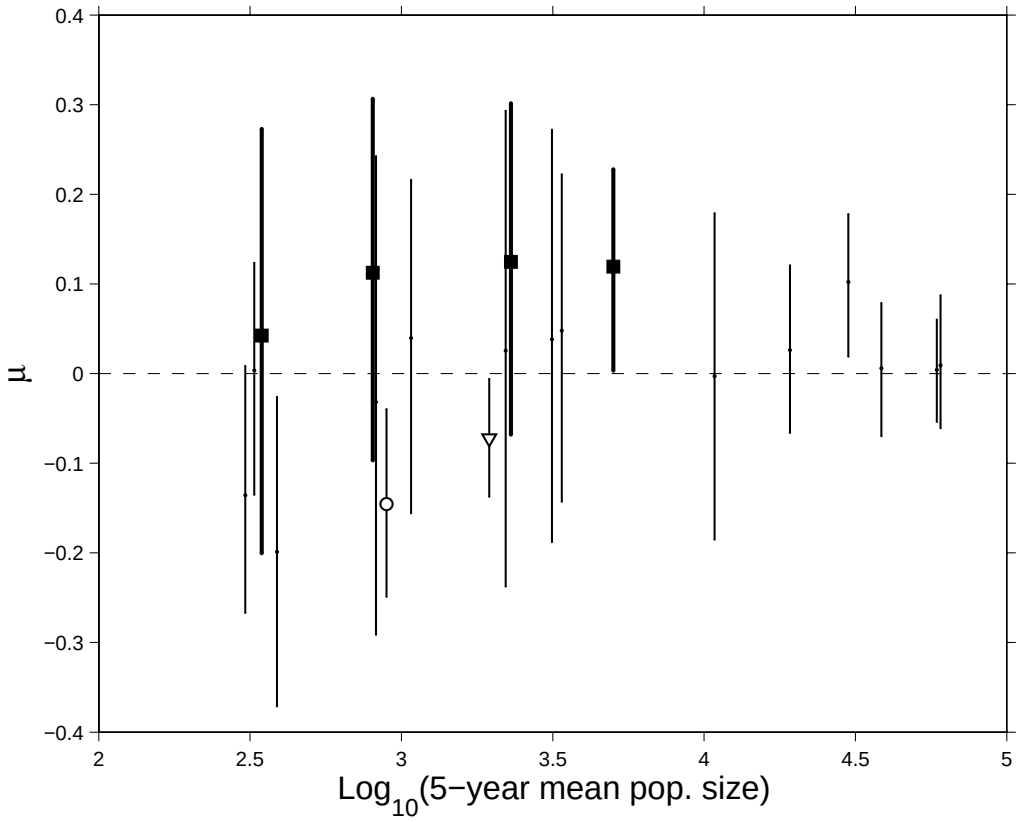


Figure A.2.5. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring-run chinook salmon; open triangle- winter-run chinook salmon; small black dots- other chinook salmon stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log[\lambda]$.)

Table A.2.9.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals.

Population	**5-yr mean**	**5-yr min**	**5-yr max**	**λ**	**μ**	**LT trend**	**ST trend**
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

New Hatchery Information

FRH currently aims to release 5 million spring-run chinook salmon smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.6). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.7).

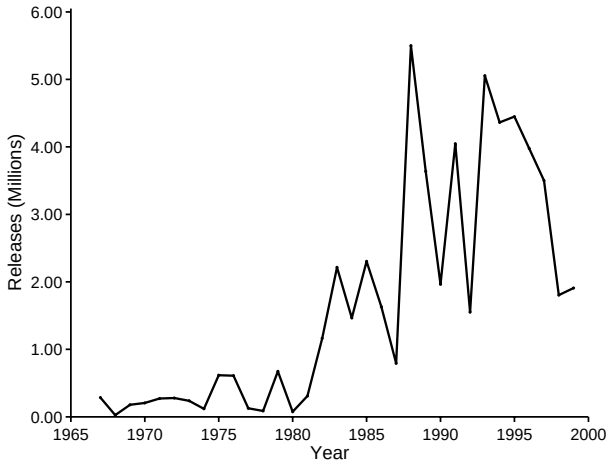


Figure A.2.9.6. Number of spring-run chinook salmon released by Feather River Hatchery.

Figure A.2.9.7. Number of spring-run chinook salmon returning to Feather River Hatchery.

New Comments

The State Water Contractors (SWC) submitted several documents, one of them relevant to the status review for CV spring-run chinook salmon. The document, "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," argues that Feather River spring-run chinook salmon should not be included in the CV spring-run chinook salmon ESU and do not otherwise warrant protection under the ESA. SWC also suggested that NMFS conduct a series of evaluations of the following topics:

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation
3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included: 1) an analysis by B.J. Miller showing that significant and expensive

changes to water operations in the delta provide fairly modest benefits to chinook salmon populations; 2) "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," discussed in the preceding paragraph; 3) a memo from J.F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

A.2.9.3 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer, and Butte Creek populations noted in the most recent previous status review (NMFS 1999) have apparently continued, probably due in part to the combined effects of habitat restoration, reduced fishing effort in the ocean, and favorable climatic conditions. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring-run chinook salmon are not closely related to the Mill, Deer, and Butte Creek spring-run chinook salmon populations.

A.3 CHINOOK SALMON BRT CONCLUSIONS

Snake River fall-run chinook salmon ESU

A majority (60%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). This represented a somewhat more optimistic assessment of the status of this ESU than was the case at the time of the original status review, when the BRT concluded that Snake River fall-run chinook salmon "face a substantial risk of extinction if present conditions continue" (Waples et al. 1991). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.0 for growth rate/productivity to 3.6 for spatial structure (Table A.3.2).

On the positive side, the number of natural origin spawners in 2001 was well in excess of 1000 for the first time since counts at Lower Granite Dam began in 1975. Management actions have reduced (but not eliminated) the fraction of fish passing Lower Granite Dam that are strays from out-of-ESU hatchery programs. Returns in the last two years also reflect an increasing contribution from supplementation programs based on the native Lyons Ferry Broodstock. With the exception of the increase in 2001, the ESU has fluctuated between approximately 500-1000 adults, suggesting a somewhat higher degree of stability in growth rate and trends than is seen in many other salmon populations.

In spite of the recent increases, however, the recent geometric mean number of naturally produced spawners is still less than 1000, a very low number for an entire ESU. Because of the large fraction of naturally spawning hatchery fish, it is difficult to assess the productivity of the natural population. The relatively high risk matrix scores for spatial structure and diversity (3.5-3.6) reflect the concerns of the BRT that a large fraction of historic habitat for this ESU is inaccessible, diversity associated with those populations has been lost, the single remaining population is vulnerable to variable environmental conditions or catastrophes, and continuing immigration from outside the ESU at levels that are higher than occurred historically. Some BRT members were concerned that the efforts to remove stray, out-of-ESU hatchery fish only occur at Lower Granite Dam, well upstream of the geographic boundary of this ESU. Specific concerns are that natural spawners in lower river areas will be heavily affected by strays from Columbia River hatchery programs, and that this approach effectively removes the natural buffer zone between the Snake River ESU and Columbia River ocean-type chinook salmon. The effects of these factors on ESU viability are not known, as the extent of natural spawning in areas below Lower Granite Dam is not well understood, except in the lower Tucannon River.

Snake River spring/summer-run chinook salmon ESU

About two-thirds (68%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). As indicated by mean risk matrix scores, the BRT had much higher concerns about abundance (3.6) and growth rate/productivity (3.5) than for spatial structure (2.2) and diversity (2.3) (Table A.3.2).

Although there are concerns about loss of an unquantified number of spawning aggregations that historically may have provided connectivity between headwater populations, natural spawning in this ESU still occurs in a wide range of locations and habitat types.

Like many others, this ESU saw a large increase in escapement in many (but not all) populations in 2001. The BRT considered this an encouraging sign, particularly given the record low returns seen in many of these populations in the mid 1990s. However, recent abundance in this ESU is still short of the levels that the proposed recovery plan for Snake River salmon indicated should be met over at least an eight year period (NMFS 1995). The BRT considered it a positive sign that the non-native Rapid River broodstock has been phased out of the Grande Ronde system, but the relatively high level of both production/mitigation and supplementation hatcheries in this ESU leads to ongoing risks to natural populations and makes it difficult to assess trends in natural productivity and growth rate.

Upper Columbia River spring-run chinook salmon ESU

Assessments by the BRT of the overall risks faced by this ESU were divided, with a slight majority (53%) of the votes being cast in the "danger of extinction" category and a substantial minority (45%) in the "likely to be endangered" category (Table A.3.1). The mean risk matrix scores reflect strong ongoing concerns regarding abundance (4.4) and growth rate/productivity (4.5) in this ESU and somewhat less (but still significant) concerns for spatial structure (2.9) and diversity (3.5) (Table A.3.2).

Many populations in this ESU have rebounded somewhat from the critically low levels that immediately preceded the last status review evaluation, and this was reflected in the substantial minority of BRT votes cast that were not cast in the "danger of extinction" category. Although this was considered an encouraging sign by the BRT, the last year or two of higher returns come on the heels of a decade or more of steep declines to all time record low escapements. In addition, this ESU continues to have a very large influence by hatchery production, both from production/mitigation and supplementation programs. The extreme management measures taken in an effort to maintain populations in this ESU during some years in the late 1990s (collecting all adults from major basins at downstream dams) are a strong indication of the ongoing risks to this ESU, although the associated hatchery programs may ultimately play a role in helping to restore self-sustaining natural populations.

Lower Columbia River chinook salmon ESU

A majority (71%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.2 for abundance to 3.9 for diversity (Table A.3.2).

All of the risk factors identified in previous reviews were still considered important by the BRT. The Willamette/Lower Columbia River TRT has estimated that 8-10 historic populations

in this ESU have been extirpated, most of them spring-run populations. Near loss of that important life history type remains in important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most populations in this ESU have not seen as pronounced increases in recent years as occurred in many other geographic areas.

Upper Willamette River chinook salmon ESU

A majority (70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements (mean risk matrix scores ranged from 3.1 for growth rate/productivity to 3.6 for spatial structure) (Table A.3.2).

Although the number of adult spring-run chinook salmon crossing Willamette Falls is in the same range (about 20,000–70,000) it has been for the last 50 years, a large fraction of these are hatchery produced. The score for spatial structure reflects concern by the BRT that perhaps a third of the historic habitat used by fish in this ESU is currently inaccessible behind dams, and the BRT remained concerned that natural production in this ESU is restricted to a very few areas. Increases in the last 3-4 years in natural production in the largest remaining population (the McKenzie) were considered encouraging by the BRT. With the relatively large incidence of hatchery fish, it is difficult to determine trends in natural production.

Puget Sound chinook salmon ESU

A majority (74%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 2.9 for spatial structure to 3.6 for growth rate/productivity (Table A.3.2).

Most population indices for this ESU have not changed substantially since the last BRT assessment. The Puget Sound TRT has identified approximately 31 historic populations, of which 9 are believed to be extinct, with most of the populations that have been lost being early run. Other concerns noted by the BRT are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity (and, likely, associated life history types). Although populations in this ESU have not experienced the sharp increases in the last 2-3 years seen in many other ESUs, more populations increased than decreased over the 4 years since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent natural production within the ESU is only a fraction of estimated historic run size. On the positive side, harvest rates for all populations have been reduced from their peaks in the 1980s, and some hatchery reforms have been implemented (e.g., elimination of many net pen programs that were leading to widespread straying, and transition of other programs to more local

broodstocks). The BRT felt that these management changes should help facilitate recovery if other limiting factors (especially habitat degradation) are also addressed. The BRT felt that the large recovery effort organized around the Puget Sound Shared Strategy was a positive step because it could help to link and coordinate efforts in many separate, local watersheds.

California Coastal chinook salmon ESU

A majority (67%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with votes falling in the "danger of extinction" category outnumbering those in "not warranted" category by nearly 2-to-1 (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.1 for diversity to 3.9 for abundance (Table A.3.2).

The BRT was concerned by continued evidence of low population sizes relative to historical abundance and mixed trends in the few time series of abundance indices available for analysis, and by the low abundances and potential extirpations of populations in the southern part of the ESU. The BRT's concerns regarding genetic integrity of this ESU were moderate or low relative to similar issues for other ESUs because 1) hatchery production in this ESU is on a minor scale, and 2) current hatchery programs are largely focused on supplementing and restoring local populations. However, the BRT did have concerns with respect to diversity that were based largely on the loss of spring-run chinook salmon in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU. Overall, the BRT was strongly concerned by the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity and distribution of chinook salmon in this ESU.

Sacramento River winter-run chinook salmon ESU

A majority (60%) of the BRT votes fell into the "in danger of extinction" category, with a minority (38%) voting for the "likely to become endangered" and only 2% voting for "not warranted." (Table A.3.1). The main VSP concerns were in the spatial structure and diversity categories (4.8 and 4.2, respectively), although there was significant concern in the abundance and productivity categories (3.7 and 3.5, respectively) (Table A.3.2).

The main concerns of the BRT relate to the lack of diversity within this ESU. The BRT was very troubled by the fact that this ESU is represented by a single population that has been displaced from its historic spawning habitat into an artificial habitat created and maintained by a dam. The BRT presumed that several independent populations of winter-run chinook salmon were merged into a single population, with the potential for a significant loss of life history and genetic diversity. Furthermore, the population has passed through at least two recent bottlenecks—one when Shasta Dam was filled and another in the late 1980s-early 1990s—that probably further reduced genetic diversity. The population has been removed from the environment where it evolved, dimming its long-term prospects for survival. The BRT was modestly heartened by the increase in abundance since the lows of the late 1980s and early 1990s.

Central Valley spring-run chinook salmon ESU

A large majority (69%) of the BRT votes fell into the "likely to become endangered" category, with a minority (27%) of votes going to "in danger of extinction" and 4% "not warranted" (Table A.3.1). There was roughly equal concern about abundance, spatial structure and diversity (3.5-3.8), and less concern about productivity (2.8) (Table A.3.2).

A major concern of the BRT was the loss of diversity caused by the extirpation of spring-run chinook salmon populations from most of the Central Valley, including all San Joaquin tributaries. The only populations left in the Sierra Nevada ecoregion are supported by the Feather River hatchery. Another major concern of the BRT was the small number and location of extant spring-run chinook salmon populations-- only three streams, originating in the southern Cascades, support self-sustaining runs of spring-run chinook salmon, and these three streams are close together, increasing their vulnerability to catastrophe. Two of the three extant populations are fairly small, and all were recently quite small. The BRT was also concerned about the Feather River spring-run chinook salmon hatchery population, which is not in the ESU but does produce fish that potentially could interact with other spring-run chinook salmon populations, especially given the off-site release of the production.

Table A.3.1. Tally of FEMAT vote distribution regarding the status of 9 chinook salmon ESUs reviewed by the chinook salmon BRT. Each of 15 BRT members allocated 10 points among the three status categories.

ESU	At Risk of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River fall-run	38	91	21
Snake River spring/summer-run	30	102	18
Upper Columbia River spring-run	79	67	4
Puget Sound	12	111	27
Lower Columbia River	25	107	18
Upper Willamette River	32	105	13
California Coastal[1]	36	100	13
Sacramento River winter-run[2]	78	49	3
CA Central Valley spring-run[2]	35	90	5

[1] One BRT member assigned 9 points [2] Votes tallied for 13 BRT members

Table A.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 9 chinook salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River fall-run	3.4 (2-5)	3.0 (2-5)	3.6 (2-5)	3.5 (2-5)
Snake River spring/summer-run	3.6 (2-5)	3.5 (3-5)	2.2 (1-3)	2.3 (1-3)
Upper Columbia River spring-run	4.4 (3-5)	4.5 (3-5)	2.9 (2-4)	3.5 (2-5)
Puget Sound	3.3 (2-4)	3.6 (3-4)	2.9 (2-4)	3.2 (2-4)
Lower Columbia River	3.2 (2-4)	3.7 (3-5)	3.5 (3-4)	3.9 (3-5)
Upper Willamette River	3.7 (2-5)	3.1 (2-5)	3.6 (3-4)	3.2 (2-4)
California Coastal[1]	3.9 (3-5)	3.3 (3-4)	3.2 (2-4)	3.1 (2-4)
Sacramento River winter-run[2]	3.7 (3-5)	3.5 (2-5)	4.8 (4-5)	4.2 (3-5)
CA Central Valley spring-run[2]	3.5 (3-4)	2.8 (2-4)	3.8 (3-5)	3.8 (3-5)

A.4 REFERENCES

Anonymous. 1998. ODFW Columbia River Management unpublished files: Willamette Falls fish passage 1946-97.

Beamesderfer, R. C. P., H. P. Schaller, M. P. Zimmerman, C. E. Petrosky, O. P. Langness, and L. LaVoy. 1997. Spawner-recruit data for spring and summer chinook salmon populations in Idaho, Oregon, and Washington. Unpublished draft manuscript dated 6/23/97, 78 p. (Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C.)

Bennett, D. E. 1986. Fish passage at Willamette Falls in 1985, Annual report, January 1-December 31, 1985. ODFW, Portland, OR.

Bennett, D. E. and C.A. Foster. 1990. 1989 Willamette River spring chinook run, fisheries, and passage at Willamette Falls. ODFW.

Bennett, D. E. and C. A. Foster. 1994. 1993 Willamette River spring chinook salmon run. ODFW, Portland, OR.

Bennett, D. E. and C.A. Foster. 1995. 1994 Willamette river spring chinook run, fisheries, and passage at Willamette Falls, draft. Unpublished.

Bishop, S. and A. Morgan (eds.). 1996. Critical habitat issues by basin for natural chinook salmon stocks in the coastal and Puget Sound areas of Washington State. Northwest Indian Fisheries Commission, Olympia, WA, 105 p.

Botsford, L. W. and J. G. Brittnacher. 1998. Viability of Sacramento River winter-run chinook salmon. Conserv. Biol. 12:65-79.

Bugert, R. M., and B. Hopley. 1989. The Snake River fall chinook salmon egg bank program: The final chapter. Washington Department of Fisheries, 7 p. (Available from Washington Department of Fish and Wildlife, 600 Capital Way N., Olympia WA 98501-1091.)

Bugert, R.M., C. W. Hopley, C. A. Busack, and G. W. Mendel. 1995. Maintenance of stock integrity in Snake River fall chinook salmon. Uses and Effects of Cultured Fishes in Aquatic Ecosystems. American Fisheries Society, Bethesda, MD, Vol. 15: 267-276.

Burgner, R. L. 1991. the life history of sockeye salmon (*Oncorhynchus nerka*). *In* C. Groot and L. Margolis (eds.), Life history of Pacific salmon, p. 3-117. Univ. B.C. Press, Vancouver, B.C.

Busack, C. and D. Rawding. 2003. HPVA results for salmon and steelhead production in Washington Lower Columbia Basins. Appendix J in McElhany et al. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. NMFS-NWFSC.

Carie, D. G. 2000. Spring and summer chinook salmon spawning ground surveys on the Entiat River, 2000. U.S. Fish & Wildlife Service Rept. Mid-Columbia River Fishery Resource Office. Leavenworth, Washington. 17 pp.

CDFG (California Department of Fish and Game). 1998. Report to the Fish and Game Commission: a status review of the spring-run chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. California Department of Fish and Game, Sacramento, CA.

CDFG (California Department of Fish and Game). 2001. Final report on anadromous salmonid fish hatcheries in California. Technical report, California Department of Fish and Game and National Marine Fisheries Service Southwest Region. (http://swr.nmfs.noaa.gov/ HatcheryReviewPublicDraft2.pdf)

Campbell, B. 2000. Salmonid Stock Inventory (SaSSI) database.

Castle, P. and N. Currens. 2001a. Personal communication from Nooksack comanagers to the Puget Sound Technical Recovery Team. December 11, 2001.

Castle, P. and N. Currens. 2001b. North Fork Nooksack native spring chinook escapement methodology. Memo to the Puget Sound Technical Recovery Team. December 2001

Chapman, D. W. 1986. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Trans. Am. Fish. Soc. 115:662-670.

Chilcote, M. W. 2001. Conservation Assessment of Steelhead Populations in Oregon. Oregon Department of Fish and Wildlife. Portland, OR.

Cooney, T. 2001. Upper Columbia River steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary analysis of extinction risks. National Marine Fisheries Service. Hydro Program. Technical Review Draft.

Craig, J. A., and A. J. Suomela. 1941. Time of appearance of the runs of salmon and steelhead trout native to the Wenatchee, Entiat, Methow, and Okanogan Rivers. Cited In J. W. Mullan, K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre (editors). 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. U.S. Fish Wildl. Serv. Monograph I:J358-J380.

Cramer, D. 2002d. Sandy R Spring Chinook Counts at Marmot Dam. Portland General Electric Excel Workbook delivered via e-mail to Paul McElhany and Sarah Sydor, NWFSC.

Cramer, D. 2002e. Portland General Electric - Clackamas River spring chinook adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Dauble, D. D., R. L. Johnson, and A. P. Garcia. 1999. Fall chinook salmon spawning in the tailraces of lower Snake River hydroelectric projects. Trans. Amer. Fish Soc. 128 (4): 672-679.

Dennis, B., P. L. Munholland, and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecol. Mono. 61:115-143.

FCRPS (Federal Columbia River Power System). 2000. Endangered Species Act - Section 7 Consultation, Biological Opinion; Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin between the U.S. Army Corps of Engineers, Bonneville Power Administration, Bureau of Reclamation, and the National Marine Fisheries Service. National Marine Fisheries Service, Northwest Region. December 21, 2000.

Fisher, F. W. 1994. Past and present status of Central Valley chinook salmon. Conserv. Biol. 8:870-873.

Ford, M, P. Budy, C. Busack, D. Chapman, T. Cooney, T. Fisher, J. Geiselman, T. Hillman, J. Lukas, C. Peven, C. Toole, E. Weber, and P. Wilson. 2001. Final report of the Upper Columbia River Steelhead and Spring Chinook Salmon Biological Requirements Committee, March 2001. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA.

Foster, C. A. 1998. Excerpt from: 1997 Willamette River spring chinook salmon run fisheries and passage at Willamette Falls (draft). Unpublished.

Foster, C. A. 2000. 1999 Willamette River Spring Chinook Run, Fisheries, and Passage at Willamette Falls. (Draft).

Foster, C. A. 2002. Willamette Falls Counts by Year (dynamic database).

Fulop, J. 2002. Oregon Lower Columbia River Fall and Winter Chinook Spawning Ground Surveys, 1948-2000. Oregon Department of Fish and Wildlife, Columbia River Management. Portland, OR.

Fulop, Jeff. 2003. Oregon Lower Columbia River Fall and Winter Chinook Spawning Ground Surveys, 1952-2002. Focus on 2001-2002 Oregon Department of Fish and Wildlife, Columbia River Management. Portland, OR.

Fulton, L. A. 1968. Spawning areas and abundance of chinook salmon, *Oncorhynchus tshawytscha*, in the Columbia River Basin--Past and present. U.S. Fish. Wildl. Serv. Spec. Sci. Rep.--Fish. 571, 26 p.

Gilbert, C. H. 1912. Age at maturity of Pacific coast salmon of the genus *Oncorhynchus*. Bull. U.S. Fish Comm. 32:57-70.

Hallock, R. J. and F. W. Fisher. 1985. Status of winter-run chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. California Department of Fish and Game, Anadromous Fisheries Branch. 29 p.

Hankin, D. G., J. W. Nicholas and T. W. Downey. 1993. Evidence for inheritance of age of maturity in chinook salmon, *Onchorhynchus tshawytscha*. Can. J. fish. Aquat. Sci.

Hayman, B. 2002. Personal communication to Norma Jean Sands, NWFSC. January 2002.

Healey, M. C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean type chinook salmon, *Oncorhynchus tshawytscha*. Canadian Field-Naturalist 97:427-433.

Healey, M. C. 1986. Optimum size and age at maturity in Pacific salmon and effects of size selective fisheries. Can. Spec. Publ. Fish. Aquat. Sci. 89:39-52.

Healey, M. C. 1991. The life history of chinook salmon (*Oncorhynchus tshawytscha*). *In* C. Groot and L. Margolis (eds), Life history of Pacific salmon, p. 311-393. Univ. BC Press, Vancouver, BC.

Hedgecock, D. 2002. Microsatellite DNA for the management and protection of California's Central Valley chinook salmon (Oncorhynchus tshawytscha). Final report for the amendment to agreement No. B-59638. UC Davis, Bodega Bay, CA.

Higgins P., S. Dobush, and D. Fuller. 1992. Factors in Northern California threatening stocks with extinction. Humboldt Chapter of the American Fisheries Society. 26 pp.

Holmes, E. E. 2001. Estimating risks in declining populations with poor data. Proc. Nat. Acad. Sci. USA 98:5072-5077.

Howell, P. J. 1986. Willamette basin fish management plan: status and progress 1979-85. ODFW, Portland, OR.

Hubble, J. and S. Crampton. 2000. Methow basin spring chinook spawner ground survey report for 1999. Fisheries Resource Management Program. Yakama Nation. Prepared for Douglas County PUD. 17 pp + tables.

Irving J. S. and T. Bjornn. 1991. A forecast of abundance of Snake River fall chinook salmon. Prepared for U.S. Fish & Wildlife Service. Unpubl. MS. 55 p. Available from Idaho Cooperative Fishery Research Unit. Univ. of Idaho, Moscow, ID.

Johnson, T. 2003a. Age data (2001 and 2002), unpublished. March 27, 2003.

Johnson, T. 2003b. Personal communication to Norma Jean Sands and co-managers. March 27, 2003.

Joint Chinook Technical Committee (CTC). 1999. Annual reports for 1995 and 1996.

Joint Chinook Technical Committee (CTC). 2000. CTC model and ER analyses output. Dell Simmons, December 2000.

Kostow, K. 2002. Leaburg and McKenzie abundance from ODFW. Data delievered via e-mail, September 2002.Kreitman, G. 1981. Addendum to 8/13/80 naturally spawning population estimates memo. Streamnet Reference.

Lampkis, N. 2003. Run reconstruction tables. Unpublished data. March 31, 2003.

Lindley, S. T. and M. H. Mohr. 2003. Predicting the impact of striped bass (Morone saxatilis) population manipulations on the persistence of winter-run chinook salmon (*Oncorhynchus tshawytscha*). Fish. Bull., U.S. 101:321-331.

Lindley, S. T. (in press). Estimation of population growth and extinction parameters from noisy data. Ecol. Appl.

Marmorek, D. R., C. N. Peters and I. Parnell (eds). 1998. Plan for analyzing and testing hypotheses (PATH): final report for fiscal year 1998. ESSA Technologies Ltd., Vancouver, BC.

Marshall, A. R., C. Smith, R. Brix, W. Dammers, J. Hymer, and L. LaVoy. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. *In* C. Busack and J. B. Shaklee (eds.), Genetic diversity units and major ancestral lineages of salmonid fishes in Washington, p. 111-173. Wash. Dep. Fish Wildl. Tech. Rep. RAD 95-02. (Available from Washington Department of Fish and Wildlife, 600 Capital Way N., Olympia WA 98501-1091)

Marshall, A. R., H. L. Blankenship, and W. P. Connor. 2000. Genetic Characterization of Naturally Spawned Snake River Fall-Run Chinook Salmon. Trans. Amer. Fish. Soc. 129: 680-698.

Matthews, G. M., and R. S. Waples. 1991. Status review for Snake River spring and summer chinook salmon. NOAA Tech. Memo. NMFS F/NWC-200, 75 p. (Available from Natl. Mar. Fish. Serv., Northwest Fisheries Science Center, Coastal Zone and Estuarine Studies Division, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

McClure, M. M., E. E. Holmes, B. L. Sanderson, and C. E. Jordan. (in press). A large-scale, multi-species status assessment: anadromous salmonids in the Columbia River Basin. *Ecol. Appl.*

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, and C. Steward. 2002. Willamette/Lower Columbia Pacific salmonid viability criteria. Draft report from the Willamette/Lower Columbia Technical Recovery Team. December 2002.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, and C. Steward. 2003. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. Report from the Willamette/Lower Columbia Technical Recovery Team. NMFS-NWFSC. March 2003.

McPhail, J.D., and C. C. Lindsey. 1970. Freshwater fishes of Northwestern Canada and Alaska. Bull. Fish. Res. Board Can. 173:381.

Miller, R. J., and E. L. Brannon. 1982. The origin and development of life-history patterns in Pacific salmon. *In* E. L. Brannon and E. O. Salo (eds), Proceedings of the Salmon and Trout Migratory Behavior Symposium., p. 296-309. Univ. Wash. Press, Seattle, WA.

Moffett, J. W. 1949. The first four years of king salmon maintenance below Shasta Dam, Sacramento River, California. Cal. Fish Game 35:77-102.

Mosey, T. R. and L. J. Murphy. 2002. Spring and summer spawning ground surveys on the Wenatchee River basin, 2001. Washington Dept. of Fish & Wildlife Rept. to Chelan County PUD. 35 pp + appendices.

Murtagh, T., J. Massey, and D. E. Bennett. 1997. Excerpt from: Sandy River basin fish management plan 1997 (draft). Unpublished. Streamnet reference.

Myers, J. M., R. G. Kope, B. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo NMFS-NWFSC-35, 443 p.

Myers, J. M., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

Nehlsen W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2): 4-21.

NMFS (National Marine Fisheries Service). 1987. Endangered and threatened species; winter-run chinook salmon. Federal Register [Docket No. 27 Febuary 1986] 52(39):6041-6048.

NMFS (National Marine Fisheries Service). 1995. Proposed recovery plan for Snake River Salmon. 364 p. + app. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon St., Suite 500, Portland, OR 97232.)

NMFS (National Marine Fisheries Service). 1997. NMFS proposed recovery plan for the Sacramento River winter-run chinook. NMFS Southwest Region, Long Beach, CA.

NMFS (National Marine Fisheries Service). 1998. Conclusions regarding the updated status of Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River spring-run ESUs of West Coast Chinook Salmon. Memorandum to U. Varanasi (Northwest Fisheries Science Center, NMFS), W. Stelle (NWFSC, NMFS), and W. Hogarth (Southwest Fisheries Science Center, NMFS) from M. Schiewe (Northwest Fisheries Science Center, NMFS), 12 February 1999. 62 p.

NMFS (National Marine Fisheries Service). 1999. Status review update for deferred ESUs of West Coast chinook salmon (*Oncorhynchus tshawytscha*) from Washington, Oregon, California, and Idaho. Memorandum to U. Varanasi (Northwest Fisheries Science Center, NMFS) and M. Tillman (Southwest Fisheries Science Center, NMFS) from M. Schiewe (Northwest Fisheries Science Center, NMFS), 16 July 1999. 116 p.

NMFS (National Marine Fisheries Service). 2002. Meeting between Nooksack co-managers (Pete Castle and Dale Griggs) and NMFS (Susan Bishop and Norma Jean Sands). July 29, 2002.

NMFS (National Marine Fisheries Service) and Co-managers. 2002. NMFS/Co-managers Meeting Point No Point. August 8, 2002.

Nisqually Co-managers. 2002. Personal communication to the Puget Sound Technical Recovery Team.

Norman, G. 1982. Population estimates of natural spawning adults and jack fall chinook on the Wind, Big White Salmon, and Klickitat rivers, 1964-81. Unpublished Streamnet Reference.

NWIFC (Northwest Indian Fisheries Commission). 2001. Estimation of contribution of hatchery origin fall chinook salmon to Duwamish-Green River spawning ground populations. NWIFC memo to Distribution June 30, 2001.

ODFW (Oregon Dept of Fish and Wildlife). 1990. Sandy River subbasin: Salmon and steelhead production plan. Oregon Department of Fish and Wildlife. Northwest Power Planning Council. Streamnet Reference.

ODFW (Oregon Dept of Fish and Wildlife). 1998. ODFW Columbia River Management unpublished files: Estimated number of spawning fall chinook in lower Columbia River tributaries, 1964-1997. Unpublished abundance data and refererence from Streamnet.org.

ODFW (Oregon Department of Fish and Wildlife). 2002. Spring Chinook Salmon in the Willamette and Sandy Rivers. Oregon Department of Fish and Wildlife, Fish Research Project Oregon, Annual Progress Report. Portland, OR.

ODFW (Oregon Dept of Fish and Wildlife). 1999. Field data forms and files of ODFW spawning ground surveys, Columbia River Management. ODFW.

PFMC (Pacific Fishery Management Council). 1997. Review of the 1996 ocean salmon fisheries. PFMC, 275 p.

PFMC (Pacific Fishery Management Council). 2001. Review of 2000 ocean salmon fisheries. (Document prepared for the Council and its advisory entities.). Technical report, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR

PFMC (Pacific Fishery Management Council). 2002a. Review of 2001 ocean salmon fisheries. (Document prepared for the Council and its advisory entities.). Technical report, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR.

PFMC (Pacific Fishery Management Council). 2002b. Preseason Report I Stock Abundance Analysis for 2002 Ocean Fisheries. Pacific Fishery Management Council, Portland, OR.

PFMC (Pacific Fishery Management Council). Central Valley winter and spring chinook salmon workgroup report. Exhibit B.8.b, March 2003. Pacific Fishery Management Council, Portland, OR.

PSC (Pacific Salmon Commission). 1994. Pacific Salmon Commission Joint Chinook Technical Committee 1993 annual report. Pacific Salmon Commission. Report Chinook (94)-1, 121 p. + app.

PSC (Pacific Salmon Commission). 2002. Lower Columbia Harvest Rate. Unpublished. Excel spreadsheets provided by Dell Simmons that include age structure information. Based on PFMC Chinook Technical Committee CWT analysis.

Phinney, C. 2001. Personal communication from Puyallup Indian Fisheries to Puget Sound Technical Recovery Team. January 25, 2001.

Puget Sound Indian Tribes and WDFW (Washington Department of Fish and Wildlife). 2001. Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component. March 2001.

PSTRT (Puget Sound Technical Recovery Team). 2001. Independent populations of chinook salmon in Puget Sound. Puget Sound Technical Recovery Team Report. 92 pp.

PSTRT (Puget Sound Technical Recovery Team). 2002. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound chinook salmon

evolutionarily significant unit . Puget Sound Technical Recovery Team Report. 17 pp. (available at: http://www.nwfsc.noaa.gov/cbd/trt/trt_puget.htm).

Rawding, D. 2001a. Lower Columbia Chinook Escapement (WDFW). Excel file provided by Dan Rawding in Fall 2001.

Rawson, K. 2001. Terminal harvest rates for Snohomish River using terminal run reconstruction. November 2001.

Rawson, K. and Kraemer, C. Personal communication to the Puget Sound Technical Recovery Team.

Rawson, K. and Kraemer, C. 2001. Unpublished data from otolith sampling on spawning grounds. February 2001.

Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Sacramento, CA.

SSHAG (Salmon Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum Salmon, Coho Salmon, Chinook Salmon, and Steelhead within Listed and ESUs. Technical review draft. NMFS Northwest and Southwest Fisheries Science Centers.

Sands, N. J. A User's Guide to the abundance and productivity tables (Excel Workbook). In prep.

Sanford, B. 2003. WDFW pers. com. Washington chinook escapement data emailed to Paul McElhany April 1, 2003Scott, J. 2002. Personal communication to the Puget Sound Technical Recovery Team. May 21, 2002.

Serl, J. and Morrill C. 2002. Draft 2002 annual report for the Cowlitz Falls project. Prepared by WDFW for BPA contract number 96B192557.

Shardlow, T.F., T. M. Webb and D. T. Lightly. 1986. Chinook salmon escapement estimation on the Campbell and Quinsam Rivers in 1984: accuracy and precision of mark/recapture techniques using tagged salmon carcasses. Canadian Technical Report of Fisheries and Aquatic Sciences 1507. 52 p.

Snider, B. and B. Reavis and S. Hill. 1999. 1998 Upper Sacramento River winter-run chinook salmon escapement survey May-August 1998. California Department of Fish and Game, Water and Aquatic Habitat Conservation Branch, Stream Evaluation Program Report. January 1999.

Steel, E. A. and M. B. Sheer. 2002. Broad-scale habitat analyses to estimate fish densities for viability criteria. Appendix C *in* Willamette/Lower Columbia Pacific salmonid viability criteria. Willamette/Lower Columbia Technical Recovery Team Report. December 2002.

Steel, A. and M. Sheer. 2003. Broad-scale habitat analysis to estimate fish densities for viability criteria. Appendix I in McElhany et al. Interim report on viability criteria for Willamette and lower Columbia basin Pacific salmonids. NMFS-NWFSC.

USFWS (United States Fish and Wildlife Service). 1997. Documents submitted to the ESA Administrative Record for west coast chinook salmon by D. Finberg, 26 February 1997, 4p.

Wahle R. J., Pearson. 1987. A listing of Pacific Coast spawning streams and hatcheries producing chinook and coho spawners. NOAA Tech. Memo. NMFS F/NWC-122, 32 p .

Waknitz, F. W., G. M. Matthews, T. Wainwright, and G. A. Winans. 1995. Status review for Mid-Columbia River summer chinook salmon. NOAA Tech. Mem. NMFS-NWFSC-22, 80 p.

Waples, R. S. 1991. Pacific salmon, Oncorhynchus spp., and the definition of "species" under the Endangered Species Act. Marine Fisheries Review 53:11-22.

Waples, R. S., J. Robert, P. Jones, B. R. Beckman, and G. A. Swan. 1991. Status review for Snake River fall chinook salmon. NOAA Tech. Memo. NMFS F/NWC-201, 73 p. (Natl. Mar. Fish. Serv., Northwest Fisheries Science Center, Coastal Zone and Estuarine Studies Division, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Ward, P., T. McReynolds, and C. Garman. 2002. Butte and Big Chico Creeks spring-run chinook salmon, Oncorhynchus Tshawytscha, life history investigation 2000-2001. California Department of Fish and Game, Chico, CA.

WDF (Washington Department of Fisheries), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildl., Olympia, 212 p. + 5 regional volumes. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091.)

WDFW (Washington Department of Fish and Wildlife) and Point No Point Treaty Tribes. 2000. Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region. April 2000.

WDFW (Washington Department of Fish and Wildlife) et al. 2001a. Data obtained from the WDFW age database. March 2001.

WDFW (Washington Department of Fish and Wildlife) and Point No Point Treaty Tribes. 2001b. Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual Report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region. December 2001.

WDFW (Washington Department of Fish and Wildlife), Point No Point and Makah Tribes. 2001c. Management Framework Plan and Salmon Runs' Status for the Strait of Juan de Fuca. November 2001.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historic and present distribution of chinook salmon in the Central Valley drainage of California. In R. L. Brown, editor, *Fish Bulletin 179: Contributions to the biology of Central Valley salmonids.*, volume 1, pages 71-176. California Department of Fish and Game, Sacramento, CA.

A.5 APPENDICES

Appendix A.5.1. SSHAG (2003) categorizations of hatchery populations of the nine chinook salmon ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

	Stock	Run	Basin	SSHAG Category
Snake River fall-run	Lyons Ferry	Fall	Snake River	2a
Snake River spring/summer-run	McCall (supplementation)	Spring	Salmon	1a
	McCall (production)	Spring	Salmon	2a
	Rapid River	Spring	Little Salmon	3c
	Sawtooth	Spring	Salmon	1a
	Pahsimeroi	Summer	Salmon	1a and 2a
	Captive Broodstock			
	Catherine Creek	Summer	Grande Ronde	1a
	Upper Grande Ronde	Summer	Grande Ronde	1a
	Lostine River	Summer	Grande Ronde	1a
	Clearwater	Spring	Clearwater	2b
	Imnaha (# 29)	Spr/Sum	Imnaha	1a
	Dworshak	Spring	Clearwater	3b or 4
	Kooskia	Spring	Clearwater	3b or 4
	Tucannon	Spring	Tucannon	1a
Upper Columbia River spring-run	Leavenworth NFH	Spring	Wenatchee	3c or 4
	Entiat NFH	Spring	Entiat	3c, 4, or 2b
	Winthrop NFH	Spring	Methow	3c or 4
	Chiwawa	Spring	Wenatchee	1a
	Methow Composite	Spring	Methow	2a/c
	Twisp	Spring	Methow	1a
	Chewuch	Spring	Methow	1a
	Methow	Spring	Methow	3c or 4
	U. Columbia River Captive			
	Nason	Spring	Wenatchee	1a
	White River	Spring	Wenatchee	1a

Appendix A.5.1 (cont.)				
	Twisp	Spring	Methow	1a
	Methow	Spring	Methow	1a
	Ringold Hatchery	Spring	U. Col. River	3c or 4
	Carson Hatchery	Spring	Wind	3c or 4
Puget Sound	Kendall Creek	Spring	Nooksack	2a
	Lummi Bay	Fall	Nooksack	3b or 3c
	Samish River	Fall	Samish	3b
	Marblemount	Spring	Skagit	2c
	Marblemount	Summer	Skagit	1a
	Marblemount	Fall	Skagit	1a
	Tulalip	Spring	Tulalip Bay	3b or 3c
	Tulalip	Summer	Tulalip Bay	2b or 2c
	Tulalip	Fall	Tulalip Bay	3b or 3c
	N. Fork Stillaguamish	Summer	Stillaguamish	1a
	Wallace River	Summer	Snohomish	2a
	Issaquah Hatchery	Fall	Lake Washington	2b
	UW Portage Bay	Fall	Lake Washington	3b or 4
	Soos Creek	Fall	Green	2a
	Keta Creek	Fall	Green	2a
	Grover's Creek	Fall	East Kitsap	2b
	Garrison Springs	Fall	Chambers Creek	2b
	Voights Creek	Fall	Puyallup	2b or 2c
	Diru Creek	Fall	Puyallup	2b or 2c
	White River	Spring	Puyallup	2a
	Clear/Kalama Creeks	Fall	Nisqually	2a or 2b
	Minter Creek	Fall	S. Sound	2b
	Tumwater Falls	Fall	Deschutes	2b
	George Adams	Fall	Skokomish	2b or 3c
	WSC Hood Canal	Fall	Skokomish	2b or 3c
	Finch Creek	Fall	S. Hood Canal	2b or 3c
	Hamma Hamma	Fall	S. Hood Canal	2b or 3c
	Big Beef Creek	Fall	N. Hood Canal	2b

Appendix A.5.1 (cont.)				
	Dungeness	Spring	Dungeness	1a
	Elwha	Fall	Elwha	2a
	Glenwood Springs	Fall	San Juan Islands	2b
Lower Columbia River	Sea Resources	Fall	Chinook River	2b
	Abernathy NFH	Fall	Abernathy Creek	2b
	Grays River	Fall	Grays	2b
	Elochoman	Fall	Elochoman	2b
	Cowlitz	Fall	Cowlitz	2a
	Cowlitz	Spring	Cowlitz	2a
	Toutle	Spring	Cowlitz	2c
	Kalama	Fall	Kalama	2a
	Kalama	Spring	Kalama	2b
	Lewis	Spring	Lewis	2a or 2b
	Washougal	Fall	Washougal	2a or 2b
	Carson	Spring	Wind	4
	LWS NFH	Fall	Little White	4
	Spring Creek NFH	Fall	Spring Creek	2a
	Klickitat	Fall	Klickitat	4
	Willamette	Spring	Youngs Bay	4
	Big Creek	Fall	Big Creek	3b
	Rogue River (#52)	Fall	Youngs Bay	4
	Klaskanine (# 15)	Fall	Klaskanine	2b
	Willamette	Spring	Klaskanine	4
	Bonneville (#14)	Fall	Gorge	3a
	Bonneville (#95)	Fall	Gorge	4
	Hood River	Spring	Hood	4
Upper Willamette River	N. Fork Santiam (#21)	Spring	Santiam	2a and 2b
	Willamette Hatchery (#22)	Spring	M. Fork Willamette	2b or 2c
	McKenzie (#24)	Spring	McKenzie	2a
	S. Fork Santiam (#23)	Spring	Santiam	2b
	Clackamas (# 19)	Spring	Clackamas	2b or 2c

Appendix A.5.1 (cont.)				
California Coastal	Mad River	Fall	Mad River	2q,b,c
	Freshwater Creek	Fall	Humboldt Bay	1a
	Yaeger Creek	Fall	Van Duzen	1a
	Redwood Creek	Fall	Redwood Creek	1a
	Hollow Tree Creek	Fall	Eel River	1a
	Van Arsdale	Fall	Eel River	2a
	Mattole	Fall	Mattole River	1a
Sacramento River winter-run	Livingston Stone	Winter	Sacramento River	1a
California Central Valley spring-run	Feather River	Spring	Feather River	4 or 2b

Appendix A.5.2. Chinook Salmon Time Series Data Sources

Snake River Fall Chinook Salmon ESU

Population	Snake River fall-run
Years of Data, Length of Series	1975 - 2001, 27 years
Abundance Type	Dam count
Abundance Notes / References	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Hatchery Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Harvest Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)
Age Notes / Reference	Used run reconstruction spreadsheet (Henry Yuen, USFWS) to update PATH data set (Marmorek et al., 1998)

Snake River Spring/Summer Chinook ESU

Population	Snake River spring-run total
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Dam Count
Abundance Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Hatchery Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Average from Beamesderfer et al. 1998
Population	Snake River summer-run total
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Dam Count
Abundance Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Hatchery Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Yearly data from Beamesderfer et al. 1998, recent years updated with an average
Population	Alturas Lake Creek
Years of Data, Length of Series	1957 - 2001, 45 years

Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Myers et al. 1998 (org. citation is Keifer et al. 1992), used Salmon River age structure

Population	Bear Valley / Elk Creek
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Expanded Redd Count
Abundance Notes / Reference	Beamesderfer et al 1998, IDFG updated redd counts
Hatchery Notes / Reference	Beamesderfer et al 1998
Harvest Notes / Reference	CTC db from Tom G.
Age Notes / Reference	IDFG, used MF composite to fill in missing years

Population	Big Creek summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet 2000, Brown 2002 (1998-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	MF Composite Age Data

Population	Big Sheep Creek
Years of Data, Length of Series	1957 - 2001, 39 years
Abundance Type	Redd Count
Abundance Notes / Reference	Abundance database reference #52 (all years prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998

Population	Camas Creek
Years of Data, Length of Series	1972 - 2001, 29 years
Abundance Type	Redd Count
Abundance Notes / Reference	1998-2001 redd counts: 2002 IDFG comment letter
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)

Age Notes / Reference	Middle Fork composite age data
Population	Catherine Cr (Index Area)
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Abundance database reference #52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Chamberlain Creek
Years of Data, Length of Series	1952 - 1997, 22 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41052
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	Keifer et al. 1992 (in Myers et al. 1998), used Middle Fork Salmon River age structure
Population	Grande Ronde River, Upper (Index area)
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Redd count
Abundance Notes / Reference	Streamnet (prior to 1997); Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	R. Carmichael, ODFW. 1/2003
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Herd Creek
Years of Data, Length of Series	1958 - 1986, 28 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41018
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Used Valley Creek spring chinook age structure
Population	Imnaha River
Years of Data, Length of Series	1953 - 2001, 49 years
Abundance Type	Expanded redd count

Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Beamesderfer et al. 1998
Harvest Notes / Reference	R. Carmichael, ODFW. 1/2003
Age Notes / Reference	Beamesderfer et al. 1998
Population	Johnson Creek
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Expanded redd count
Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Beamesderfer et al. 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used South Fork aggregate data to fill in missing years
Population	Lake Creek summer-run
Years of Data, Length of Series	1952 - 2000, 49 years
Abundance Type	Redds per Mile
Abundance Notes / Reference	Streamnet: 41059
Hatchery Notes / Reference	R.A.A.C. run reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. run reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used South Fork Salmon aggregate data to fill in missing years
Population	Lemhi River
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used a weigted average to fill in missing years
Population	Lick Creek (Imnaha)
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Redd count
Abundance Notes / Reference	Adundance database reference #52 (prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998

Population	Lookingglass Creek
Years of Data, Length of Series	1957 - 2001, 44 years
Abundance Type	Redd count
Abundance Notes / Reference	Streamnet 2000 (prior to 1997), Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years

Population	Loon Creek
Years of Data, Length of Series	1957 - 2001, 43
Abundance Type	Redd count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Middle Fork Salmon River composite age structure data

Population	Lostine River (Index Area)
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Redd Count
Abundance Notes / Reference	Adundance database reference #52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC
Harvest Notes / Reference	Beamesderfer et al 1998, recent years updated with U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years

Population	Marsh Creek
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total Live Count
Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used Middle Fork Salmon River composite to fill in missing years

Population	Minam River
Years of Data, Length of Series	1964 - 2001, 38 years
Abundance Type	Total live count

Abundance Notes / Reference	Beamesderfer et al. 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	ODFW, used Grande Ronde River aggregate to fill in missing years
Population	Pahsimeroi River
Years of Data, Length of Series	1980 - 2001, 22 years
Abundance Type	Total live count
Abundance Notes / Reference	Streamnet 2002 (1980-2000), Rogers 2002 (2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Used Lemhi River age structure
Population	Poverty Flat
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total Live Count
Abundance Notes / Reference	Beamesderfer et al 1998
Hatchery Notes / Reference	Marmorek and Peters 1998
Harvest Notes / Reference	CTC database from Tom G.
Age Notes / Reference	IDFG, used South Fork Salmon River aggregate to fill in missing years
Population	Rapid River (L. Salmon)
Years of Data, Length of Series	1972 - 2001, 30 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet 2002 (1972-2000), Rogers 2002 (2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	
Population	Salmon River, East Fork summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41016
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat summer-run

Population	Salmon River, South Fork summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG

Population	Salmon R, North Fork spring-run
Years of Data, Length of Series	1960 - 2000, 27 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet, Brown 2002 (1996-2000)
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	

Population	Salmon River, Upper spring-run
Years of Data, Length of Series	1954 - 2001, 48 years
Abundance Type	Redd Count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG

Population	Salmon River, Upper summer-run
Years of Data, Length of Series	1957 - 1997, 40 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41002
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat age structure

Population	Secesh River summer-run
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Redd count

Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1.
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 1. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used South Fork Salmon aggregate to fill in missing years
Population	Snake River spring-run
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Total live count
Abundance Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Hatchery Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Harvest Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Age Notes / Reference	Beamesderfer at al. 1998
Population	Snake River summer-run
Years of Data, Length of Series	1979 - 2002, 24 years
Abundance Type	Dam count
Abundance Notes / Reference	CTC Report 2002
Hatchery Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Harvest Notes / Reference	CTC Report 2002
Age Notes / Reference	Beamesderfer at al. 1998
Population	Sulphur Cr
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Total live count
Abundance Notes / Reference	IDFG comments to NMFS, 2002
Hatchery Notes / Reference	Beamesderfer at al. 1998
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used Middle Fork Salmon River composite to fill in missing years
Population	Tucannon River
Years of Data, Length of Series	1979 - 2001, 23 years
Abundance Type	Total live count

Abundance Notes / Reference	WDFW comments to NMFS, 2003.
Hatchery Notes / Reference	WDFW comments to NMFS, 2003.
Harvest Notes / Reference	Columbia River Basin Fish Management Plan Tech. Adv Comm. 2002: spreadsheets sent from Henry Yuen, USFWS
Age Notes / Reference	1985-99 average and 2000 estimate of spring chinook age composition from WDFW Rep. Gallinat, J. P., J. Bumgarner, L. Ross and M. Varney. 2001. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program. 2000 annual rept. FPA01-05. 44p.

Population	Valley Creek, Upper spring-run
Years of Data, Length of Series	1957 - 2001, 44 years
Abundance Type	Redd count
Abundance Notes / Reference	Elms-Cockrom 1998, Kiefer 2002 (1999-2001)
Hatchery Notes / Reference	No annual sampling, assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	IDFG, used Salmon River aggregate to fill in missing years

Population	Valley Creek, Upper summer-run
Years of Data, Length of Series	1952 - 1997, 49 years
Abundance Type	Redds per mile
Abundance Notes / Reference	Streamnet: trend 41009
Hatchery Notes / Reference	
Harvest Notes / Reference	
Age Notes / Reference	

Population	Wallowa River
Years of Data, Length of Series	1963 - 2001, 39 years
Abundance Type	Redd count
Abundance Notes / Reference	52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	R. Carmichael, ODFW. 1/2003
Harvest Notes / Reference	Beamesderfer et al 1998, recent years updated with U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Beamesderfer et al. 1998, used Grande Ronde age structure

Population	Wenaha River (Index Area)
Years of Data, Length of Series	1963 - 2001, 39 years
Abundance Type	Redd Count

Abundance Notes / Reference	52, ODFW 1997, Keniry 2002 (1997-2001)
Hatchery Notes / Reference	12 ESU's data file, Eli Holmes, NWFSC (used South Fork Wenaha values)
Harvest Notes / Reference	Beamesderfer et al. 1998, recent years from U.S. v Oregon T.A.C. spreadsheet from Henry Yuen
Age Notes / Reference	Used pooled Grande Ronde River age structure values (Beamesderfer)

Population	Yankee Fork River summer-run
Years of Data, Length of Series	1960 - 2001, 42 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet (SN ref: Elms-Cockrum 1994-1997), Brown 2002 (1998-2001)
Hatchery Notes / Reference	No annual sampling; assumed natural returns
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Beamesderfer et al. 1998, used Poverty Flat age structure

Population	Yankee Fork, West Fork spring-run
Years of Data, Length of Series	1960 - 2001, 41 years
Abundance Type	Redd Count
Abundance Notes / Reference	Streamnet, Brown 2002 (1998-2001)
Hatchery Notes / Reference	
Harvest Notes / Reference	R.A.A.C. Run Reconstructions, EDT Validation. CD 2. HR = 1-(1-Columbia HR)*(Trib HR)
Age Notes / Reference	Keifer et al. 1992 (in Myers et al. 1998), used Salmon River age structure

Puget Sound Chinook Salmon ESU

Population	South Fork Nooksack River
Years of Data, Length of Series	1984-2001
Abundance Type	Carcass/redd
Abundance References	Pete Castle & Ned Currens, personal communication (2001a); Nooksack co-manager meeting (NMFS and Co-managers 2002)
Abundance Notes	Escapements are an expansion of carcass spawning surveys in the upper south fork and in Huchinson and Skookum creeks prior to 1999 and redd counts times 2.5 from 1999 on. They are designated early spawners; counts stop 1 October (fish after that thought to be out of basin strays)
Hatchery Reference	Pete Castle & Ned Currens (2001a); Nooksack co-manager meeting (NMFS and co-managers 2002)
Hatchery Notes	Contribution rate of hatchery fish to natural spawning only estimated since 1999 (carcass surveys

	looking for marked fish). It is assumed that the number of hatchery fish on spawning grounds is correlated with number of hatchery fish returning rather than number of fish on spawning grounds. Therefore, the stray rate of hatchery to spawning grounds for years without data is estimated as the average of the three years observed, not to exceed 43% of the spawning fish
Harvest Reference	CTC Model and ER analyses output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates from CTC model run for Nooksack stock.
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=226 fish sampled from 1993-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Cedar River
Years of Data, Length of Series	1965-2002
Abundance Type	Live count surveys
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Escapement estimates are from live count surveys and expanded by area under the curve method
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=9 fish sampled in 1988. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dosewallips River
Years of Data, Length of Series	1987-2002
Abundance Type	Live/dead surveys and redd counts
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Three years reported no escapement; the TRT is using 1 fish each for those years (the surveyors could easily have missed one fish and it makes calculations easier)
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Hatchery Notes	Probably few if any hatchery strays into the Dosewallips.
Harvest Reference	1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	n=9 fish sampled from 1995-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dungeness River
Years of Data, Length of Series	1986-2002
Abundance Type	
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001)
Abundance Notes	Escapements for Dungeness are for spring/summer stock with spawning from August to mid-Oct
Hatchery Reference	Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF et. al 1992)
Hatchery Notes	There are no estimates of contribution rate of hatchery fish to natural spawners?
Harvest Reference	
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis

	may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=99 fish sampled from 1987-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Elwha River
Years of Data, Length of Series	1986-2002
Abundance Type	
Abundance References	2001 Management Framework Plan and Salmon Runs' Status for the Strait of Juan de Fuca (WDFW et al 2001c); NMFS/Co-managers Meeting Point No Point (NMFS and Co-managers 2002)
Abundance Notes	Escapement to natural grounds equals total post fishery escapement minus broodstock take and rack return, and includes pre-spawning mortality
Hatchery Reference	2001 Management Framework Plan and Salmon Runs' Status for the Strait of Juan de Fuca (WDFW et al 2001c); NMFS/Co-managers Meeting Point No Point (NMFS and Co-managers 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=2322 fish sampled from 1989-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Green River
Years of Data, Length of Series	1968-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Estimation of

	contribution of hatchery origin fall-run chinook salmon to Duwamish-Green River spawning ground populations (NWIFC 2001)
Abundance Notes	Escapements for this population do not include spawning in Newaukum Creek. Escapement estimates are based on redd counts in specified sections of the river and expanded by a factor to reflect the total spawning habitat of the river.
Hatchery Reference	Estimation of contribution of hatchery origin fall-run chinook salmon to Duwamish-Green River spawning ground populations (NWIFC 2001)
Hatchery Notes	Hatchery contribution estimates from Soos, Icy, and Keta creeks hatcheries
Harvest Reference	CTC Model and ER analyses output (CTC 2000)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=2454 fish sampled from 1988-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Lower Sauk River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data. (Hayman 2002)
Abundance Notes	
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries

	and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling from Upper Skagit; n=1362 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Lower Skagit River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Abundance Notes	
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002)
Hatchery Notes	Marblemount Hatchery rack returns.
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=440 fish sampled from 1992-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Nisqually River
Years of Data, Length of Series	1968-2002
Abundance Type	Carcass

Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers.comm. (Scott 2002)
Abundance Notes	Escapements are an expansion of spawning surveys in Prairie River/creek.
Hatchery Reference	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	No estimates of contribution of hatchery fish to natural spawning have been made in past, but will start in 2002
Harvest Reference	CTC ER and chinook model output (CTC 1999); Review of 2000 Ocean Salmon Fisheries (PFMC 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling from Upper Skagit; n=1362 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	North Fork Nooksack River
Years of Data, Length of Series	1984-2001
Abundance Type	Carcass
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002); Pete Castle and Ned Currens pers comm, memo “North Fork Nooksack native spring chinook escapement methodology” (Castle and Currens 2001a,b)
Abundance Notes	Total chinook on the spawning grounds = expanded carcass counts on spawning grounds plus turnback hatchery fish.
Hatchery Reference	SaSI datbase (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002); Pete Castle and Ned Currens pers comm, memo “North Fork Nooksack native spring chinook escapement methodology” (Castle and Currens 2001a,b)

Hatchery Notes	Contribution rate of cultured fish (hatchery and acclimation releases) to natural spawning started in 1988 with significant returns from the hatchery program.
Harvest Reference	CTC model and ER analyses output (CTC 2000) 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=359 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands).

Population	Lake Washington tributaries
Years of Data, Length of Series	1983-2002
Abundance Type	Live counts
Abundance References	SaSI database (Campbell 2000); NMFS/Co-manager meeting on abundance and productivity data (NMFS and Co-managers 2002)
Abundance Notes	Escapement estimates are from live counts expanded for area under the curve.
Hatchery Reference	SaSI database (Campbell 2000); NMFS/Co-manager meeting on abundance and productivity data (NMFS and Co-managers 2002)
Hatchery Notes	No estimate of contribution rate of hatchery fish to spawning. There are trapping data that indicate the presence of hatchery strays.
Harvest Reference	CTC model and ER analyses output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=82 fish sampled in 1985 and 1988. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years

	(Norma Sands).
Population	North Fork Stillaguamish River
Years of Data, Length of Series	1974-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Escapement estimates are from foot and boat surveys of the mainstem and foot surveys of the tributaries of redd counts.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Indian Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	Stillaguamish Tribal Harvey Creek Hatchery, supplementation program, does not have rack returns. Return to hatchery is actual brood stock take which occurs in the North Fork. Hatchery supplementation program began in early 1980s. Returns started in 1986
Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Otolith project; n=2840 fish sampled from 1987 and 1988-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Puyallup River
Years of Data, Length of Series	1968-2002
Abundance Type	Redd and live/dead fish count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); 1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); Jim Scott, pers comm (Scott 2002)

Abundance Notes	Index counts of spawning from South Prairie Creek, which in the past were from a limited area and not a good index of the system. Surveys now are from the entire S. Prairie Creek basin. These started in 1992 by float and foot surveys of redds and live/dead fish. However, estimates given here are based on index count only through 1998. Revisions are being made back to 1992 and should be available soon.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); 1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	There is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	CTC ER and chinook model output for fishing rates and new runs with fingerling releases (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=930 fish sampled from 1992-2000. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Skokomish River
Years of Data, Length of Series	1987-2002
Abundance Type	Various
Abundance References	Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF 1993); NMFS/comanager meeting, Point No Point (NMFS and Comanagers 2002)
Abundance Notes	Escapements are from the Comanagers management report. Estimates should be available from 1976 although there is concern about data prior to 1990 (T. Johnson) (see NWIFC website). This population includes index survey sites in both main river including NF and several tributaries; mainly foot, sometimes float. Escapement estimates vary from year to year in survey type and expansion (from 1990 on no expansion for unsurvey areas - in other words all spawning areas are

	surveyed). Quality of escapement data considered good (SASSI document)
Hatchery Reference	Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Washington State salmon and steelhead stock inventory and Appendix 1 Puget Sound Stocks (WDF 1993); NMFS/comanager meeting, Point No Point (NMFS and Comanagers 2002)
Hatchery Notes	Hatchery strays from the George Adams H, HoodCanal (Hoodsport H, and Enetai H) are found on the spawning grounds, but there is no estimate of the contribution rate of hatchery fish to natural spawning
Harvest Reference	1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1 fish sampled in 2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)
Population	Skykomish River
Years of Data, Length of Series	1965-2002
Abundance Type	Aerial surveys, redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Abundance Notes	Escapements for the Skykomish population have been updated from the comanagers (Curt Kraemer & Kit Rawson 1/9/02) for 1979-2001. The Skykomish population includes 10 survey sites in the Skykomish, Wallace, Bridal Veil, Sunset Falls, Pilchuck, and Sultan rivers. Escapement estimates are from aerial surveys of the mainstem and foot surveys of the tributaries (redd counts). Escapement estimates for the total Snohomish system are available from 1965. Skykomish estimates for 1965-1978 are made by subtracting Skykomish population escapements from the total system escapements
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)

Hatchery Notes	From 1997 to the present, contribution rate of hatchery fish to natural spawning is estimated by sampling spawning grounds for otolith marked hatchery fish from Tulalip and Wallace Hatcheries. Prior to 1997, the hatchery contribution is estimated from "run reconstruction" of hatchery returns (Kit Rawson 11/19/01).
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); Terminal Harvest Rates for Snohomish R. Using Terminal Run Reconstruction (Rawson 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001); Age database (WDFW et al 2001a)
Age Notes	Scale or otolith sampling; n=561 fish sampled from 1989-1999, except years 1990 and 1994. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands).

Population	Snoqualmie River
Years of Data, Length of Series	1965-2002
Abundance Type	From hatchery straying estimates and otolith sampling
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Abundance Notes	Escapements for the Snoqualmie population have been updated from the comanagers (Curt Kraemer & Kit Rawson 11/19/01 7 1/9/02) for 1979-2000. The Snoqualmie population includes 6 survey sites in the Snoqualmie River and tributaries of the Snoqualmie R. Escapement for the SaSSI Snohomish fall-run stock are available from 1965 (Jim Scott spreadsheet) and, on average, the Snoqualmie portion represented 62% of the Snohomish fall-run escapement. Thus, estimates of Snoqualmie escapement prior to 1979 are estimated as 62% of the Snohomish fall-run escapement.
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan:

	Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001)
Hatchery Notes	From 1997 to the present, contribution rate of hatchery fish to natural spawning is estimated by sampling spawning grounds for otolith marked hatchery fish from Tulalip and Wallace Hatcheries. Prior to 1997, the hatchery contribution is estimated from "run reconstruction" of hatchery returns (Kit Rawson 11/19/01).
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); Terminal Harvest Rates for Snohomish R. Using Terminal Run Reconstruction (Rawson 2001)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Kit Rawson and Curt Kraemer, otolith sampling on spawning grounds (Rawson and Kraemer 2001); Age database (WDFW et al 2001a)
Age Notes	Scale sampling and scale/otolith sampling; n=572 fish sampled from 1989 and 1992-1999. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	South Fork Stillaguamish River
Years of Data, Length of Series	1974-2002
Abundance Type	redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm. (Scott 2002)
Abundance Notes	Escapement estimates are from foot and boat surveys of the mainstem and foot surveys of the tributaries of redd counts
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Kit Rawson and Curt Kraemer, pers comm. (Rawson and Kraemer); Jim Scott, pers comm. (Scott 2002)
Hatchery Notes	It is assumed that no hatchery fish stray to the spawning grounds of the South Fork Stillaguamish

Harvest Reference	CTC Model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Otholith project; n=1641 fish sampled from 1987 and 1989-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Suiattle River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count; peak live/dead counts
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Before 1994 esc method was peak live/dead counts for partial spawning grounds to get fish per mile and then expand for total spawning grounds (by 8.5). 1994 and after use redd counts cover entire spawning area
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	No hatchery in basin; broodstock take from the Suiattle 1974-1988 to the Marblemount Hatchery (and fry released at Hatchery)
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source

Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=672 fish sampled from 1986-1990 and 1992-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Upper Cascade River
Years of Data, Length of Series	1984-2002
Abundance Type	Live/dead counts expanded for area/redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002); NMFS/Comanagers meeting (NMFS and Comanagers 2002)
Abundance Notes	Before 1992 esc method was peak live/dead counts with expansion for uncovered ground. 1992 and after use redd counts cover entire spawning area
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002); NMFS/Comanagers meeting (NMFS and Comanagers 2002)
Hatchery Notes	The hatchery is at the mouth of the Cascade, but releases fish into the Suiattle.
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=157 fish sampled from 1992-1998 and 2000-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	Upper Sauk River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count; peak live/dead
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Before 1994 escapement estimation method was peak live/dead counts with expansion for uncovered ground. 1994 and after use redd counts and cover entire spawning area
Hatchery Reference	
Hatchery Notes	No hatchery in Upper Sauk. Assume the hatchery releases from the Marblemount Hatchery do not influence the Sauk populations
Harvest Reference	CTC CWT ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=349 fish sampled from 1986, 1992-1995, 1997-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	Upper Skagit River
Years of Data, Length of Series	1952-2002
Abundance Type	Redd count
Abundance References	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Escapements are based on redd counts and are considered a good measure of relative abundance from year to year
Hatchery Reference	SaSI database (Campbell 2000); Puget Sound Comprehensive Chinook Management Plan:

	Harvest Management Component (Puget Sound Tribes and WDFW 2001); Bob Hayman, unpublished data (Hayman 2002); Jim Scott, pers comm (Scott 2002)
Hatchery Notes	Marblemount Hatchery rack returns. The Marblemount Hatchery is situated at the mouth of the Cascade River, such that returns pass through the Lower and Upper Skagit River
Harvest Reference	CTC model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook Technical Committee (CTC 1999); A User's Guide to the A&P Tables (Sands, in prep)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1731 fish sampled from 1992-2001. Age distribution reconstructed for other years using an average cohort distribution weighted by the annual abundance of contributing years (Norma Sands)

Population	White River
Years of Data, Length of Series	1970-2002
Abundance Type	Trap
Abundance References	1992 Washington State salmon and steelhead stock inventory (WDF et al 1993); SaSI database (Campbell 2000); Chris Phinney, pers comm (Phinney 2001); Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component (Puget Sound Tribes and WDFW 2001); Jim Scott, pers comm (Scott 2002)
Abundance Notes	Chinook counts from 1970-present are from Buckley trap for the entire season (year round). Does not include any spawning the occurs below the dam which may represent abut 25% of total spawning (11/21/02). Glacial system, thus spawning ground surveys difficult. Starting this year rejecting (not passing upstream) tagged or marked fish (except acclimated fish). Earlier years may include fall-run hatchery fish.
Hatchery Reference	
Hatchery Notes	There is a program to put acclimated hatchery fish on the spawning grounds, will begin to estimate this. No estimates of hatchery contribution prior to 2001. Assume no contribution of hatchery fish to natural spawning
Harvest Reference	CTC ER and model output (CTC 2000); 1995 and 1996 annual report of the Joint Chinook

	Technical Committee (CTC 1999)
Harvest Notes	Fishing rates are a function of catch and escapement estimates (usually based on CWT recoveries and estimates incidental mortalities by the CTC) and of the natural mortality constants. Maturation rates are calculated from age data, but independent estimates from CWT analysis may be used as an alternative data source
Age Reference	Age database (WDFW et al 2001a)
Age Notes	Scale sampling; n=1335 fish sampled from 1990, 1993-1998. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Lower Columbia River chinook salmon ESU

Population	Big White Salmon River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-2000 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Spring Creek
Harvest Reference	Pacific Salmon Commission 2002
Harvest Notes	Estimated exploitation rate on hatchery stocks applied to natural stocks.
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Clackamas River fall-run
Years of Data, Length of Series	1967 - 2001, 35 years
Abundance Type	Peak Count
Abundance References	ODFW 1998.

Hatchery Reference	No Hatchery Data
Hatchery Notes	No Hatchery Data
Harvest Reference	No Harvest Data Available
Age Reference	Myers, et al.1998.
Age Notes	Generic fall-run age structure

Population	Coweeman River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates extrapolated from peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	Harvest data based on PFMC models provided by Dell Simmons.
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000

Population	East Fork Lewis River fall-run
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Harvest Reference Stock	Lewis Wild
Harvest Reference	Rawding, Dan (WDFW). 2001a.
Harvest Notes	AEQ ER for Lewis River from Dell Simmons
Age Reference	Rawding, Dan (WDFW). 2001a.

Age Notes	Age distribution for 1980-1983 based on an average of 1984-2000
Population	Lewis River (Brights) fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a. Kreitman, G.. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Lewis Wild
Harvest Reference	Pacific Salmon Commission. 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000
Population	Middle Gorge Tributaries fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Norman, G. 1982.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1980-2000 data from Rawding. 1964-1979 data from streamnet reference (Norman)
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1980-1990 and estimate based on average from 1991-2000. Age distribution data missing for 1993
Population	Mill Creek fall-run

Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Coweeman
Harvest Reference	Pacific Salmon Commission. 2002
Age Reference	Rawding, Dan (WDFW).2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.

Population	Sandy River fall-run
Years of Data, Length of Series	1988 - 2001, 14 years
Abundance Type	Total from redd count
Abundance References	ODFW 1998
Abundance Notes	The estimate of spawning abundance is based on a one time peak count of live fish on the Sandy River. The index area is 10 miles from the mouth of Gordon Cr. To Lewis & Clark ramp. The number of fish is then multiplied by 2.5 to get the estimate (Streamnet ref # 50070). Fish counts are provided in Streamnet trend # 57517. Surveys were not conducted prior to 1988
Hatchery Reference	ODFW 1998.
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners
Harvest Reference	No Harvest Data Available
Age Reference	Myers et al. 1998.
Age Notes	Generic fall-run age structure

Population	Sandy River late fall-run
Years of Data, Length of Series	1984 - 2001, 18 years
Abundance Type	Total from redd count
Abundance References	ODFW 2002; ODFW 1990; Murtagh, T.; Massey, J.; Bennett, D.E. 1997.
Hatchery Reference	ODFW 1998
Hatchery Notes	Michelle McClure (NOAA Fisheries) references ODFW for proportion of natural spawners

Harvest Reference	No Harvest Data Available.
Age Reference	Myers et al.1998.
Age Notes	Generic fall-run age structure
Population	Washougal River fall-run
Years of Data, Length of Series	1964 - 2000, 37 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a; Kreitman, G. 1981.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate. 1964-1979 spawning data from Kreitman; 1980-2000 from Rawding.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference Stock	Cowlitz Hatchery
Harvest Reference	Pacific Salmon Commission 2002.
Harvest Notes	AEQ provided by Dell Simmons
Age Reference	Rawding, Dan (WDFW). 2001a.
Age Notes	Age distribution for 1982-1990 based on an average of 1991-2000.
Population	Kalama River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Lewis River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years

Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Upper Cowlitz River spring-run
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Peak Count
Abundance References	Rawding, Dan (WDFW). 2001a.
Abundance Notes	Abundance data are for adults and jacks. Estimates of spawner abundance are extrapolations made using peak count data and marking rate.
Hatchery Reference	Rawding, Dan (WDFW). 2001a.
Hatchery Notes	Hatchery data are part of the escapement data from Dan Rawding, WDFW.
Harvest Reference	No Harvest Data Available.
Age Reference	Myers, et al. 1998.
Population	Youngs Bay fall-run
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish/Mile
Abundance References	Fulop 2002, 2003
Population	Big Creek fall-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile
Abundance References	Fulop 2003
Population	Clatskanie River fall-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Fish/Mile

Abundance References	Fulop 2003

Upper Willamette River Chinook Salmon ESU

Population	Clackamas River spring-run
Years of Data, Length of Series	1958 - 2002, 45 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002e.
Abundance Notes	Data are dam counts for NF Dam; adults only, production is mixed
Hatchery Reference	Cramer, Doug. 2002e.
Hatchery Notes	Counts of hatchery vs wild done only for 2001-2002 (Doug Cramer). Doug Cramner estimates the number of marked hatchery fish to be 50%.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle. 2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to Clackamas R Spring-run Chinook.

Population	Mckenzie River spring-run
Years of Data, Length of Series	1970 - 2001, 32 years
Abundance Type	Dam/weir count
Abundance References	Kostow, Kathryn (ODFW). 2002b.
Abundance Notes	Data come from dam counts at Leaburg Dam. Spawning also occurs below the dam.
Hatchery Reference	Kostow, Kathryn (ODFW). 2002b.
Hatchery Notes	Hatchery fish have only been 100% marked in recent years. The hatchery marks are no6t 100% detectable at the dam because a portion of the hatchery fish is double index marked to evaluate the fishery impact to wild fish. Double index markes mean that the hatchery fish has a coded wire tag but it is not externally marked (that is, no fin clip). Therefore, the fish "looks wild" both to the fisherman (who must release the fish) and in the raw dam count. The McKenzie fish managers therefore do several expansions to deal with these issues.
Harvest Reference	No Harvest Data Available.
Age Reference	McClure, Michelle. 2002.
Age Notes	Age distribution is taken from the Upper Willamette Chinook totals, not specific to McKenzie R

	Spring-run Chinook.
Population	Sandy River spring-run
Years of Data, Length of Series	1977 - 2001, 25 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002d.
Abundance Notes	Abundance estimates only
Hatchery Reference	No Hatchery Data.
Harvest Reference	No Harvest Data Available.
Age Reference	No Age Data Available.
Population	Willamette Falls fall-run
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Howell, P.J.. 1986; Bennett, D.E.. 1986; Bennett, D.E. and C.A. Foster. 1990; Bennett, D.E. and Foster, C.A.. 1994; Bennett, D.E. and C.A. Foster. 1995; Foster, C.A. 1998.
Abundance Notes	2 additional references: Foster 2000 and Foster 2002. Data are for adults and jacks.
Population	Willamette Falls spring-run
Years of Data, Length of Series	1946 - 2001, 56 years
Abundance Type	Dam/weir count
Abundance References	Anonymous. 1998; Foster, C.A. 1998; Foster, C.A. 2000.
Abundance Notes	Data are for adults and jacks.

Appendix A.5.3. Lower Columbia River hatchery release**s.**

Lower Columbia River fall-run chinook salmon (Washington)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Chinook River	1990-1994	Sea Resources	Chinook River	Chinook River	2,598,400
	1990	Sea Resources	Washougal	Chinook River	629,500
	1997-2000	Sea Resources	Chinook River	Chinook River	820,627
	1993	Lower Columbia	Kalama Falls	Deep River	49,400
Grays River	1990-1994	Grays River	Grays River	Grays River	2,767,900
	1991, 1993	Grays River	Kalama Falls	Grays River	1,332,380
	1992	Grays River	Spring Creek	Grays River	1,107,000
	1995-1997	Grays River	Kalama	Grays River	764,550
	1996, 1997	Grays River	Washougal	Grays River	1,745,500
Elochomin River	1990-1994	Elokomin	Elochomin	Elochomin River	17,809,719
	1991	Elokomin	Kalama Falls	Elochomin River	1,046,700
	1995	Beaver Creek	Abernathy	Beaver Creek	377,252
	1997	Beaver Creek	Big Creek	Beaver Creek	1,096,198
	1996-1999	Beaver Creek	Elochoman	Elochoman River	2,081,670
	1995	Beaver Creek	Kalama	Beaver Creek	760,039
	1995-2001	Elochoman	Elochoman	Elochoman River	15,280,038
	1999	Elochoman	Grays River	Elochoman River	174,500
	1997-1998	Elochoman	Washougal	Elochoman River	1,633,200
Lower Columbia River	1996-1998	Cathlamet Ffa	Washougal	Columbia River	1,132,500
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	28,757,600
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	42,322,920
Toutle River	1990-1993	Toutle	Kalama Falls	Green River	5,718,000
	1991-1993	Toutle	Toutle	Green River	2,941,000
	1994	Toutle	Tule	Green River	2,044,500
	1990-1993	Toutle	Washougal	Green River	2,693,400
	2000	North Toutle	Elochoman	Green River	618,266
	1996	North Toutle	Kalama	Green River	1,588,937
	1996-2001	North Toutle	Toutle	Green River	10,584,543
	1996	North Toutle	Washougal	Green River	633,414
Kalama River	1991-1994	Lower Kalama	Kalama	Kalama River	10,701,203
	1990-1994	Kalama Falls	Kalama Falls	Kalama River	17,600,800

	1996-2001	Fallert Cr	Kalama	Fallert Creek	13,998,602
	1995-2001	Kalama Falls	Kalama	Kalama River	20,198,653
Washougal River	1994	Washougal	Kalama Falls	Washougal River	2,443,100
	1992	Washougal	Spring Creek	Washougal River	1,409,300
	1991-1994	Washougal	Washougal	Washougal River	27,002,103
	2000	Washougal	Elochoman	Washougal River	1,312,680
	1995-2001	Washougal	Washougal	Washougal River	32,878,694
Spring Creek	1992	Ringold	L White Salmon	Spring Creek	82,511

Lower Columbia River fall-run chinook salmon (Oregon)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
	1991-1995	Astoria H.S.	Big Creek	Youngs Bay	15,500
	1991-1994	Cedc	Rogue River	Youngs Bay	394,382
	1991, 1992	Step	Big Creek	Youngs Bay	13,758
	1992, 1993	Step	Klaskanine	Youngs Bay	15,700
	1996-1998	Step	Big Creek	Youngs Bay	63,050
	1997, 1998	Step	Unknown	Youngs Bay	16,500
	1995-2002	Youngs Bay	Rogue River	Youngs Bay	4,248,147
	1996-1998	Youngs Bay	Urb	Youngs Bay	828,884
Lower Columbia River	1991	Step	Unknown	Lower Columbia River	25,000
	1996, 1997	Tongue Pt	Rogue River	Tongue Point	54,274
	1996, 1997	Tongue Pt	Urb	Tongue Point	299,715
	1995-1997	Blind Slough	Rogue River	Blind Slough	54,793
Skipanon River	1992-1993	Step	Klaskanine	Skipanon River	3,550
	1996-1999	Step	Big Creek	Skipanon River	15,193
Plympton Creek	1991	Big Creek	Big Creek	Plympton Creek	50,278
Big Creek	1991-1994	Big Creek	Big Creek	Big Creek	34,675,446
	1991-1994	Big Creek	Rogue River	Big Creek	2,798,710
	1993	Big Creek	Kalama Falls	Big Creek	886,471
	1995-2002	Big Creek	Big Creek	Big Creek	40,633,091
	1995-1996	Big Creek	Rogue River	Big Creek	1,530,550
Klaskanine River	1995	Cedc	Rogue River	Klaskanine River	15,758
	1996-1999	Klaskanine	Rogue River	Klaskanine River	3,694,245
Wahkeena Pond	1991-1993	Bonneville	Urb	Columbia River	1,183,764
Johnson Creek	1994, 1995	Step	Tanner Creek	Johnson Creek	99,008

Tanner Creek	1991	Bonneville	Big Creek	Tanner Creek	2,580,763
	1991-1994	Bonneville	Tanner Creek	Tanner Creek	32,862,338
	1991	Bonneville	Wa Tule	Tanner Creek	1,534,122
	1991-1994	Bonneville	Urb	Tanner Creek	26,877,822
	1993	Bonneville	Kalama Falls	Tanner Creek	1,505,421
	1995-1996	Bonneville	Tanner Creek	Tanner Creek	15,369,642
	1995-1996	Bonneville	Wa Tule	Tanner Creek	10,922,745
	1995-2002	Bonneville	Urb	Tanner Creek	43,729,497
	2000-2001	Bonneville	Wa Urb	Tanner Creek	328,426

Lower Columbia River spring-run chinook salmon (Washington)					
ershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Deep River	1999-2001	Deep River	Cowlitz	Deep Creek	255,657
Abernathy Creek	1991-1996	Abernathy NFH	Abernathy Creek	Abernathy Creek	6,853,504
	1997-1999	Abernathy NFH	Abernathy Creek	Abernathy Creek	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz River	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton River	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz River	53,800
Toutle River	1991, 1993	Toutle	Cowlitz	Green River	641,382
	1995	North Toutle	Toutle	Green River	1,412,100
	1995	North Toutle	Washougal	Green River	1,086,100
	1995-2001	North Toutle	Cowlitz	Green River	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis River	1,229,262
	1994	Lewis River	Kalama	North Fork Lewis River	975,700
	1991, 1992	Lewis River	Lewis	Lewis River	1,885,900
	1990-1994	Lewis River	N F Lewis	North Fork Lewis River	1,801,800
	1996	Fish First Np	Lewis	Lewis River	55,872
	1997-2000	Fish First Np	Lewis	Lewis River	570,857
	1996, 1998	Lewis River	Lewis	Lewis River	2,074,841
	2001	Lewis River	Lewis	Lewis River	34 Adults
	1995-2001	Lewis River	Lewis	Lewis River	4,692,781
	2001	Speelyai	Lewis	Lewis River	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Creek	2,455,252

	1995-2001	Fallert Cr	Kalama	Fallert Creek	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Creek	615,463
	1999	Gobar Pond	Kalama	Gobar Creek	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Creek	332,281
Spring Creek	1993	Ringold	Carson	Spring Creek	68,900
	1993	Ringold	Kalama	Spring Creek	462,700
	1990	Ringold	Klickitat	Spring Creek	40,264
	1994	Ringold	L White Salmon	Spring Creek	336,268
	1993-1994	Ringold	Ringold	Spring Creek	596,274
	1992-1994	Ringold	Wind River	Spring Creek	2,250,000
Wind River	1991-1996	Carson NFH	Carson	Wind River	13,350,658
	1997-2001	Carson NFH	Carson	Wind River	7,096,346
Little White Salmon River	1991-1994	Little White Salmon NFH	Spring Creek	Little White Salmon River	2,757,539
	1992	Willard NFH	Carson	Little White Salmon River	869,952
	1991-1994	Little White Salmon NFH	Carson	Little White Salmon River	4,780,148
	1997	Little White Salmon NFH	Carson	Little White Salmon River	2,835,741
	1998-2001	Little White Salmon NFH	L White Salmon	Little White Salmon River	4,272,833
	1998-2001	Little White Salmon NFH	Urb-Mixed	Little White Salmon River	8,057,188
Drano Lake		Abernathy NFH	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek NFH	Urb-Bonn Dam	Spring Creek	14,348,604
	1991	Spring Creek NFH	Clackamas	Spring Creek	3,292,304
	1992-1996	Spring Creek NFH	Spring Creek	Spring Creek	89,083,822
	1997-2001	Spring Creek NFH	Spring Creek	Spring Creek	70,435,986
Big White Salmon River	1991-1996	Big White Salmon NFH	Carson	Big White Salmon River	3,581,536
	1997-1999	Big White Salmon NFH	Carson	Big White Salmon River	2,795,464
	2001	Big White Salmon NFH	Methow	Big White Salmon River	1,238,764
	1997	Spring Creek NFH	Carson	Big White Salmon River	543,270
Deep River	1999-2001	Deep River	Cowlitz	Deep River	255,657
Abernathy Creek	1991-1996	Abernathy NFH	Abernathy Cr	Abernathy Creek	6,853,504
	1997-1999	Abernathy NFH	Abernathy Cr	Abernathy Creek	1,223,647
Cowlitz River	1990-1994	Cowlitz	Cowlitz	Cowlitz River	9,016,451
	1992-1994	Friends Of Cow	Cowlitz	Cowlitz River	115,800
	1995-2001	Cowlitz	Cowlitz	Cowlitz River	8,870,002
	1995, 1997	Cowlitz	Cowlitz	Tilton River	3,074 Adults
	1996, 1999	Friends Of Cowlitz	Cowlitz	Cowlitz River	53,800

Toutle River	1991, 1993	Toutle	Cowlitz	Green River	641,382
	1995	North Toutle	Toutle	Green River	1,412,100
	1995	North Toutle	Washougal	Green River	1,086,100
	1995- 2001	North Toutle	Cowlitz	Green River	766,740
Lewis River	1990-1993	Speelyai	Lewis	Lewis River	1,229,262
	1994	Lewis River	Kalama	North Fork Lewis River	975,700
	1991, 1992	Lewis River	Lewis	Lewis River	1,885,900
	1990-1994	Lewis River	N F Lewis	North Fork Lewis River	1,801,800
	1996	Fish First Np	Lewis	Lewis River	55,872
	1997-2000	Fish First Np	Lewis	Lewis River	570,857
	1996, 1998	Lewis River	Lewis	Lewis River	2,074,841
	2001	Lewis River	Lewis	Lewis River	34 Adults
	1995-2001	Lewis River	Lewis	Lewis River	4,692,781
	2001	Speelyai	Lewis	Lewis River	566,373
Kalama River	1990-1994	Lower Kalama	Kalama	Hatchery Creek	2,455,252
	1995-2001	Fallert Cr	Kalama	Fallert Creek	2,129,550
	1998, 2000	Fallert Cr	Lewis	Fallert Creek	615,463
	1999	Gobar Pond	Kalama	Gobar Creek	87,500
	1997, 2001	Kalama Falls	Kalama	Gobar Creek	332,281
Spring Creek	1993	Ringold	Carson	Spring Creek	68,900
	1993	Ringold	Kalama	Spring Creek	462,700
	1990	Ringold	Klickitat	Spring Creek	40,264
	1994	Ringold	L White Salmon	Spring Creek	336,268
	1993-1994	Ringold	Ringold	Spring Creek	596,274
	1992-1994	Ringold	Wind River	Spring Creek	2,250,000
Wind River	1991-1996	Carson NFH	Carson	Wind River	13,350,658
	1997-2001	Carson NFH	Carson	Wind River	7,096,346
Little White Salmon River	1991-1994	L White Salmon NFH	Spring Creek	Little White Salmon River	2,757,539
	1992	Willard NFH	Carson	Little White Salmon River	869,952
	1991-1994	L White Salmon NFH	Carson	Little White Salmon River	4,780,148
	1997	L White Salmon NFH	Carson	Little White Salmon River	2,835,741
	1998-2001	L White Salmon NFH	L White Salmon	Little White Salmon River	4,272,833
	1998-2001	L White Salmon NFH	Urb-Mixed	Little White Salmon River	8,057,188
Drano Lake		Abernathy NFH	Spring Creek	Dranos Lake	40,756
Spring Creek	1991	Spring Creek NFH	Urb-Bonn Dam	Spring Creek	14,348,604

	1991	Spring Creek NFH	Clackamas	Spring Creek	3,292,304
	1992-1996	Spring Creek NFH	Spring Creek	Spring Creek	89,083,822
	1997-2001	Spring Creek NFH	Spring Creek	Spring Creek	70,435,986
Big White Salmon River	1991-1996	Big White Salmon NFH	Carson	Big White Salmon River	3,581,536
	1997-1999	Big White Salmon NFH	Carson	Big White Salmon River	2,795,464
	2001	Big White Salmon NFH	Methow	Big White Salmon River	1,238,764
	1997	Spring Creek NFH	Carson	Big White Salmon River	543,270

Lower Columbia River spring-run chinook salmon (Oregon)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Youngs Bay	1991-1992	Cedc	Clackamas	Youngs Bay	242,534
	1994	Cedc	North Santiam	Youngs Bay	301,361
	1992	Cedc	Willamette	Youngs Bay	301,786
	1996	Youngs Bay	Clackamas	Youngs Bay	97,945
	1995-1999	Youngs Bay	Willamette	Youngs Bay	3,114,060
	1996	Youngs Bay	South Santiam	Youngs Bay	276,493
Lower Columbia River	1996	Blind Slough	South Santiam	Blind Slough	199,389
	1995-2002	Blind Slough	Willamette	Blind Slough	1,457,655
	1996	Tongue Pt	South Santiam	Tongue Point	242,319
	1997-2000	Tongue Pt	Willamette	Tongue Point	1,029,850
Klaskanine River	1991	Cedc	Clackamas	South Fork Klaskanine River	119,627
	1994	Cedc	North Santiam	South Fork Klaskanine River	109,974
	1992, 1997	Cedc	Willamette	South Fork Klaskanine River	238,316
	1996	Cedc	South Santiam	South Fork Klaskanine River	76,618
Multnomah Channel	1997-1998	Step	McKenzie	Little Willamette River	123,134
Sandy River	1991-1994	Clackamas	Clackamas	Sandy River	1,316,973
	1991-1993	Clackamas	Clackamas	Salmon River	594,656
	1995-2002	Clackamas	Clackamas	Sandy River	3,539,458
Hood River	1991-1992	Bonneville	Lookingglass	Hood River	288,727
	1993-1995	Bonneville	Deschutes	Hood River	245,209
	1996-2001	Various (3)	Deschutes	Hood River	677,652
	2000-2002	Parkdale	Wild Origin	Hood River	101,883
	2000	Parkdale	Hood River	Hood River	4,126

Lower Columbia River up-river bright chinook salmon (Washington)					
Watershed	**Years**	**Hatchery**	**Stock**	**Release Site**	**Total**
Little White Salmon River	1991-1993	L. White Salmon NFH	Urb-Eggbank	Little White Salmon River	8,758,842
	1994-1996	L. White Salmon NFH	Carson	Little White Salmon River	8,453,502
	1994-1996	L. White Salmon NFH	Carson	Little White Salmon River	1,225Adults
Spring Creek	1994	Ringold	Urb-Bonn Dam	Spring Creek	4,217,491

Note: "up-river bright" chinook salmon are not in the Lower Columbia River chinook salmon ESU.

B. STEELHEAD

B.1. BACKGROUND AND HISTORY OF LISTINGS

Primary contributors: Thomas P. Good and Robin S. Waples
(Northwest Fisheries Science Center)

Background

Steelhead is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss*. The present distribution of steelhead extends from Kamchatka in Asia, east to Alaska, and down to southern California (NMFS 1999), although the historical range of *O. mykiss* extended at least to the Mexico border (Busby et al. 1996). *O. mykiss* exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident (and under some circumstances, apparently yield offspring of the opposite form). Those that are anadromous can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. The half-pounder life-history type in Southern Oregon and Northern California spends only 2 to 4 months in salt water after smoltification, then returns to fresh water and outmigrates to sea again the following spring without spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus* except *O. clarki* spawn once and then die (semelparous). The anadromous form is under the jurisdiction of the National Marine Fisheries Service (NMFS), while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of U. S. Fish and Wildlife Service (FWS).

Although no subspecies are currently recognized within any of the species of Pacific salmon, Behnke (1992) has proposed that two subspecies of *O. mykiss* with anadromous life history occur in North America: *O. mykiss irideus* (the "coastal" subspecies), which includes coastal populations from Alaska to California (including the Sacramento River), and *O. mykiss gairdneri* (the "inland" subspecies), which includes populations from the interior Columbia, Snake and Fraser Rivers. In the Columbia River, the boundary between the two subspecies occurs at approximately the Cascade Crest. A third subspecies of anadromous *O. mykiss* (*O. mykiss mykiss*) occurs in Kamchatka, and several other subspecies of *O. mykiss* are also recognized which only have resident forms (Behnke 1992).

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these *runs* are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer, or fall steelhead. For example, large rivers, such as the Columbia, Rogue, and Klamath rivers, have migrating adult steelhead at all times of the year. There are local variations in the names used to identify the seasonal runs of steelhead; in Northern California, some biologists have retained the use of the terms spring and fall steelhead to describe what others would call summer steelhead.

Steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry, and duration of spawning migration (Burgner et al.

1992). The *stream-maturing* type (summer steelhead in the Pacific Northwest and Northern California) enters fresh water in a sexually immature condition between May and October and requires several months to mature and spawn. The *ocean-maturing* type (winter steelhead in the Pacific Northwest and Northern California) enters fresh water between November and April with well-developed gonads and spawns shortly thereafter. In basins with both summer and winter steelhead runs, it appears that the summer run occurs where habitat is not fully utilized by the winter run or a seasonal hydrologic barrier, such as a waterfall, separates them. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966, Roelofs 1983, Behnke 1992). Coastal streams are dominated by winter steelhead, whereas inland steelhead of the Columbia River Basin are almost exclusively summer steelhead. Winter steelhead may have been excluded from inland areas of the Columbia River Basin by Celilo Falls or by the considerable migration distance from the ocean. The Sacramento-San Joaquin River Basin may have historically had multiple runs of steelhead that probably included both ocean-maturing and stream-maturing stocks (CDFG 1995, McEwan and Jackson 1996). These steelhead are referred to as winter steelhead by the California Department of Fish and Game (CDFG); however, some biologists call them fall steelhead (Cramer et. al 1995). It is thought that hatchery practices and modifications in the hydrology of the basin caused by large-scale water diversions may have altered the migration timing of steelhead in this basin (D. McEwan, pers. comm.).

Inland steelhead of the Columbia River Basin, especially the Snake River Subbasin, are commonly referred to as either *A-run* or *B-run*. These designations are based on a bimodal migration of adult steelhead at Bonneville Dam (235 km from the mouth of the Columbia River) and differences in age (1- versus 2-ocean) and adult size observed among Snake River steelhead. It is unclear, however, if the life-history and body size differences observed upstream are correlated back to the groups forming the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas throughout the Snake River Basin is not well understood. A-run steelhead are believed to occur throughout the steelhead-bearing streams of the Snake River Basin and the inland Columbia River; B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers (IDFG 1994).

The *half-pounder* is an immature steelhead that returns to fresh water after only 2 to 4 months in the ocean, generally overwinters in fresh water, and then outmigrates again the following spring. Half-pounders are generally less than 400 mm and are reported only from the Rogue, Klamath, Mad, and Eel Rivers of Southern Oregon and Northern California (Snyder 1925, Kesner and Barnhart 1972, Everest 1973, Barnhart 1986); however, it has been suggested that as mature steelhead, these fish may only spawn in the Rogue and Klamath River Basins (Cramer et al. 1995). Various explanations for this unusual life history have been proposed, but there is still no consensus as to what, if any, advantage it affords to the steelhead of these rivers.

In May 1992, NMFS was petitioned by the Oregon Natural Resources Council (ONRC) and 10 co-petitioners to list Oregon's Illinois River winter steelhead (ONRC et al. 1992). NMFS concluded that Illinois River winter steelhead by themselves did not constitute an ESA "species" (Busby et al. 1993, NMFS 1993a). In February 1994, NMFS received a petition seeking protection under the Endangered Species Act (ESA) for 178 populations of steelhead (anadromous *O. mykiss*) in Washington, Idaho, Oregon, and California. At the time, NMFS was

conducting a status review of coastal steelhead populations (*O. m. irideus*) in Washington, Oregon, and California. In response to the broader petition, NMFS expanded the ongoing status review to include inland steelhead (*O. m. gairdneri*) occurring east of the Cascade Mountains in Washington, Idaho, and Oregon.

In 1995, the steelhead Biological Review Team (BRT) met to review the biology and ecology of West Coast steelhead. After considering available information on steelhead genetics, phylogeny, and life history, freshwater ichthyogeography, and environmental features that may affect steelhead, the BRT identified 15 ESUs—12 coastal forms and three inland forms. After considering available information on population abundance and other risk factors, the BRT concluded that five steelhead ESUs (Central California Coast, South-Central California Coast, Southern California, Central Valley, and Upper Columbia River) were presently in danger of extinction, five steelhead ESUs (Lower Columbia River, Oregon Coast, Klamath Mountains Province, Northern California, and Snake River Basin) were likely to become endangered in the foreseeable future, four steelhead ESUs (Puget Sound, Olympic Peninsula, Southwest Washington, and Upper Willamette River) were not presently in significant danger of becoming extinct or endangered, although individual stocks within these ESUs may be at risk, and one steelhead ESU (Middle Columbia River) was not presently in danger of extinction but the BRT was unable to reach a conclusion as to its risk of becoming endangered in the foreseeable future.

Of the 15 steelhead ESUs identified by NMFS, five are not listed under the ESA: Southwest Washington, Olympic Peninsula, and Puget Sound (Federal Register, Vol. 61, No. 155, August 9, 1996, p. 41558), Oregon Coast (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), and Klamath Mountain Province (Federal Register, Vol. 66, No. 65, April 4, 2001, p. 17845); eight are listed as threatened: Snake River Basin, Central California Coast and South-Central California Coast (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937), Lower Columbia River, California Central Valley (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), Upper Willamette River, Middle Columbia River (Federal Register, Vol. 64, No. 57, March 25, 1999, p. 14517), and Northern California (Federal Register, Vol. 65, No. 110, June 7, 2000, p.36074), and two are listed as endangered: Upper Columbia River and Southern California (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937).

The West Coast steelhead BRT[1] met in January, March, and April 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original BRTs. This report summarizes new information and the preliminary BRT conclusions on the following ESUs: Snake River Basin, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Northern California, Central California Coast, South-Central California Coast, Southern California, and California Central Valley.

[1] The biological review team (BRT) for the updated status review for West Coast steelhead included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, Dr. David Boughton, Dr. John Carlos Garza, Dr. Steve Lindley, and Dr. Brian Spence; from the U.S. Fish and Wildlife Service, Abernathy, WA: Dr. Donald Campton; and from the USGS Biological Resources Division, Seattle: Dr. Reginald Reisenbichler.

Resident fish

As mentioned earlier, *O. mykiss* exhibits varying degrees of anadromy. Non-anadromous forms are usually called rainbow trout; however, nonanadromous inland *O. mykiss* are often called Columbia River redband trout. A form that occurs in the upper Sacramento River is called Sacramento redband trout. Although the anadromous and nonanadromous forms have long been taxonomically classified within the same species, the exact relationship between the forms in any given area is not well understood. In coastal populations, it is unusual for the two forms to co-occur; they are usually separated by a natural or man-made migration barrier. Co-occurrence of the two forms in inland populations appears to be more frequent. Where they co-occur, "it is possible that offspring of resident fish may migrate to the sea, and offspring of steelhead may remain in streams as resident fish" (Burgner et al. 1992, p. 6; Shapovalov and Taft 1954). Mullan et al. (1992) found evidence that in very cold streams, juvenile steelhead had difficulty attaining mean threshold size for smoltification and concluded that most fish in the Methow River in Washington that did not emigrate downstream early in life were thermally-fated to a resident life history regardless of whether they were the progeny of anadromous or resident parents. Additionally, Shapovalov and Taft (1954) reported evidence of *O. mykiss* maturing in fresh water and spawning prior to their first ocean migration; this life-history variation has also been found in cutthroat trout (*O. clarki*) and some male chinook salmon (*O. tshawytscha*).

As part of this status review update process, a concerted effort was made to collect biological information for resident populations of *O. mykiss*. Information from listed ESUs in Washington, Oregon, and Idaho is contained in a draft report by Kostow (2003) and summarized in Appendix B.5.1; relevant information for specific ESUs is presented in subsequent sections. Information about resident *O. mykiss* populations in California is summarized in Appendix B.5.2.

The BRT had to consider in more general terms how to conduct an overall risk assessment for an ESU that includes both resident and anadromous populations, particularly when the resident individuals may outnumber the anadromous ones but their biological relationship was unclear or unknown. Some guidance is found in Waples (1991), which outlines the scientific basis for the NMFS ESU policy. That paper suggested that an ESU that contains both forms could be listed based on a threat to only one of the life-history traits “if the trait were genetically based and loss of the trait would compromise the ‘distinctiveness’ of the population” (p. 16). That is, if anadromy were considered important in defining the distinctiveness of the ESU, loss of that trait would be a serious ESA concern. In discussing this issue, the NMFS ESU policy (Federal Register 56:58612; 20 November 1991) affirmed the importance of considering the genetic basis of life-history traits such as anadromy, and recognized the relevance of a question posed by one commenter: “What is the likelihood of the nonanadromous form giving rise to the anadromous form after the latter has gone locally extinct?”

The BRT also discussed another important consideration, which is the role anadromous populations play in providing connectivity and linkages among different spawning populations within an ESU. An ESU in which all anadromous populations had been lost and the remaining resident populations were fragmented and isolated would have a very different future evolutionary trajectory than one in which all populations remained linked genetically and ecologically by anadromous forms. Furthermore, in many (if not all) *O. mykiss* ESUs, the

geographic area utilized by anadromous (but not resident) fish may represent a "significant portion of the range" of the ESA species, especially if the area encompassed by the marine migration is considered.

In spite of concerted efforts to collect and synthesize available information on resident forms of *O. mykiss*, existing data are very sparse, particularly regarding interactions between resident and anadromous forms (Kostow 2003). The BRT was frustrated by the difficulties of considering complex questions involving the relationship between resident and anadromous forms, given this paucity of key information. To help focus this issue, the BRT considered a hypothetical scenario that has varying degrees of relevance to individual steelhead ESUs. In this scenario, the once-abundant and widespread anadromous life history is extinct or nearly so, but relatively healthy native populations of resident fish remain in many geographic areas. The question considered by the BRT was the following: Under what circumstances would you conclude that such an ESU was not in danger of extinction or likely to become endangered? The BRT identified the required conditions as:

1) The resident forms are capable of maintaining connectivity among populations to the extent that historical evolutionary processes of the ESU are not seriously disrupted;
2) The anadromous life history is not permanently lost from the ESU but can be regenerated from the resident forms.

Regarding the first criterion, although some resident forms of salmonids are known to migrate considerable distances in freshwater, extensive river migrations have not been demonstrated to be an important behavior for resident *O. mykiss*, except in rather specialized circumstances (e.g., forms that migrate from a stream to a large lake or reservoir as a surrogate for the ocean). Therefore, the BRT felt that loss of the anadromous form would, in most cases, substantially change the character and future evolutionary potential of steelhead ESUs. Regarding the second criterion, it is well established that resident forms of *O. mykiss* can occasionally produce anadromous migrants, and vice versa (Mullan et al. 1992, Zimmerman and Reeves 2000, Kostow 2003), just as has been shown for other salmonid species (e. g., *O. nerka,* Foerster 1947, Fulton and Pearson 1981, Kaeriyama et al. 1992; coastal cutthroat trout *O. clarki clarki,* Griswold 1996, Johnson et al. 1999; brown trout *Salmo trutta,* Jonsson 1985; and Arctic char *Salvelinus alpinus*, Nordeng 1983). However, available information indicates that the incidence of these occurrences is relatively rare, and there is even less empirical evidence that, once lost, a self-sustaining anadromous run can be regenerated from a resident salmonid population. Although this must have occurred during the evolutionary history of *O. mykiss,* the BRT found no reason to believe that such an event would occur with any frequency or within a specified time period. This would be particularly true if the conditions that promote and support the anadromous life history continue to deteriorate. In this case, the expectation would be that natural selection would gradually eliminate the migratory or anadromous trait from the population, as individuals inheriting a tendency for anadromy migrate out of the population but do not survive to return as adults and pass on their genes to subsequent generations.

Given the above considerations, the BRT focused primarily on information for anadromous populations in the risk assessments for steelhead ESUs. This was particularly true with respect to Case 3 resident fish populations, the vast majority of which are of uncertain ESU

status. However, as discussed below in the "BRT Conclusions" section, the presence of relatively numerous, native resident fish was considered to be a mitigating risk factor for some ESUs.

B.2.1. SNAKE RIVER BASIN STEELHEAD ESU

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The Snake River steelhead ESU is distributed throughout the Snake River drainage system, including tributaries in southwest Washington, eastern Oregon and north/central Idaho (NMFS, 1996). Snake River steelhead migrate a substantial distance from the ocean (up to 1,500 km) and use high elevation tributaries (typically 1,000-2,000 m above sea level) for spawning and juvenile rearing. Snake River steelhead occupy habitat that is considerably warmer and drier (on an annual basis) than other steelhead ESUs. Snake River basin steelhead are generally classified as summer run, based on their adult run timing patterns. Summer steelhead enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn during the following spring (March to May). Managers classify up-river summer steelhead runs into to groups based primarily on ocean age and adult size upon return to the Columbia River. A-run steelhead are predominately age-1 ocean fish while B-run steelhead are larger, predominated by age-2 ocean fish.

With the exception of the Tucannon River and some small tributaries to the mainstem Snake River, the tributary habitat used by Snake River steelhead ESU is above Lower Granite Dam. Major groupings of populations and/or subpopulations can be found in 1) the Grande Ronde River system; 2) the Imnaha River drainage; 3) the Clearwater River drainages; 4) the South Fork Salmon River; 5) the smaller mainstem tributaries before the confluence of the mainstem; 6) the Middle Fork salmon production areas, 7) the Lemhi and Pahsimeroi valley production areas and 8) upper Salmon River tributaries.

Resident *O. mykiss* are believed to be present in many of the drainages utilized by Snake River steelhead. Very little is known about interactions between co-occurring resident and anadromous forms within this ESU. The following review of abundance and trend information focuses on information directly related to the anadromous form.

Historical Returns

Although direct historical estimates of production from the Snake basin are not available, the basin is believed to have supported more than half of the total steelhead production from the Columbia basin (Mallet 1974). There are some historical estimates of returns to portions of the drainage. Lewiston Dam, constructed on the lower Clearwater, began operation in 1927. Counts of steelhead passing through the adult fish ladder at the dam reached 40-60,000 in the early 1960s (Cichosz et al. 2001). Based on relative drainage areas, the Salmon River basin likely supported substantial production as well. In the early 1960s, returns to the Grande Ronde River and the Imnaha River may have exceeded 15,000 and 4,000 steelhead per year, respectively (ODFW 1991). Extrapolations from tag/recapture data indicate that the natural steelhead return to the Tucannon River may have exceeded 3,000 adults in the mid-1950s (WDF 1991).

B.2.1.1. Summary of Previous BRT Conclusions

The primary concern regarding Snake River steelhead identified in the 1998 status review was a sharp decline in natural stock returns beginning in the mid-1980s. Of 13 trend indicators at that time, nine were in decline and four were increasing. In addition, Idaho Department of Fish and Game parr survey data indicated declines for both A and B run steelhead in wild and natural stock areas. The high proportion of hatchery fish in the run was also identified as a concern, particularly because of the lack of information on the actual contribution of hatchery fish to natural spawning. The review recognized that some wild spawning areas have relatively little hatchery spawning influence (Selway River, lower Clearwater River, the Middle and South forks of the Salmon River and the lower Salmon River). In other areas, such as the upper Salmon River, there is likely little or no natural production of locally native steelhead. The review identified threats to genetic integrity from past and present hatchery practices as a concern. Concern for the North Fork Clearwater stock was also identified. That stock is currently maintained through the Dworshak Hatchery program but cut off from access to its native tributary by Dworshak Dam. The 1998 review also highlighted concerns for widespread habitat degradation and flow impairment throughout the Snake basin as well as for the substantial modification of the seaward migration corridor by hydroelectric power development on the Snake and Columbia mainstem.

Previous Abundance

Although direct historical estimates of production from the Snake basin are not available, the basin is believed to have supported more than half of the total steelhead production from the Columbia basin (Mallet 1974). There are some historical estimates of returns to portions of the drainage. Lewiston Dam, constructed on the lower Clearwater, began operation in 1927. Counts of steelhead passing through the adult fish ladder at the dam reached 40-60,000 in the early 1960s (Cichosz et al. 2001). Based on relative drainage areas, the Salmon River basin likely supported substantial production as well. In the early 1960s, returns to the Grande Ronde River and the Imnaha River may have exceeded 15,000 and 4,000 steelhead per year, respectively (ODFW 1991). Extrapolations from tag/recapture data indicate that the natural steelhead return to the Tucannon River may have exceeded 3,000 adults in the mid-1950s (WDF 1991).

The previous status review noted that the aggregate trend in abundance as measured by ladder counts at the upper most Snake River dam (Lower Granite Dam since 1972) has been upward since the mid-1970s while the aggregate return of naturally produced steelhead was downward for the same period (Table B.2.1.1). The decline in natural production was especially pronounced in the later years in the series.

Table B.2.1.1. Summary of abundance and trend estimates for Snake River Steelhead ESU. Interim delisting target levels are explained in text. Estimates from previous status review in brackets.

Population(s)	5-year mean % natural origin	Recent Five-Year Geometric Mean			Short-term Trend (%/yr)		Interim Target	Current vs. Target
		Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Tucannon **	26 [44]	407 (257 – 628)	106	140	-3.7	-18.3	1,300	8%
Lower Granite Run*	14	106,175 (70,721- 259,145)	14,864	9,500	+6.1	+6.9	52,100	29%
Snake A run*	15	87,842 (50,974 – 25,950)	12,667		+8.5			
Snake B run*	11	17,305 (9,736– 33,195)	1,890		-0.6			
Asotin Cr++	?	87 Exp. Redds (0 – 543)		200	+4.0	-19.7	500	
Upper Grande Ronde+	77	1.54 RPM (0.3 – 4.7)			-2.9			
Joseph Cr	100^	1,542 (1,077 – 2,385)	1,542		+5.0		1,400	110%
Imnaha+	80	3.7 RPM (2.0 – 6.8)			-3.7			
Camp Creek	100^	155 (55 – 307)	155	80	+2.0	+1.7		

* 5-year geometric mean calculated using years 1997–2001
** 5-year geometric mean calculated using years 1999–2001
\+ 5-year geometric mean calculated using years 1996–2000
++ 5-year geometric mean calculated using years 1998–2001
^ Assumed, no hatchery releases into basin

B.2.1.2. New Data and Updated Analyses

Estimates of annual returns to specific production areas are not available for most of the Snake River ESU. Estimates are available for two tributaries below Lower Granite Dam (Tucannon and Asotin Creek). Annual ladder counts at Lower Granite Dam and associated sampling information allows for an estimate of the aggregate returns to the Snake River basin. In addition, area specific estimates are available for the Imnaha River and two major sections of the Grande Ronde River system. Updated estimates of return levels are summarized in Table B.2.1.1. Returns to Lower Granite Dam remained at relatively low levels through the 1990s; the 2001 run size at Lower Granite Dam was substantially higher relative to the 1990s. The recent geometric mean abundance was down for the Tucannon River relative to the last BRT status review. Returns to the Imnaha River and to the Grande Ronde River survey areas were generally higher relative to the early 1990s.

Overall, long-term trends remained negative for four of the nine available series (including aggregate measures and specific production area estimates; Figure B.2.1.7). Short-term trends improved relative to the period analyzed for the previous status review. The median short-term trend was +2.0% for the 1990-2001 period. Five out of the nine data sets showed a positive trend (Figure B.2.1.8).

IDFG has provided updated analyses of parr density survey results through 1999. IDFG concluded that "generational parr density trends, which are analogous to spawner to spawner survivorship, indicate that Idaho spring-summer chinook and steelhead with and without hatchery influence failed to meet replacement for most generations competed since 1985 (IDFG 2002). These data do not reflect the influence of increased returns in 2001 and 2002.

Population growth rate (λ) estimates for Snake River steelhead production areas (Table B.2.1.2, Figures B.2.1.6, B.2.1.7) demonstrate a similar pattern when compared to the simple trend analysis described above. The median long-term λ estimate across the nine series was 0.998 assuming that natural returns are produced only from natural-origin spawners and 0.733 if both hatchery and wild potential spawners are assumed to have contributed to production at the same rate-. Short-term λ estimates are higher, 1.013, assuming a hatchery effectiveness of 0, and .753, assuming hatchery and wild fish contribute to natural production in proportion to their numbers. These values are consistent with another recent analysis of population growth rates (McClure et al. 2003), which estimated λ at the ESU-level as 0.96 if hatchery fish do not reproduce, and 0.73 if they reproduce at a rate equal to that of wild fish. This analysis spanned the time period from 1980-2000, making it clear that the most recent returns have had an influence on lambda estimates, particularly in the short-term. [Note that population growth rate calculations in the Biological Opinion on the Federal Columbia River Power System (NMFS 2000) used assumptions of hatchery fish effectiveness bracketed by those in McClure et al. 2003.]

The standarized abundance trend and population growth rate estimates provided in this report do not explicitly differentiate potential density dependent effects from density independent survival effects. Abundance levels for many of the production areas considered in the analyses varied over a wide range. In several cases, it is likely that abundance, at least in some years,

could be high enough to affect survival through density dependent mechanisms. To provide perspective on the potential for density dependent influences, recent geometric mean spawner abundance estimates are contrasted with interim delisting levels provided by NOAA fisheries regional office (http://www.nwr.noaa.gov/occd/InterimTargets.html). Interim delisting levels for Snake River spring/summer chinook production units were derived from recommendations of the Bevan Recovery Team. Interim delisting levels for upper Columbia spring chinook and steelhead were from Ford et al. (2001). The method described in Ford et al. (2001) was used to develop interim delisting levels for Mid-Columbia and Snake River steelhead production areas. The approach uses estimates of habitat area and, where available, estimates of spawning escapements during historical periods of high, sustained returns.

Table B.2.1.2 Snake River Steelhead. Population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions; HF = 0.0 hatchery fish available to spawn do not contribute to natural production, HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts; RC – redd counts; RPM – redds per mile index; TLC – estimated total live fish on spawning grounds, N/A – not available.

Snake River Steelhead	**Series Length**	**Method**	**% wild 1987-1996**	**% wild 1997-2001**	**1997-2001 geomean**	**HF**	**Long-term λ**	**Prob. λ<1**	**Short-term λ**	**Prob. λ<1**
Lower Granite Dam - Aggregate	1990-2001	DC	0.18	0.14	14,768	0 1	0.994 0.703	0.551 1.000	1.051 0.687	0.297 0.999
Lower Granite Dam – A run	1985-2001	DC	0.18	0.15	12,666	0 1	0.998 0.674	0.512 1.000	1.078 0.692	0.215 0.999
Lower Granite Dam - B run	1985-2001	DC	0.18	0.11	1,890	0 1	0.927 0.655	0.915 1.000	0.941 0.646	0.782 1.000
Tucannon River	1987-2001	DC	0.39	0.26	95	0 1	0.886 0.733	0.998 0.998	0.924 0.712	0.895 0.988
Grand Ronde River - Upper	1967-2000	RPM	0.83	0.77	N/A	0 1	0.967 0.951	0.668 0.736	1.013 0.958	0.436 0.705
Grand Ronde River - Joseph Creek	1974-2002	TLC	1.00	1.00	1,542	N/A	1.069	0.130	1.018	0.418
Imnaha River	1974-2000	RPM	0.80	0.80	N/A	0 1	1.042 1.026	0.242 0.534	0.929 0.899	0.873 0.927
Imnaha River - Camp Creek	1974-2002	TLC	1.00	1.00	154	N/A	1.077	0.099	1.007	0.460
Imnaha River - Little Sheep Creek	1985-2002	TLC	0.30	0.14	42	0 1	1.045 0.718	0.323 0.998	1.082 0.794	0.267 0.984

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident trout for this ESU. IDFG presence/absence survey results indicate that *O. mykiss* were found in 48% of the 84 streams sampled throughout the Salmon River Basin. Westslope Cutthroat Trout were found in 43% of the locations sampled. When the species co-occurred in a tributary system, the cutthroat trout tended to be found in smaller headwater tributaries, while *O. mykiss* were in larger tributaries lower in the system. Steelhead occupied lower mainstem and associated tributaries. IDFG has suggested that some of the resident rainbow in the Salmon and Clearwater drainages may be the result of hatchery rainbow introductions.

The relative abundance of resident *O. mykiss* in the Imnaha and Grande Ronde River basins has not been clearly defined. *O. mykiss* production has been documented in both basins. Kostow (2003) reports that while no formal surveys of resident trout abundance have been conducted in the Imnaha River basin, the results of genetics sampling in the basin support the presence of a resident form. Resident O. mykiss abundance in the Tucannon River is believed to be relatively low based on observations during steelhead redd count surveys (Kostow 2003).

Resident *O. mykiss* populations are present above the Hells Canyon Dam complex, but their relationship to existing steelhead populations below the dams has not been determined (Kostow 2003). There have been relatively few specific studies of potential relationships between sympatric resident and anadromous *O. mykiss* in the Snake River basin.

Table B.2.1.3. Distribution of *O. mykiss* trout by category relative to the Snake Basin steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Snake River Basin steelhead	Potentially all areas that are/were used by steelhead. Tucannon Asotin Grande Ronde Imnaha Salmon found in about 43% of streams Clearwater Selway Other areas?	Palouse River Malad River Several Hells Canyon tributaries Upper Malheur Basin "recent" disconnect from lower Malheur Lakes Basin	Trout distributions currently more restricted than historically North Fork Clearwater (Dworshak Dam) Mainstem Snake (Hells Canyon Dam) Powder Burnt Malheur Owyhee Weiser Payette Boise Burneau Salmon Falls Cr. Several small tributaries

Genetic analysis of Case 3 resident *O. mykiss* above Dworshak Dam shows that the sampled population is genetically more similar to Dworshak steelhead than are other Snake River *O. mykiss* populations (Waples 1998; Waples et al. 1993). This suggests that the sampled population may be derived primarily from residualized steelhead or native resident fish from the North Fork Clearwater River. However, the genetic data cannot rule out some introgression from non-native rainbow trout.

Kostow (2003) reported that field biologists noted spatial and temporal overlaps in spawning between resident and anadromous *O. mykiss* in the Grande Ronde, Imnaha, Tucannon and Upper Snake River basins. ODFW is conducting experimental cross breeding studies using resident and anadromous *O. mykiss* from the Grande Ronde Basin. Preliminary results indicate that all potential crosses produce outmigrating smolts. Steelhead x steelhead crosses had the highest smolt production rate and resident trout x resident trout crosses had the lowest. Adult female steelhead x resident male trout crosses, the combination most likely to occur in nature, had the second highest smolt production rate. Adult returns from the study are forthcoming.

Wishard et al. (1984), Williams et al. (1996), and Leary (2001) have genetically examined Case 3 resident populations in tributaries above the Hells Canyon Dam complex and have concluded that some populations are native redband trout but others are hybridized with hatchery rainbow trout. A number of genetic studies of Snake River *O. mykiss* that are currently underway should provide more specific information about resident populations in the future.

B.2.1.3. New Hatchery Information

Artificial production history

Almost all artificial production of steelhead within the Snake River ESU has been associated with two major mitigation initiatives—the Lower Snake River Compensation Program (LSRCP) and the mitigation program for Dworshak Dam on the North Fork of the Clearwater River. The LSRCP is administered by the USFWS and was established as compensation for losses incurred as a result of the construction and operation of the four lower Snake River hydroelectric dams. Production under this initiative generally began in the mid 1980s. The Dworshak mitigation program provides for artificial production as compensation for the loss of access to the North Fork Clearwater, a major historical production area. Dworshak Hatchery, completed in 1969, is the focus for that production.

Hatchery releases of steelhead within the Snake River ESU are summarized by time period and production area in Table B.2.1.4. The following sections summarize historical and current artificial production programs for steelhead by major geographic area within the ESU.

Table B.2.1.4. Hatchery releases of steelhead in the Snake River basin, organized by major steelhead production areas and broodstock of the release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
Mainstem Snake	Dworshak B	2,400	1,760	-
	Lyons Ferry	141,383	72,306	73,616
	Oxbow A	912,769	651,723	440,999
	Salmon River A	68,800	-	93,325
	Wallowa	205,133	138,915	-
	Wells	112,559	-	-
	Mixed	20,352	-	-
	Imnaha River	-	6,722	-

	Snake River A			95,018
	Pahsimeroi A	-	8,695	-
	Mainstem Total	1,463,397	880,123	702,958
Tucannon	Lyons Ferry	32,300	14,116	151,723
	Tucannon River	157,469	62,860	8,574
	Wallowa	16,197	-	-
	Wells	40,229	-	-
	Pahsimeroi A	-	23,852	-
	Mixed	-	26,008	-
	Tucannon Total	246,197	126,838	160,297
Asotin	Lyons Ferry	16,895	6,092	16,328
	Oxbow A	-	27,200	-
	Pahsimeroi A	-	27,569	-
	Wallowa	5,800	-	-
	Wells	8,930	-	-
	Asotin Total	31,625	60,861	16,328
Mainstem Clearwater	Dworshak B	1,618,440	1,893,944	1,755,111
	Clearwater B	-	-	113,581
North Fork Clearwater	Dworshak B	-	-	391,210
South Fork Clearwater	Clearwater B	-	-	85,398
	Dworshak B	612,152	869,839	739,543
	Selway River	-	14,313	19,483
	Clearwater Total	2,230,593	2,778,097	3,104,325
Mainstem Grande Ronde	Wallowa	782,060	616,379	975,089
Wallowa	Wallowa	529,852	985,339	524,416
	Grande Ronde Total	1,311,912	1,601,718	1,499,505
Lower & Mainstem Salmon	Salmon River A	325,000	432,867	161,537
	Salmon River B	9,900	-	24,940
	Dworshak B	-	112,291	109,015
Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
	Oxbow A	-	100,972	63,879
	Pahsimeroi A	-	235,306	68,695
Little Salmon	Hagerman A	61,621	-	-
	Oxbow A	120,261	200,380	341,639
	Salmon River A	399,135	232,716	271,400
	Dworshak B	-	367,068	222,438
	Pahsimeroi A	-	65,632	39,933
	Salmon River B	-	-	48,471
Panther	Pahsimeroi A	49,264	-	-
	Salmon River A	141,100	-	-

North Fork Salmon	Salmon River A	92,300	71,600	30,070
	Oxbow A	-	26,995	-
	Pahsimeroi A	-	38,100	43,500
Lemhi	Dworshak B	125,000	86,857	-
	Pahsimeroi A	-	-	132,741
	Salmon River A	-	-	129,287
Pahsimeroi	Pahsimeroi A	845,968	693,118	718,435
	Salmon River A	-	-	114,506
East Fork Salmon	E Fk Salmon B	475,023	197,670	34,283
	Dworshak B	87,315	773,329	240,523
	Hagerman B	54,042	-	-
	Salmon River B	-	-	71,494
Upper Salmon	Hagerman A	157,237	-	-
	Pahsimeroi A	-	447,944	368,748
	Salmon River A	889,353	669,844	590,289
	Dworshak B	-	-	130,186
	Salmon River B	-	-	18,387
	Sawtooth A	-	-	32,348
	Salmon Total	3,832,518	4,752,697	4,006,745
Imnaha	Imnaha River	188,275	325,833	169,758
	Little Sheep Creek	-	-	131,776
	Imnaha Total	188,275	325,833	301,534
ESU Total	All Stocks	10,097,233	10,526,167	10,033,360

Tucannon River—Artificial production of steelhead in the Tucannon River has been carried out since the early 1980s in response to the LSRCP objective of 878 steelhead to the project area. Until 1998, releases of hatchery steelhead into the Tucannon River occurred via the upriver Curl Lake acclimation site. Release numbers ranged from 120,000 to 160,000 between 1985 and 1997. The broodstock for Tucannon releases was primarily the Lyons Ferry stock, which was originally derived from Wells Hatchery and Wallowa Hatchery stocks. The Wallowa Hatchery stock was originally derived by ODFW through trapping returning adults in the lower Snake River. Pahsimeroi Hatchery stock was used in the program in one year when full production was lost at Lyons Ferry due to disease outbreaks, primarily IHNV (Gephart and Nordheim 2001).

Return rates to the Tucannon River from the hatchery program have been relatively low. Beginning in 1998, the release location for hatchery steelhead was moved down river in response to studies indicating improved survivals from lower river releases and to minimize the opportunity for interbreeding between hatchery and natural returns (included listed spring chinook) to the basin. Beginning with the 1999/2000-cycle year, the Tucannon River hatchery steelhead program began an evaluation of the feasibility of using local broodstock for the program. A full switch over to an endemic broodstock may occur in the future, depending upon the success of the pilot program. Problems associated with trapping and rearing of the new broodstock, as well as genetic questions still need to be addressed (B. Leland WDFW, pers. comm.).

Grande Ronde/Imnaha Rivers—There are LSRCP steelhead hatchery mitigation releases in the Grande Ronde and Imnaha River systems. The LSRCP compensation objective for Grande Ronde steelhead returns is 9,200. Trapping facilities for adult broodstock are located at Big Canyon Creek acclimation site. The original program used outside broodstock (including Skamania Hatchery stock) from 1979-1982 before switching to the Wallowa broodstock. Smolts are acclimated and released at two sites—one within the Wallowa drainage, the other at Big Canyon Creek. Oregon manages the Minam River, Joseph Creek and the Wenaha River drainages for natural production. Other sections of the Grande Ronde have been outplanted to supplement natural production (Nowak 2001).

LSCRP program releases into the Imnaha River are released from a satellite facility on Little Sheep Creek after primary rearing at Wallowa Hatchery. Additional releases are targeted in Horse Creek and the Upper Imnaha basin (Bryson 2001).

Clearwater Basin—Steelhead hatchery releases into the Clearwater basin are managed under two programs—LRSCMP and Dworshak Dam mitigation. The Lower Snake Compensation Plan program in the Clearwater River drainage utilizes the Clearwater hatchery as a central rearing facility and has an overall production objective of 14,000 adult steelhead returns to the Snake River. Program release sites include acclimation ponds on the Powell River (Lochsa River drainage), the Red River, and Crooked River sites in the South Fork of the Clearwater River. The Dworshak mitigation program has an adult return objective of 20,000 adult steelhead as compensation for losses due to Dworshak Dam, an anadromous block that cuts off the North Fork of the Clearwater River. Genetics studies have indicated that the hatchery stock used in the Dworshak program may be representative of the original North Fork run (Cichosz et al. 2001).

Salmon River Basin—Steelhead hatchery releases into the Salmon River drainage are under the auspices of two major steelhead hatchery programs—LSRCP and Idaho Fish and Game Department programs funded by Idaho Power Company. In addition, there are state and tribal experimental supplementation programs in the drainage. The LSRCP program goal for the Salmon basin is to produce an annual return of 25,000 adult steelhead above Lower Granite Dam. Juvenile steelhead produced at Magic Valley Hatchery and Hagerman National Fish Hatchery are released into the Salmon drainage. The Idaho Power Company-funded program for steelhead has an objective of releasing 400,000 pounds of steelhead smolts (Servheen 2001).

The Middle Fork Salmon drainages have had minimal or no hatchery releases. The Upper Salmon drainages, the Pahsimeroi, Lemhi, Little Salmon River and Lower Salmon River areas have received releases in recent years.

Categorizations of hatchery Snake River Basin hatchery stocks (SSHAG 2003) are summarized in Appendix B.5.3.

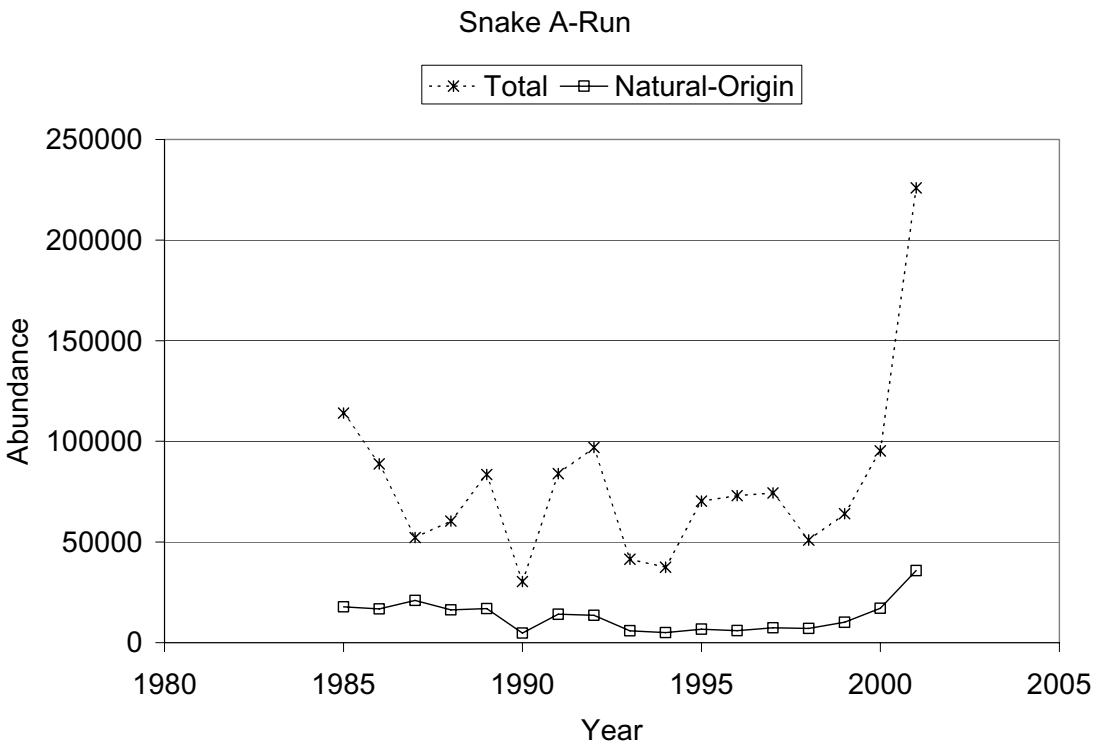


Figure B.2.1.1. Lower Granite Dam counts of Snake River A-run steelhead: US v Oregon Technical Advisory Committee estimates (source: H. Yuen, USFWS, Vancouver, WA).

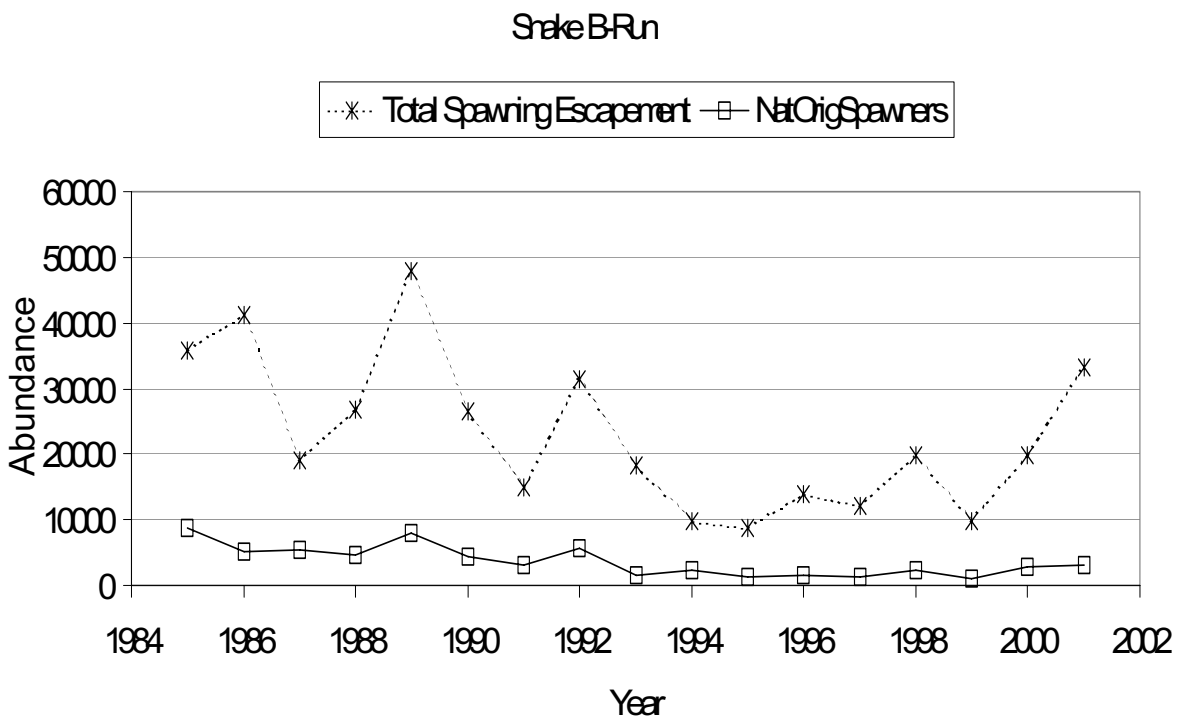


Figure B.2.1.2. Lower Granite Dam counts of Snake River B-run steelhead: US v Oregon Technical Advisory Committee estimates (source: H. Yuen, USFWS, Vancouver, WA).

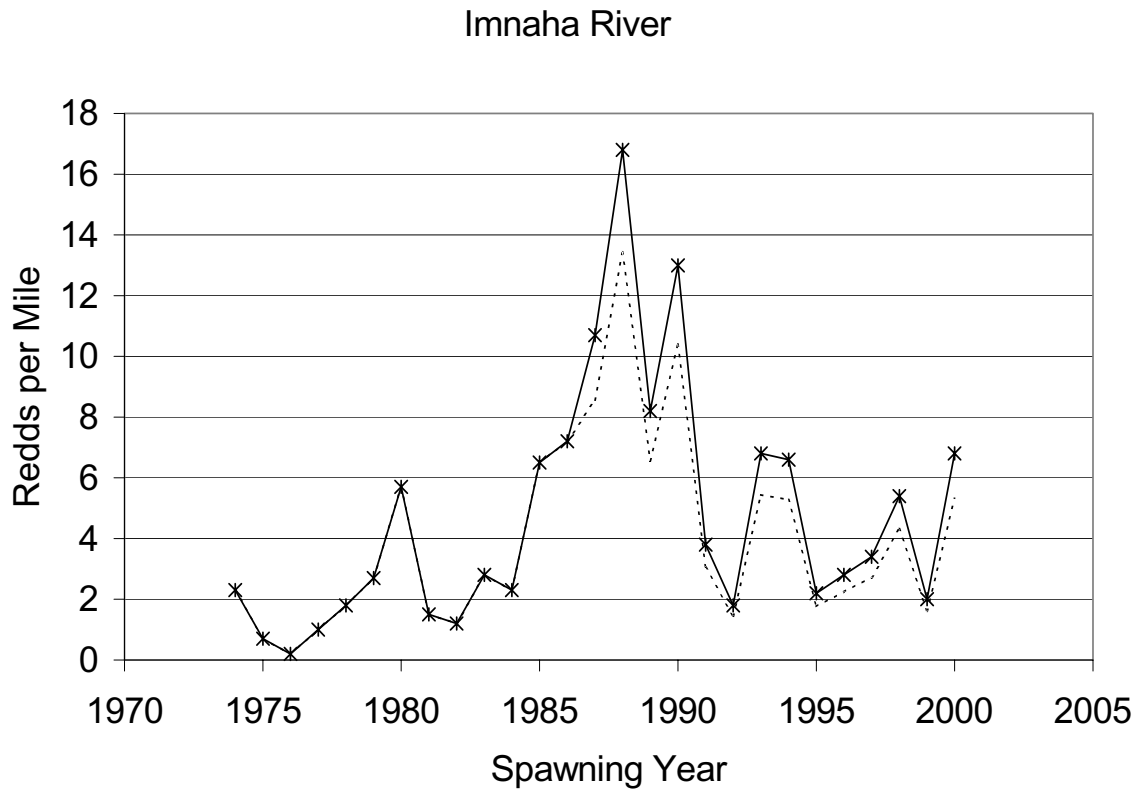


Figure B.2.1.3. Spawner abundance counts (redds/mile) for Imnaha River steelhead.

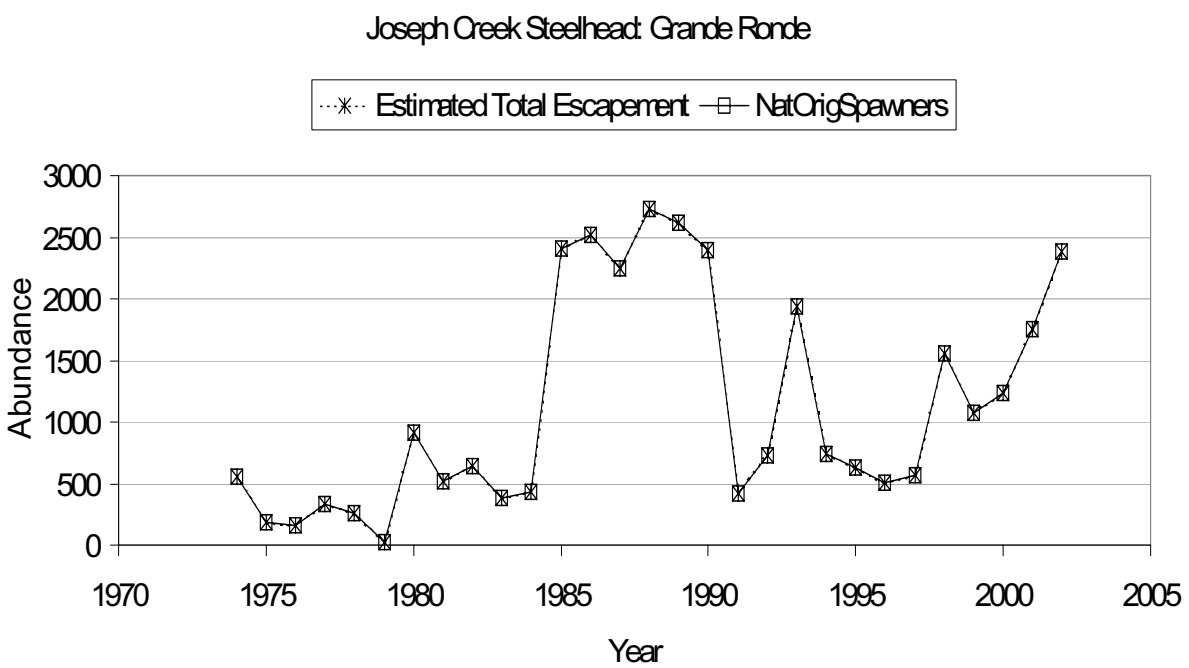


Figure B.2.1.4. Spawner escapement for Joseph Creek steelhead: Grande Ronde. Expanded from redd counts (ODFW).

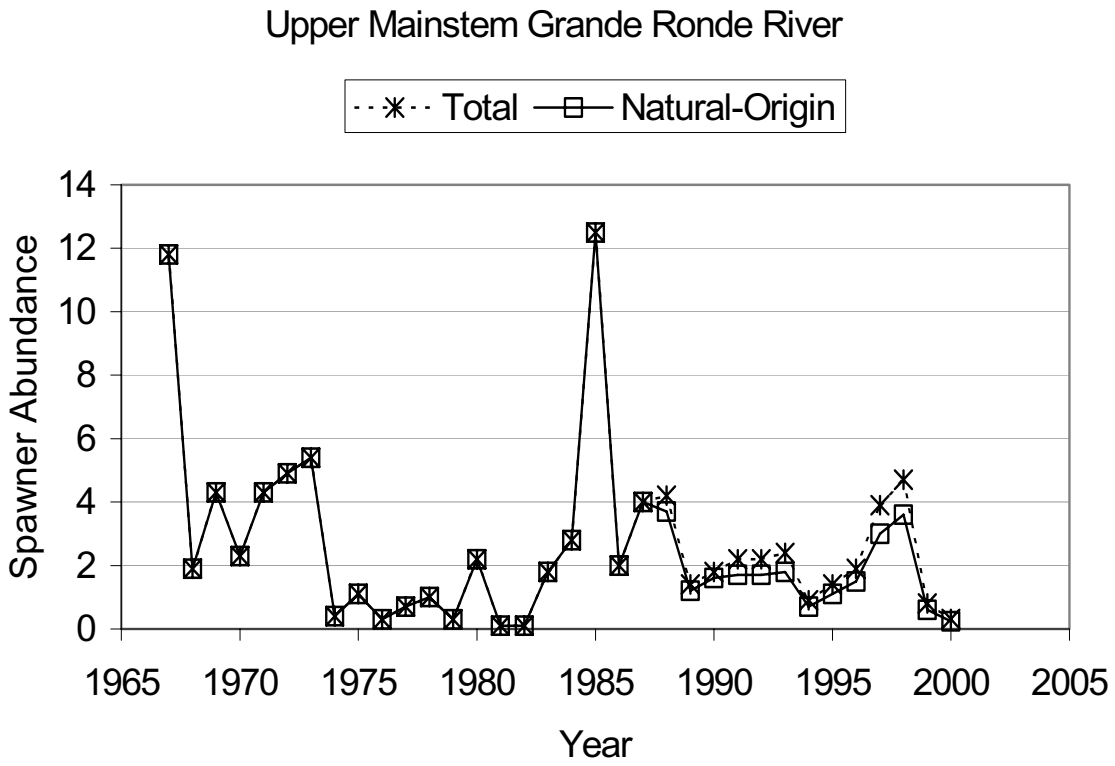


Figure B.2.1.5. Spawner escapement for the Upper Mainstem Grande Ronde River (ODFW spawning ground survey data).

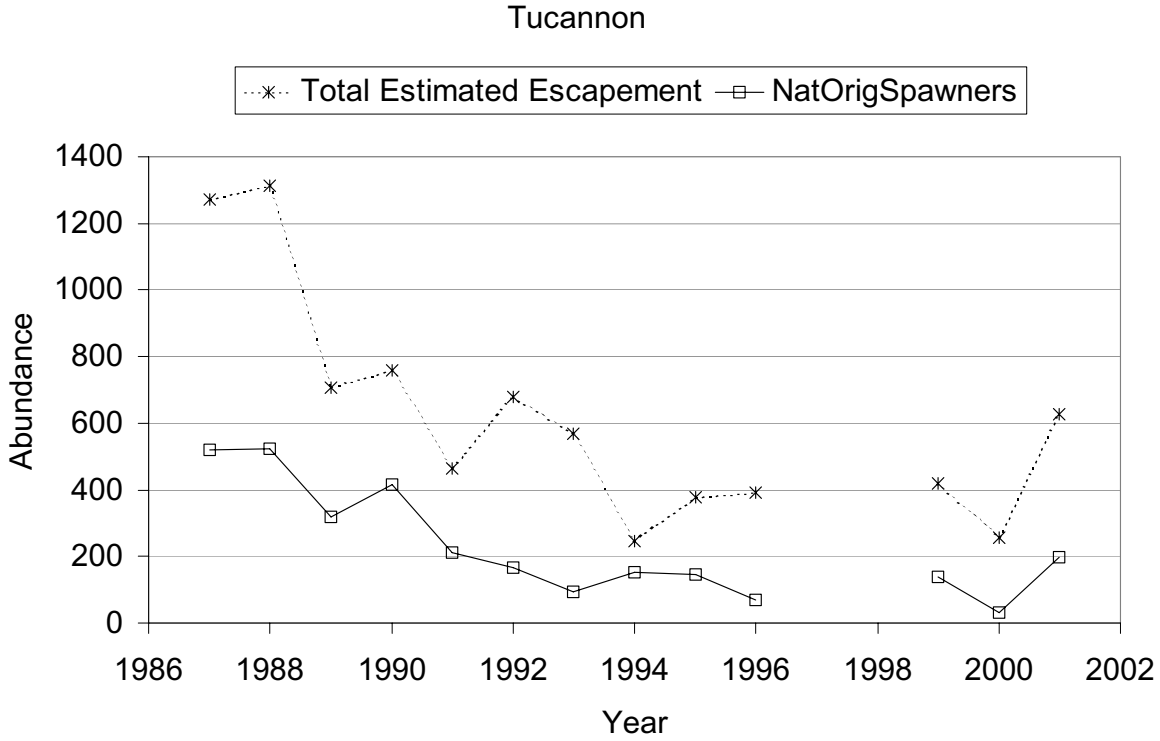


Figure B.2.1.6. Estimated spawner escapement for Tucannon River steelhead (WDFW).

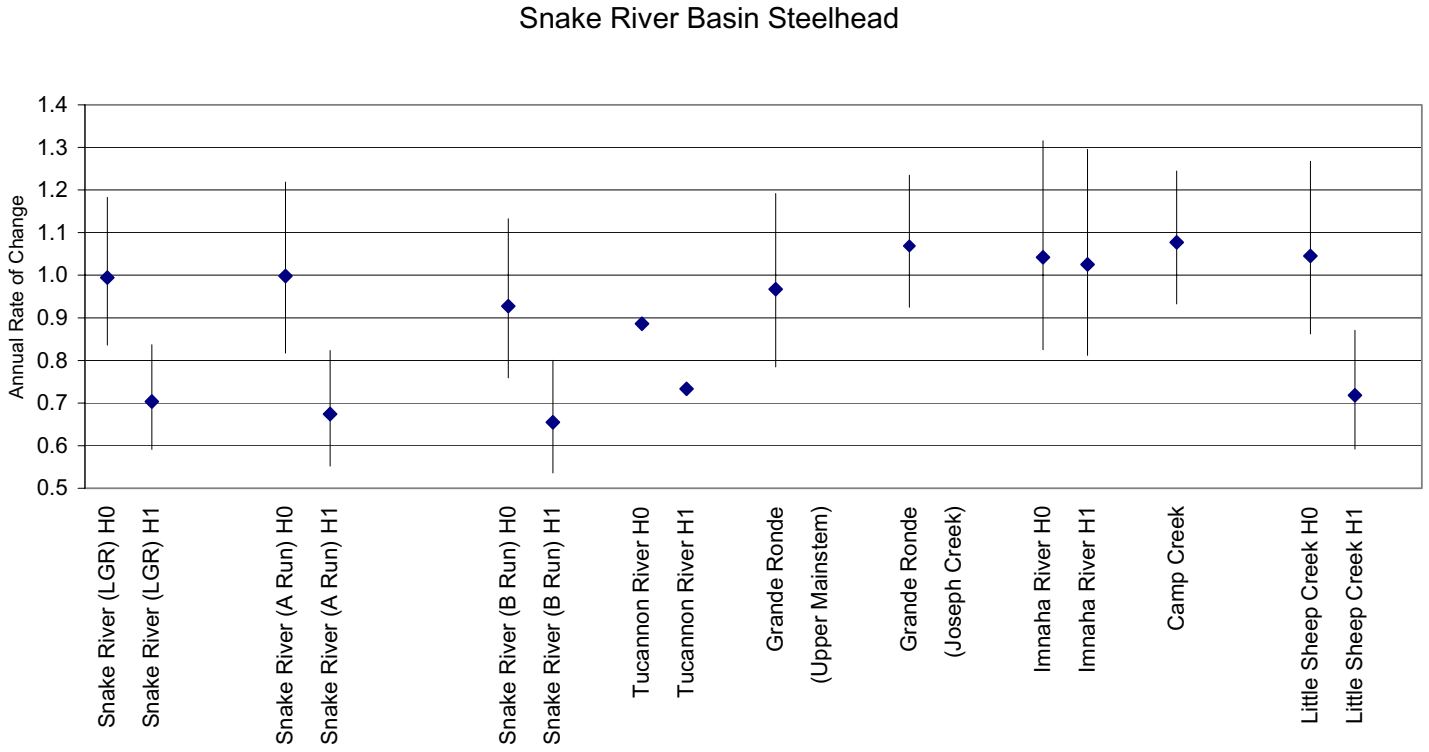


Figure B.2.1.7. Long term median population growth rate estimates and 95% confidence limits for the Snake River Basin steelhead ESU. Paired estimates are based on calculations where hatchery-origin spawners have reproductive success equal to zero (H0) or equivalent to natural-origin spawners (H1) (some hatchery confidence limits estimated by extrapolation).

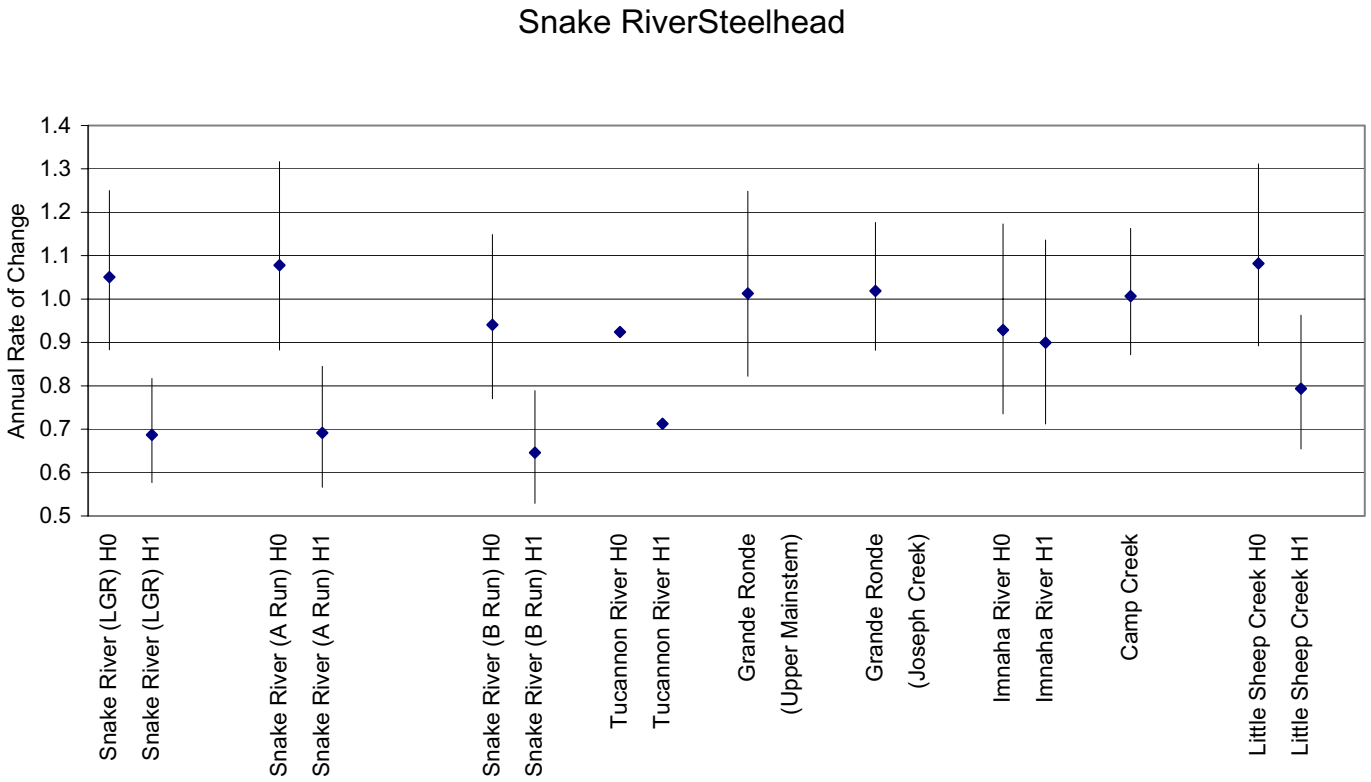


Figure B.2.1.8. Short-term median population growth rate estimates and 95% confidence limits for the Snake River Basin steelhead ESU. Paired estimates are based on calculations where hatchery-origin spawners have reproductive success equal to zero (H0) or equivalent to natural-origin spawners (H1).

B.2.2. UPPER COLUMBIA RIVER STEELHEAD

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The life-history patterns of Upper Columbia River steelhead are complex. Adults return to the Columbia River in the late summer and early fall; most migrate relatively quickly up the mainstem to their natal tributaries. A portion of the returning run overwinters in the mainstem reservoirs, passing over the upper mid-Columbia dams in April and May of the following year. Spawning occurs in the late spring of the calendar year following entry into the river. Juvenile steelhead spend 1 to 7 years rearing in freshwater before migrating to the ocean. Smolt outmigrations are predominately age 2 and age 3 juveniles. Most adult steelhead return after 1 or 2 years at sea, starting the cycle again.

Estimates of the annual returns of upper Columbia River steelhead populations are based on dam counts. Cycle counts are used to accommodate the prevalent return pattern in up-river summer steelhead (runs enter the Columbia River in late summer and fall, some fish overwinter in mainstem reservoirs—migrating past the upper dams prior to spawning the following spring). Counts over Wells Dam are assumed to be returns originating from natural production and hatchery outplants into the Methow and Okanogan river systems. The total returns to Wells Dam are calculated by adding annual broodstock removals at Wells to the dam counts. The annual estimated return levels above Wells Dam are broken down into hatchery and wild components by applying the ratios observed in the Wells sampling program for run years since 1982.

Harvest rates on upper river steelhead have been cut back substantially from historical levels. Direct commercial harvest of steelhead in non-Indian fisheries was eliminated by legislation in the early 1970s. Incidental impacts in fisheries directed at other species continued in the lower river, but at substantially reduced levels. In the 1970s and early 1980s, recreational fishery impacts in the upper Columbia escalated to very high levels in response to increasing returns augmented by substantial increases in hatchery production. In 1985, steelhead recreational fisheries in this region (and in other Washington tributaries) were changed to mandate release of wild fish. Treaty harvest of summer run steelhead (including returns to the upper Columbia) occurs mainly in mainstem fisheries directed at up-river bright fall chinook.

Hatchery returns predominate the estimated escapement in the Wenatchee, Methow and Okanogan River drainages. The effectiveness of hatchery spawners relative to their natural counterparts is a major uncertainty for both populations. Hatchery effectiveness can be influenced by at least three sets of factors: relative distribution of spawning adults, relative timing of spawning adults, and relative effectiveness of progeny. No direct information is available for the upper Columbia River stocks. Outplanting strategies have varied over the time period the return/spawner data were collected (1976-1994 broodyears). While the return timing into the Columbia River is similar for both wild and hatchery steelhead returning to the upper Columbia, the spawning timing in the hatchery is accelerated. The long-term effects of such acceleration on the spawning timing of returning hatchery-produced adults in nature is not known. We have no direct information on relative fitness of upper Columbia River steelhead progeny with at least one parent of hatchery origin.

B.2.2.1. Summary of Previous BRT Conclusions

The 1998 steelhead status review identified a number of concerns for the Upper Columbia River Steelhead ESU: "While the total abundance of populations within this ESU has been relatively stable or increasing, it appears to be occurring only because of major hatchery supplementation programs. Estimates of the proportion of hatchery fish in spawning escapement are 65% (Wenatchee River) and 81% (Methow and Okanogan Rivers). The major concern for this ESU is the clear failure of natural stocks to replace themselves. The BRT members are also strongly concerned about the problems of genetic homogenization due to hatchery supplementation...apparent high harvest rates on steelhead smolts in rainbow trout fisheries and the degradation of freshwater habitats within the region, especially the effects of grazing, irrigation diversions and hydroelectric Dams." The BRT also identified two major areas of uncertainty; relationship between anadromous and resident forms, and the genetic heritage of naturally spawning fish within this ESU.

B.2.2.2. New Data and Updated Analyses

Population definitions and criteria

An initial set of population definitions for the Upper Columbia River steelhead ESU along with basic criteria for evaluating the status of each population were developed using the Viable Salmonid Population (VSP) guidelines described in McElhany (2000). The definitions and criteria are described in Ford et al. (2000) and have been used in the development and review of Mid-Columbia PUD plans and the FCRPS Biological Opinion. The interim definitions and criteria are being reviewed as recommendations by the Interior Columbia Technical Recovery Team. Briefly, the joint technical team recommended that the Wenatchee River, the Entiat River and the Methow River be considered as separate populations within the Upper Columbia River Steelhead ESU. The Okanogan River may have supported a fourth population; the committee deferred a decision on the Okanogan to the Technical Recovery Team. Abundance, productivity and spatial structure criteria for each of the populations in the ESU were developed and are described in Ford et al. (2001).

Current abundance

Returns of both hatchery and naturally produced steelhead to the upper Columbia River have increased in recent years. Priest Rapids Dam is below Upper Columbia River steelhead ESU production areas. The average 1997-2001 return counted through the Priest Rapids fish ladder was approximately 12,900 steelhead. The average for the previous 5 years (1992-1996) was 7,800 fish.

Total returns to the upper Columbia River continue to be predominately hatchery-origin fish. The natural-origin percentage of the run over Priest Rapids increased to over 25% in the 1980s, then dropped to less than 10% by the mid-1990s. The median percent of natural-origin for 1997-2001 was 17%. Abundance estimates of returning naturally produced Upper Columbia River steelhead have been based on extrapolations from mainstem dam counts and associated sampling information (e.g. hatchery/wild fraction, age composition). The natural component of

the annual steelhead run over Priest Rapids increased from an average of 1,040 (1992-1996) to 2,200 (1997-2001).

The estimate of the combined natural steelhead return to the Wenatchee and Entiat rivers increased to a geometric mean of approximately 900 for the 1996-2001 period. The average percentage natural dropped from 35% to 29% for the recent 5-year period. In terms of natural production, recent production levels remain well below the interim recovery levels developed for these populations (Table B.2.2.1, Figure B.2.2.1).

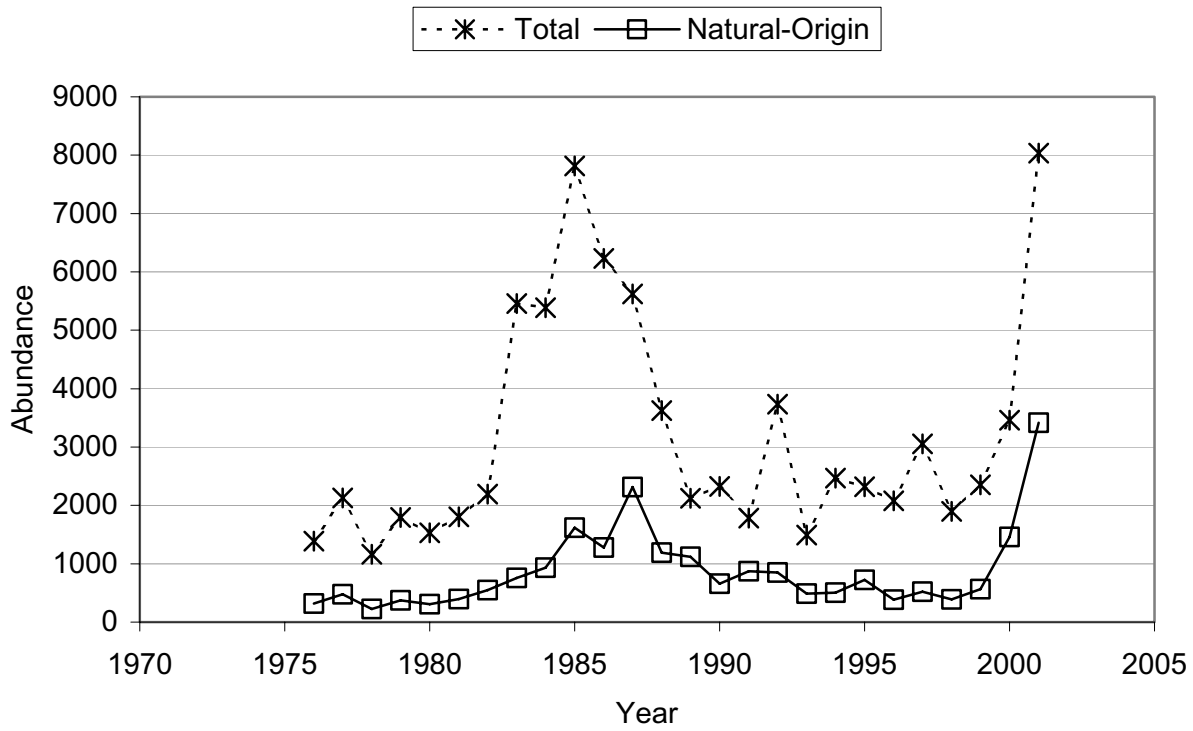


Figure B.2.2.1. Wenatchee/Entiat Rivers steelhead—estimated annual spawner escapements. Cooney, 2001. 1999-2001 data from WDFW.

The Methow River steelhead population is the primary natural production area above Wells Dam. The 1997-2001 geometric mean of natural returns over Wells Dam was 358, lower than the geometric mean return prior to the 1998 status review (Table B.2.2.1, Figure B.2.2.2). The most recent return reported in the data series, 1,380 naturally produced steelhead in 2001, was the highest single annual return in the 25-year data series. Hatchery returns continue to dominate the run over Wells Dam. The average percent of wild origin dropped to 9% for 1996-2001 compared to 19% for the period prior to the previous status review.

Table B.2.2.1. Upper Columbia River steelhead. Summary of current abundance and trend information relative to previous BRT status review. Interim targets from Ford et al. (2001).

Population	5-year mean % natural origin	Recent 5-year geometric mean			Short-term Trend (%/yr)		Interim Target	Current vs. Target
		Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Wenatchee/ Entiat	29 (35*)	3,279 (1,899-8,036)	894	800	+6.5	+2.6	3,000	30%
Methow/ Okanogan	9 (19*)	3,714 (1,879-12,801)	358	450	+13.8	-12.0	2,500	14%

* estimates from previous status review

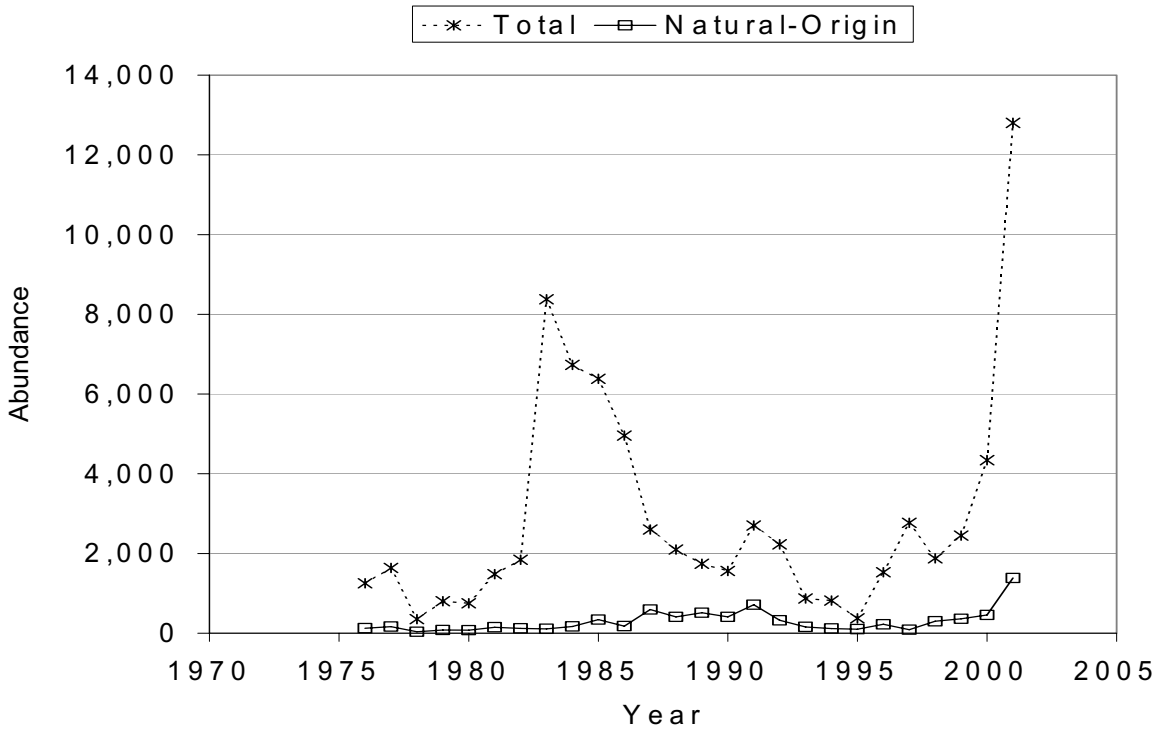


Figure B.2.2.2. Methow River steelhead—estimated annual spawner escapements. Cooney 2001. 1999-2001 data from WDFW.

The analyses described above relied on the 1976-2001 abundance data set. The starting date for that series is set by the advent of counting at Wells Dam (allowed for separate estimates of run strength to the Methow/Okanogan rivers and the Wenatchee/Entiat rivers). The median run (almost all natural origin) from 1933-1954 was approximately 2,300.

Current productivity

Natural returns have increased in recent years for both stock groupings (Table B.2.2.2). Population growth rates, expressed as λ calculated using the running sum method, are

substantially influenced by assumptions regarding the relative effectiveness of hatchery spawners. The same key factor must be considered in analyzing return-per-spawner data sets. The relative contribution of returning steelhead of hatchery origin to natural spawning is not clearly understood. There may be timing and spatial differences in the distribution of hatchery and wild origin spawners that affect production of juveniles. Eggs and subsequent juveniles, from natural spawning, involving hatchery-origin fish may survival at a differential rate relative to spawning of natural-origin adults.

Both short-term (1990-present) and long-term (1976-present) estimates of λ are positive under the assumption that hatchery fish have not contributed to natural production in recent years. λ estimates under the assumption that hatchery fish contributed at the same level as wild fish to natural production are substantially lower—under this scenario natural production is consistently and substantially below the total number (hatchery plus natural origin) of spawners in any given year. This result is consistent with those of McClure et al. (2003) and those in the 2000 FCRPS Biological Opinion (NMFS 2000), in which lambda was estimated from the ESU-level time series for the time period 1980-2000. Although the total spawners have an apparent population growth rate of 1.00 (with relatively high variability), this growth rate is lowered to 0.69 if hatchery fish contributed to subsequent generations at the same rate that wild fish do. Clearly, determining the actual contribution of hatchery fish will be an important element in determining the true status of this ESU.

Return-per-spawner patterns for the two steelhead production areas are also substantially influenced by assumptions regarding the relative effectiveness of hatchery-origin spawners (Figures B.2.2.3 and B.2.2.4). Under the assumption that hatchery and wild spawners are both contributing to the subsequent generation of natural returns, return-per-spawner levels have been

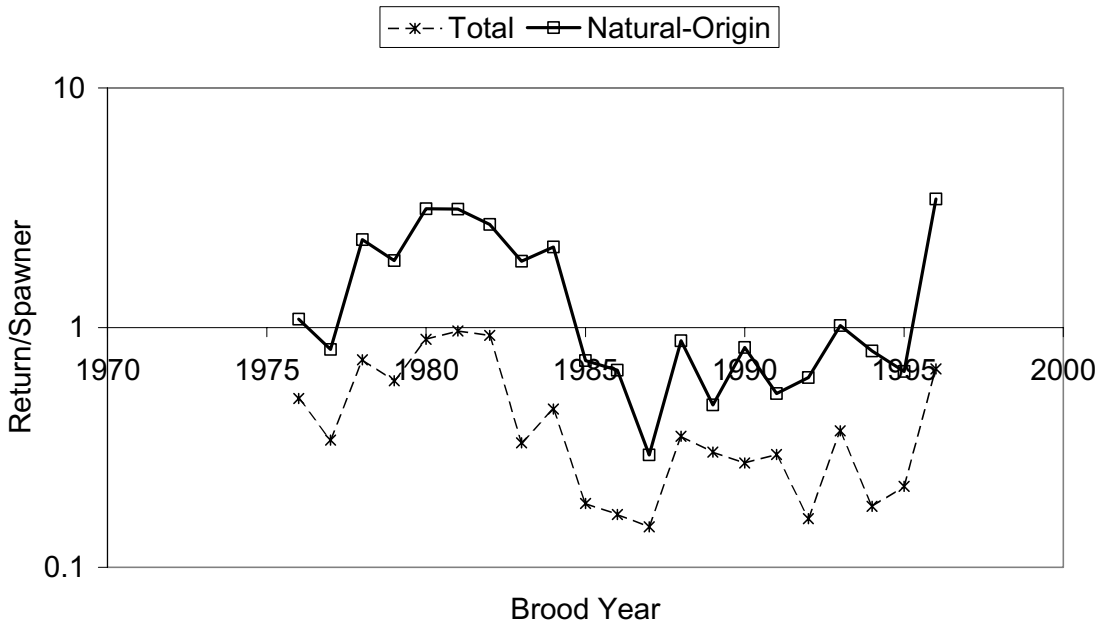


Figure B.2.2.3. Wenatchee/Entiat River steelhead—return-per-spawner vs. broodyear spawning escapement.

Table B.2.2.2: Upper Columbia River steelhead population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions: HF = 0.0 hatchery fish available to spawn do not contribute to natural production; HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts.

Upper Columbia River Steelhead	Series Length	Method	% wild 1987-1996	% wild 1997-2001	1997-2001 geomean	HF	Long-term λ	Prob. λ<1	Short-term λ	Prob. λ<1
Wenatchee/Entiat	1976-2001	DC	0.33	0.29	894	0 1	1.067 0.733	0.112 1.000	1.093 0.753	0.219 0.987
Above Wells Dam	1976-2001	DC	0.17	0.085	358	0 1	1.086 0.579	0.088 1.000	1.277 0.565	0.357 1.000
Methow River	1976-2001	DC	0.21	0.11	358	0 1	1.086 0.589	0.088 1.000	1.277 0.621	0.357 1.000

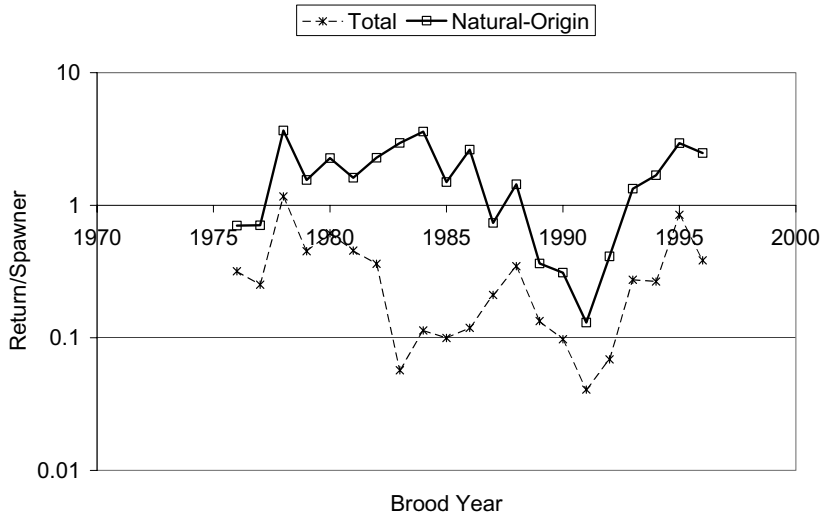


Figure B.2.2.3. Methow River steelhead—return-per-spawner vs. broodyear spawning escapement.

consistently below 1.0 since 1976. Under this scenario natural production would be expected to decline rapidly in the absence of hatchery spawners. Under the assumption that hatchery fish returning to the upper Columbia River do not contribute to natural production, return-per-spawner levels were above one until the late 1980s. Return-per-spawner estimates subsequently dropped below replacement (1.0) and remained low until the most recent broodyear with measured returns—1996. The actual contribution of hatchery returns to natural spawning remains a key uncertainty for upper Columbia River steelhead. This information need is in addition to any considerations for long-term genetic impacts of high hatchery contributions to natural spawning.

Resident *O. mykiss* considerations

This section summarizes available information on resident *O. mykiss* populations within the ESU. Table B.2.2.3 and Appendix B.5.1 provide a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Resident *O. mykiss* are relatively abundant in upper Columbia River tributaries currently accessible to steelhead as well as in upriver tributaries blocked off to anadromous access by Chief Joseph and Grand Coulee dams (Kostow 2003 draft). USFWS biologists surveyed the abundance of trout and steelhead juveniles in the Wenatchee, Entiat, and Methow River drainages in the mid 1980s (Mullan 1992). Adult trout (defined as trout > 20 cm) were found in surveys in all basins. Juvenile *O. mykiss* were reported from 94% of the surveys conducted in areas believed to be used by steelhead and resident trout (Kostow 2003 draft). The results also supported the hypothesis that resident *O. mykiss* are more abundant in tributary/mainstem areas above the general areas used by steelhead for rearing.

The original status review did not formally evaluate the current ESU status of resident populations above Chief Joseph Dam, nor did it formally consider whether *O. mykiss* in upper Columbia River tributaries historically were in the same ESU as populations in the Wenatchee, Entiat, Methow, and Okanogan Rivers. Kostow (2003) reports that biologists who are familiar with the areas above Chief Joseph Dam believe that *O. mykiss* are present in significant numbers. Several of the tributaries above Chief Joseph Dam have been blocked off by dams, and introductions of exotic gamefish and trout species have been widespread. We are not aware of specific information relevant to the ESU status of Case 3 resident populations above dams in the Okanogan or Spokane Rivers, or above Chief Joseph and Grand Coulee Dams on the mainstem Columbia River. *O. mykiss,* believed to be native populations, are present in a number of tributaries draining into Lake Roosevelt (Kostow 2003). Mullan (1992) hypothesized that the native trout populations above Chief Joseph Dam effectively preserved native steelhead lineages present before the construction of the mainstem impassable dams. Knudsen et al (2002) concluded that native resident (Case 2) populations persist in some Kootenai River tributaries, in spite of extensive stocking by non-native rainbow trout.

Table B.2.2.3. Distribution of *O. mykiss* trout by category relative to the Upper Columbia River steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Upper Columbia River steelhead	Potentially all areas that are/were used by steelhead Wenatchee Lower Entiat Methow Okanogan	Upper Entiat Upper Kootenay Okanogan: Enloe Falls? Methow: Chewuch? Lost	Trout distributions currently more restricted than historically Okanogan Basin: Conconully Dam Enloe Dam? Chief Joseph Dam Lower Spokane to Post Falls Sanpoil Several small tributaries Lower Pend Oreille to Z-Canyon Columbia headwaters in Canada

B.2.2.3. New Hatchery Information

Hatchery considerations

Hatchery production averaged approximately 300,000 smolts/year in the 1960s, 425,000 in the 1970s, 790,000 in the 1980s, and more than 800,000 in the 1990s (including releases exceeding 1.0 million). Current mitigation/supplementation targets are to use locally obtained returning adults for programs. The objective for the Wenatchee is to release 400,000 smolts per year using broodstock collected from run-of-the-river fish in the Wenatchee River (main collection point is Dryden Dam). Broodstock collected at Wells Dam are used for outplanting in the Methow (380,000 target release), and the Okanogan (100,000 target release). The Entiat basin has been designated as a natural production 'reference' drainage—

no hatchery outplanting. Presently, there exist no monitoring programs in place to directly estimate natural production of steelhead in the Entiat. Categorizations of Upper Columbia River steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

Table B.2.2.4. Hatchery releases of steelhead in the Upper Columbia River basin, organized by major steelhead production areas and broodstock of the release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	**Stock**	**Average releases per year**		
		1985 - 1989	**1990 - 1994**	**1995 - 2001**
Mainstem Columbia	Ringold	220,421	144,303	-
	Wells	27,757	26,204	202,269
	Skamania	-	35,130	70,523
	Wenatchee River	-	-	500
	Mainstem Total	177,270	146,883	273,292
Entiat	Wells	43,863	43,247	18,098
	Wenatchee River	-	-	12,465
	Entiat Total	43,863	43,247	30,564
Methow	Wells	439,926	428,894	418,227
Okanogan	Wells	133,198	123,972	119,996
Wenatchee	Leavenworth	62,376	95,631	23,960
	Ringold	113,225	-	-
	Wells	121,272	351,735	176,643
	Wenatchee River	81,072	-	106,554
	Wenatchee Total	377,945	447,366	307,158
ESU Total	All Stocks	1,243,110	1,249,116	1,149,239

B.2.3 MIDDLE COLUMBIA RIVER STEELHEAD

Primary contributor: Thomas Cooney
(Northwest Fisheries Science Center)

The Middle Columbia River Steelhead ESU includes steelhead populations in Oregon and Washington drainages upstream of the Hood and Wind river systems to and including the Yakima River. The Snake River is not included in this ESU. Major drainages in this ESU are the Deschutes, John Day, Umatilla, Walla-Walla, Yakima, and Klickitat river systems. Almost all steelhead populations within this ESU are summer-run fish, the exceptions being winter-run components returning to the Klickitat, and Fifteen Mile Creek watersheds. Most of the populations within this ESU are characterized by a balance between 1- and 2-year-old smolt outmigrants. Adults return after 1 or 2 years at sea.

Hatchery facilities are located in a number of drainages within the geographic area of this ESU, although there are also subbasins with little or no direct hatchery influence. The John Day River system, for example, has not been outplanted with hatchery steelhead. Similarly, hatchery production of steelhead in theYakima River system was relatively limited historically and has been phased out since the early 1990s. However, the Umatilla and the Deschutes river systems each have ongoing hatchery production programs based on locally derived broodstocks. Moreover, straying from out-of-basin production programs into the Deschutes River has been identified as a chronic occurrence. The Walla Walla River (three locations in Washington sections) historically received production releases of Lyons Ferry stock summer steelhead from the Lower Snake River Compensation Program (LSRCP). Mill Creek releases were halted after 1998 due to concerns associated with the then pending listing of Mid-Columbia River steelhead under the ESA. A new endemic broodstock is under development for the Touchet River release site (beginning with the 1999/2000 return year). Production levels at the Touchet and Walla Walla River release site have been reduced in recent years (WDFW comments to BRT).

Blockages have prevented access to sizable steelhead production areas in the Deschutes River and the White Salmon River. In the Deschutes River, Pelton Dam blocks access to upstream habitat historically used by steelhead. Conduit Dam, constructed in 1913, blocked access to all but 2-3 miles of habitat suitable for steelhead production in the Big White Salmon River (Rawding 2001). Substantial populations of resident trout exist in both areas.

B.2.3.1 Summary of Previous BRT Conclusions

The previous reviews (BRT 1998; BRT 1999) identified several concerns including relatively low spawning levels in those streams for which information was available, a preponderance of negative trends (10 out of 14), and the widespread presence of hatchery fish throughout the ESU. The 1999 BRT review specifically identified "...the serious declines in abundance in the John Day River Basin…" as a point of concern given that the John Day system had supported large populations of naturally spawning steelhead in the recent past. Concerns were also expressed about the low abundance of returns to the Yakima River system

relative to historical levels "...with the majority of production coming from a single stream (Satus Creek)." The sharp decline in returns to the Deschutes River system was also identified as a concern.

The 1999 BRT review identified increases of stray steelhead into the Deschutes River as a "major source of concern." The review acknowledged that initial results from radio tagging studies indicated that a substantial proportion of steelhead entering the Deschutes migrated out of the system prior to spawning.

The previous BRT review identified a set of habitat problems affecting basins within this ESU. High summer and low winter temperatures are characteristic of production or migration reaches associated with populations within this ESU. Water withdrawals have seriously reduced flow levels in several Mid-Columbia drainages, including sections of the Yakima, Walla-Walla, Umatilla, and Deschutes rivers. Riparian vegetation and instream structure has been degraded in many areas—the previous BRT report states that "(O)f the stream segments inventoried within this ESU, riparian restoration is needed for between 37% and 84% of the river bank in various basins."

B.2.3.2 New Data and Updated Analyses

Abundance

With some exceptions, the recent 5-year average (geometric mean) abundance for natural steelhead within this ESU was higher than levels reported in the last status review (BRT 1999). Information on recent returns in comparison to return levels reported in previous status reviews is summarized in Table B.2.3.1 and depicted in Figures B.2.3.1-B.2.3.10. Returns to the Yakima River, the Deschutes River, and to sections of the John Day River system were up substantially in comparison to 1992-1997. Yakima River returns are still substantially below interim target levels and estimated historical return levels, with the majority of spawning occurring in one tributary, Satus Creek (Berg 2001). The recent 5-year geometric mean return of the natural-origin component of the Deschutes River run has exceeded interim target levels. Recent 5-year geometric mean annual returns to the John Day basin are generally below the corresponding mean returns reported in the previous status reviews. However, each of the major production areas in the John Day system has shown upward trends since the 1999 return year.

Recent year (1999-2001) redds-per-mile estimates of winter steelhead escapement in Fifteen Mile Creek were also up substantially relative to the annual levels in the early 1990s. Returns to the Touchet River are lower that the previous 5-year average. Trend or count information for the Klickitat River winter steelhead run are not available but current return levels are believed to be below interim target level.

Productivity

Short-term trends in major production areas were positive for seven of the 12 areas (Table B.2.3.1). The median annual rate of change in abundance since 1990 was +2.5%, individual trend estimates ranged from -7.9% to +11%. The same basic pattern was reflected in λ estimates for the production areas. The median short-term (1990-2001) annual

Table B.2.3.1. Summary of recent 5-year average (geometric mean) population abundance and trend estimates in comparison to estimates included in previous BRT review (BRT 1999). Estimates from previous status reviews in brackets. NR = no releases.

Population	5-year mean % natural origin+	Recent 5-year geometric mean			Short-term Trend (%/yr)		Interim Target	Current vs. Target
		Total	Natural					
		Mean (Range)	Current	Previous	Current	Previous		
Klickitat River	?	155 Redds (97 – 261)			+14.6	-9.2	3,600 sum+win	below target
Yakima River *	97 [95]	1,801 (1,058– 4,061)	1,747	800	+10.0	+14.0	8,900	20%
Fifteenmile Creek *	100 [100?]	2.87 RPM (1.3 – 6.0)			+7.8	-5.4	900	
Deschutes River	38 [50]	13,455 (10026– 21457)	5,113	3,000	+11.2	+2.6	5,400	95%
John Day Upper Mainstem	96 [100]	2,122 (926 – 4,168)	2,037		-1.7	-15.2	2,000	102%
John Day Lower Mainstem	NR	1.40 RPM (0.0-5.4)			-2.5	-15.9	3,200	
John Day Upper N. Fork	NR	2.57 RPM (1.6-5.0)			+9.6	-11.8	2,700	
John Day Lower N. Fork	NR	3.52 RPM (1.5-8.8)			+11.0	-1.2		
John Day Middle Fork	NR	3.70 RPM (1.7-6.2)			-2.7	-13.7	2,700	
John Day S. Fork	NR	2.52 RPM (0.9-8.2)			-0.8	-7.4	600	
Umatilla River	60 [76]	2,486 (1,480– 5,157)	1,492	1,096	+8.6	+0.7	2,300	65%
Touchet R. **	84 [93]	345 (273 – 527)	289	300	-0.5	-2.7	900	32%

* 5-year geometric mean calculated using years 1997–2001
** 5-year geometric mean calculated using only years 1998–2001

Table B.2.3.2 Middle Columbia River Steelhead population growth rate analysis. Summary of available trend data sets, results of calculating annual population growth rates (λ: geomean, probability geomean less than 1.0) Long-term = the length of the available data series, Short term = 1990 -2001 or most recent year. Population growth rates calculated for two hatchery effectiveness (HF) assumptions; HF = 0.0 hatchery fish available to spawn do not contribute to natural production, HF = 1.0 hatchery returns available to spawn contribute to broodyear natural production at the same rate as natural-origin spawners. Methods: DC – Dam counts; RC – redd counts; RPM – redds per mile index; TLC – estimated total live fish on spawning grounds.

	Series Length		Proportion Wild			Geometric Lambda (Mean, Prob. <1.0)				
Mid-Columbia Steelhead		**Measure**	**1987-96**	**Last 5 yrs**	**Hatchery Effectiveness Assumption**	**Recent**	**Long Term**		**Short Term**	
Yakima River Aggregate	1981-2000	DC		0.942	***HF =0.0***	**901**	**1.009**	0.456	**1.002**	0.49
					HF=1.0					
Klickitat River	1990-92,96-01	RC	na	na						
Deschutes River	1978-2002	DC	0.4	0.38	***HF =0.0***	**5566**	**1.022**	0.35	**1.076**	0.276
					HF=1.0		**0.84**	0.999	**0.816**	0.964
Warm Springs (above weir)	1980-1999		1	1			**0.942**	0.852	**0.904**	0.792
			1							
John Day R. Upper Mainstem	1974-2002	Exp. RC	0.986	0.963	***HF =0.0***	**2256**	**0.975**	0.699	**0.963**	0.672
					HF=1.0		**0.966**	0.817	**0.935**	0.789
John Day R. Lower Mainstem	1965-2001	Exp. RC		1			**0.981**	0.85	**1.010**	0.463
John Day R. Upper North Fork	1977-2002	Exp. RC		1			**1.011**	0.412	**1.077**	0.132
John Day R. Lower North Fork	1976-2002	Exp. RC		1			**1.013**	0.43	**1.174**	0.026
John Day R. Middle Fork	1974-2002	Exp. RC		1			**0.966**	0.743	**0.954**	0.655
John Day R. South Fork	1974-2002	Exp. RC		1			**0.967**	0.739	**1.011**	0.459
Umatilla River	1966-2002	DC	0.758	0.674	***HF =0.0***	**1658**	**1.007**	0.399	**1.070**	0.135
					HF=1.0		**0.969**	0.854	**0.947**	0.82
Walla Walla: Touchet River	1987-2001	DC	0.911	0.842	***HF =0.0***	**290**	**0.961**	0.769	**0.984**	0.676
					HF=1.0		**0.939**	0.74	**0.959**	0.666
Walla Walla: Main fork	1993-2000	DC	Data series too short to calculate trends							
Fifteen Mile Cr. (Winter Run)	1966-2001	RPM	na	na		3.48	**0.981**	0.635	**1.129**	0.064

population growth rate estimate was 1.045, assuming that hatchery fish on the spawning grounds did not contribute to natural production, with eight of the 12 indicator trends having a positive growth rate. Assuming that potential hatchery spawners contributed at the same rate as natural-origin spawners resulted in lower estimates of population growth rates. The median short-term λ under the assumption of equal hatchery/natural-origin spawner effectiveness was .967, with six of the 12 indicator trends exhibiting positive growth rates.

Long-term trend estimates were also calculated using the entire length of the data series available for each production area (Table B.2.3.1). The median estimate of long-term trend over the 12 indicator data sets was -2.1% per year (-6.9 to +2.9), with 11 of the 12 being negative. Long-term annual population growth rates (λ) were also negative (Table B.2.3.1). The median long-term λ was .98 under the assumption that hatchery spawners do not contribute to production, and .97 under the assumption that both hatchery and natural-origin spawners contribute equally. These longer trends are consistent with another recent analysis (McClure et al. 2003) of 28 index areas in the Middle-Columbia steelhead ESU over the 1980-2000 time period. In this analysis, the average population growth rate across all streams was 0.96, with only two of the 28 index areas showing a positive trend. [Note that the analyses in McClure et al. 2003 bracket those in the 2000 FCRPS Biological Opinion, which used slightly different assumptions about hatchery fish spawning effectiveness.]

All of the production area trends available for this ESU indicate relatively low escapement levels in the 1990s. For some of the data sets, earlier annual escapements were relatively high compared to the stream miles available for spawning and rearing. In those cases, it is reasonable to assume that subsequent production may have been influenced by density-dependent effects. In addition, there is evidence of large fluctuations in marine survival for Columbia River and Oregon coastal steelhead stocks (Cooney 2000, Chilcote 2001). Spawner return data sets for Mid-Columbia production areas are of relatively short duration. As a result of these considerations, projections based on simple population growth rate trends or on stock recruit relationships derived by fitting recent year spawner return data should be interpreted with caution.

Resident *O. mykiss* considerations

This section summarizes available information on resident *O. mykiss* populations within the ESU. Table B.2.3.3 and Appendix B.5.1 provide a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Resident *O. mykiss* are sympatric with current and historical anadromous steelhead distribution throughout the Middle Columbia Steelhead ESU (Kostow 2003). Pelton/Round Butte Dam in the Deschutes River system and Condit Dam in the White

Salmon River are the major anadromous blockages within tributaries in this ESU. Irrigation diversions in other tributaries including the Umatilla and Yakima Rivers result in partial blockages or reduce the survival of migrating steelhead.

Lower reaches of most major tributaries in this ESU have been heavily affected by decades of agricultural impacts. The Deschutes River is an exception; its lower tributaries are relatively intact with strong flows of cold water. The resident *O. mykiss* population in the lower Deschutes River is highly productive, supporting some of the largest and most fecund trout in the entire Columbia Basin (Kostow 2003).

Tributaries and mainstem reaches in the upper portions of the Umatilla River, Walla Walla River and the Klickitat River are all relatively intact and support both steelhead and resident O. mykiss populations although there are no specific estimates of abundance for the resident form (Kostow 2003).

Resident *O. mykiss* production varies widely among the tributaries of the relatively large Yakima River system. Access by returning anadromous migrants to the Upper Yakima River drainage was effectively cut off for 18 years by Roza Dam. That area is believed to have been the most productive historical habitat for steelhead. Resident *O. mykiss* currently dominate production above Rosa Dam. Two lower Yakima tributaries, Satus Creek and Toppenish Creek, support most of the current steelhead production from the basin. The absence of 2+ smolts in these tributaries indicates little or no resident production. Steelhead and resident trout are present in the Naches River subbasin.

The John Day River system may have historically supported large populations of resident trout; their redds have been observed during steelhead redd surveys in this system (Kostow 2003). Some proportion of the age 0/age 1 fish counted during juvenile transects may be resident trout, although these redds are not systematically counted.

The mainstem Umatilla River has been heavily impacted by water withdrawals and other agricultural activities. However, headwater reaches are generally intact and have the capacity to support fairly large anadromous and resident *O. mykiss* juvenile production. Abundance estimates of juvenile *O. mykiss* from the upper Umatilla mainstem and tributaries show a high percentage of age 0 and 1 juveniles, while those 2+ and older make up a relatively small proportion of the juvenile sampled. Kostow (2003) concluded that resident adults may still outnumber returning steelhead in the basin.

Studies of relative spawning distributions and timing for steelhead and sympatric resident *O. mykiss* populations have been conducted on the upper Yakima River (Pearsons et al. (1998) and the Deschutes River (Zimmerman and Reeves, 2000). Pearsons et al (1998) concluded that there were substantial overlaps in spawning timing and distribution in the upper Yakima River, with steelhead spawning distributions generally nested within those of resident *O. mykiss*. The Deschutes River study indicated less overlap because of differences in microhabitat use by the two forms. In a previous study Zimmerman and Reeves (1996) did document trout and steelhead pairing late in the steelhead spawning

period. Kostow (2003) reports observations of possible steelhead resident pairings during spawning on the John Day, Klickitat, Walla-Walla and Umatilla Rivers.

Table B.2.3.3: Distribution of *O. mykiss* trout by category relative to the Middle Columbia steelhead ESU. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented.

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Middle Columbia Steelhead	Historically all areas where steelhead are/were present. Trout distributions currently more restricted. Fifteenmile Eightmile Deschutes Klickitat Umatilla: Upper Umatilla John Day: Upper tributaries Walla Walla Upper tributaries Yakima: Upper Yakima Naches Some other small tributaries	All natural barriers upstream of Klickitat and Deschutes Basins: Deschutes: White River Upper Deschutes (Big Falls) Upper NFk Crooked R. John Day: Upper SFk. John Day	Trout distributions currently more restricted than historically Little White Salmon (Conduit Dam) Deschutes (Pelton/Round Butte dams) Metolius Squaw Cr. Crooked River Umatilla (Irrigation dams) Willow Cr. Butter Cr. McKay Cr.

Zimmerman and Reeves (2000) used otolith microchemistry to compare samples of returning adult steelhead to samples taken from resident trout. They concluded that the anadromous steelhead sampled had anadromous mothers and that the resident trout sampled had resident mothers. The study was unable to determine the corresponding contributions of anadromous and resident males to anadromous and resident progeny.

In the Klickitat River basin, a sample of presumed resident fish from above Castille Falls appears to be of native origin (rather than introduced rainbow trout), based on genetic analyses conducted by WDFW (S. Phelps, unpublished data). However, this is a Case 2 population (above a natural barrier) and is also differentiated from anadromous populations within the ESU. Currens (1997) found genetic evidence for substantial isolation between resident fish in Eightmile Creek (a tributary of Fifteenmile Creek) and anadromous fish within the ESU. This is believed to be a Case 1 population—historical contact with anadromous fish and no apparent barrier to migration at present. The genetic profile for the resident fish is consistent with it being a native redband population rather than introduced rainbow trout.

Currens (1997) genetically compared Case 3 resident *O. mykiss* above artificial barriers in McKay Creek and Butter Creek (both tributaries of the Umatilla River) with samples from Umatilla River steelhead. Considerable variation was found among all samples, but the samples from McKay Creek were particularly distinctive. Currens speculated that the McKay Creek population may have been introgressed with non-native hatchery rainbow trout, which have been stocked in the area.

In the Deschutes River basin, Currens et al. (1990) found genetic differences between *O. mykiss* populations from upper and lower Nena Creek and East Fork Foley Creek that were of the same magnitude as differences among different steelhead populations within the basin. The upper and lower reaches of these creeks are separated by natural waterfalls that may or may not serve as barriers to anadromous fish (hence, it is uncertain whether these are Case 1 or Case 3 populations). White River falls is an ancient barrier, and Case 2 resident fish above the falls are genetically quite distinctive (Currens et al. 1990).

In the John Day River, Currens et al. (1987) found that genetic differences between *O. mykiss* from the North and South Forks were larger than differences between presumed steelhead and (Case 1) rainbow trout in the South Fork. Genetic analysis of Yakima River *O. mykiss* (Pearsons et al. 1998) found no significant differences between sympatric resident (Case 1) and anadromous fish, a finding that is consistent with observations of interbreeding between the two forms.

B.2.3.5. New Hatchery Information

Relatively high numbers of hatchery-origin steelhead returning from releases outside of the Deschutes River system continue to enter the Deschutes system. The actual number of out-of-basin-origin hatchery fish that spawn naturally in the Deschutes is not known. Preliminary results from recent radio tracking studies cited in Cramer et al. (2002)

backs up the hypothesis that a significant proportion of hatchery strays entering the Deschutes River are 'dip-ins,' fish that migrate out of the system prior to spawning. The estimated escapements to the spawning grounds used in the status review updates already include an adjustment to reflect out-migrating stray hatchery fish. The estimates of spawning escapement into the Deschutes River system depicted in Figure B.2.3.2 assumed that 50% of the estimated number of outside hatchery fish passing over Sherars Falls dropped back down and did not contribute to spawning in the Deschutes River system (Chilcote 2002 spreadsheet analysis). Cramer et al. (2002) identified two other sets of information regarding the potential contribution of hatchery stocks to natural spawning in the Deschutes River. ODFW spawner surveys in Buckhollow, Bakeoven, and Trout creeks indicate a relatively high proportion of wild fish in those major spawning tributaries in recent years, in comparison to the estimated fraction of wild over Sherars Falls (below major mainstem spawning areas). In addition, estimated natural-origin returns to the mainstem/lower tributary roughly track the returns to the Warm Springs River in time, in spite of large differences in estimated hatchery contributions in some years. Additional information is needed to clarify the potential impact of outside hatchery-origin fish to natural production in the system. Categorizations of Middle Columbia River steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

Table B.2.3.4. Steelhead hatchery releases in Middle Columbia River region by major steelhead production areas and release broodstock release. Averages calculated by time period to facilitate comparison of release levels since the last BRT review with previous levels.

Basin	Race	Stock	Average releases per year		
			1985 - 1989	1990 - 1994	1995 - 2001
Mainstem Columbia	Summer	Unknown	4,523	-	-
	Summer	Dworshak B	-	5,440	412
		Mainstem Total	4,523	5,440	412
White Salmon	Summer	Skamania	9,798	18,238	8,641
	Winter	Skamania	12,414	32,615	17,497
	Winter	Elochoman River	-	-	6,428
	Winter	Kalama River	-	-	3,669
	Winter	Beaver Creek	-	-	5,741
		White Salmon Total	22,212	50, 854	41,976
Little White Salmon	Summer	Skamania	0	0	15,395
Klickitat	Summer	Skamania	87,821	96,704	113,616
Deschutes	Summer	Deschutes River	209,443	163,505	168,680
Rock	Winter	Skamania	1,428	5,176	4,083
	Winter	Elochoman River	-	-	1,560
		Rock Creek Total	1,428	5,176	5,644
Umatilla	Summer	Umatilla River	66,730	130,958	142,259
Walla Walla	Summer	Lyons Ferry	191,854	208,632	293,256
	Summer	Wells	116,396	-	-
	Summer	Ringold	-	55,752	-
	Summer	Touchet River	-	-	5,212
		Walla Walla Total	308,251	264,385	298,469
Yakima	Summer	Ringold	21,726	-	-
	Summer	Wells	18,201	-	-
	Summer	Yakima River	112,641	72,039	-
		Yakima Total	152,569	72,039	0
ESU Total		All Stocks	852,978	789,063	786,451

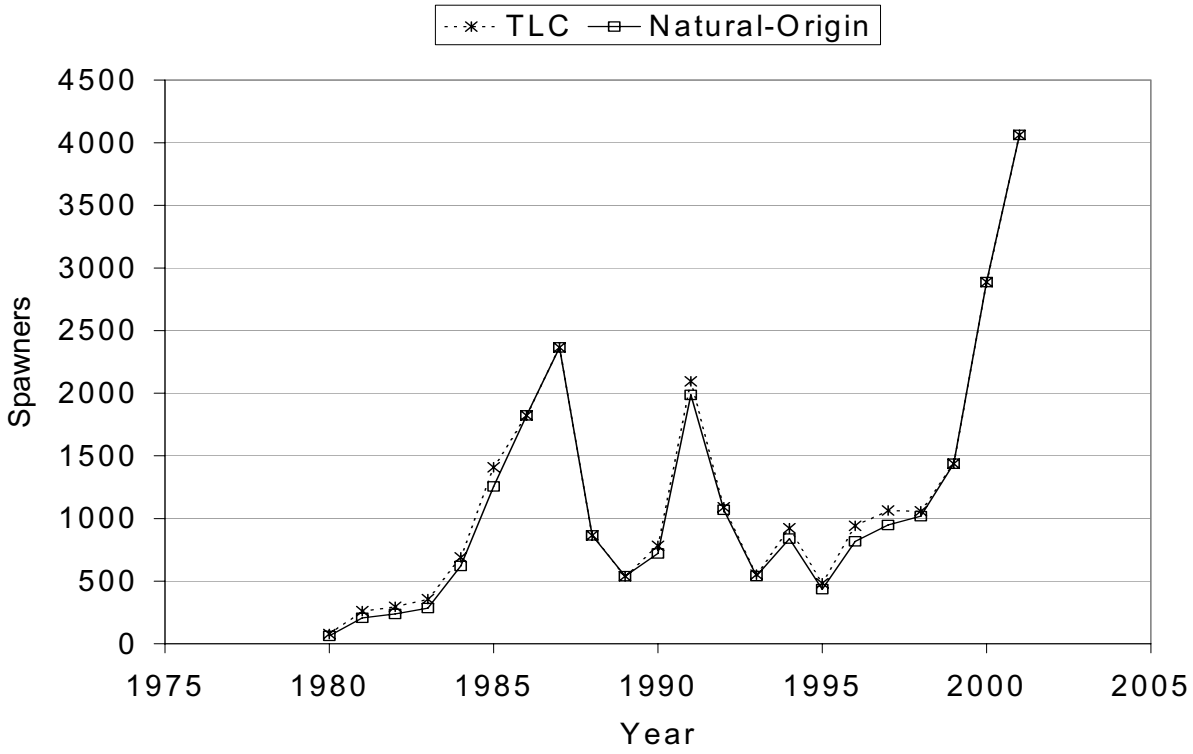


Figure B.2.3.1. Yakima River steelhead spawning escapement estimates. From WDFW database. Based on Prosser Dam count.

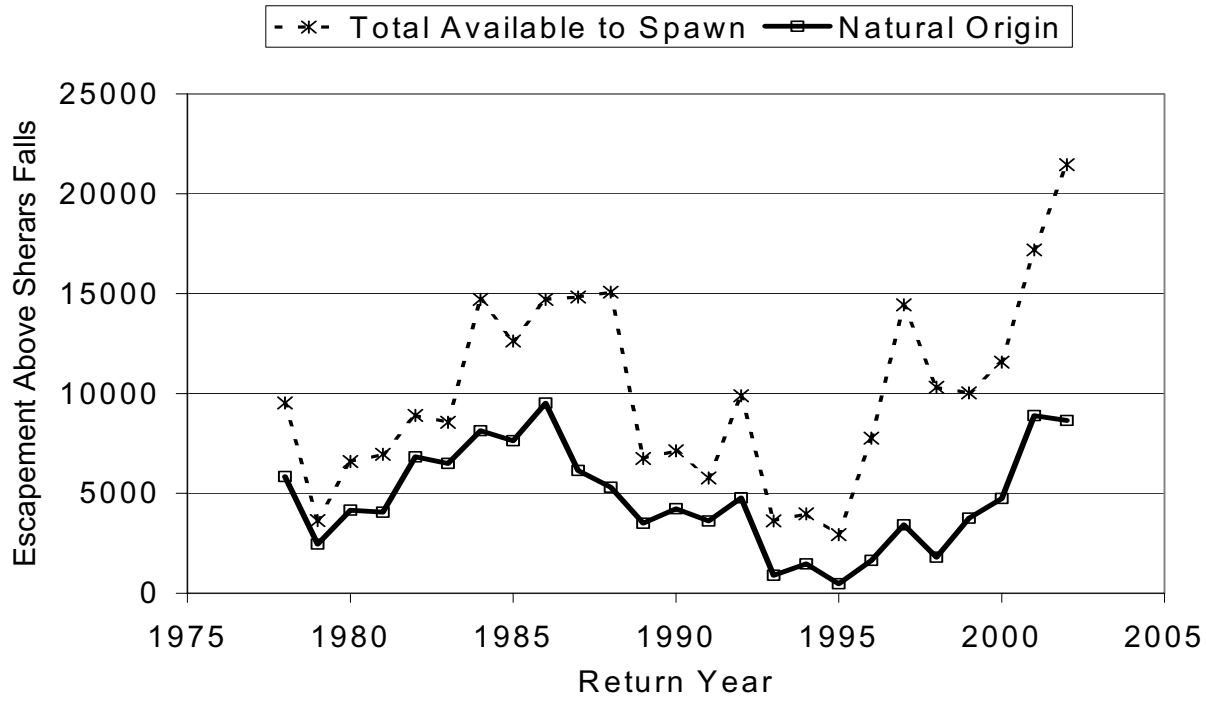


Figure B.2.3.2. Deschutes River steelhead escapement estimates over Sherars Falls. Run size estimates based on ODFW mark/recapture analysis. Hatchery/Wild ratios based on returns to Pelton Ladder and Warm Springs NFH (see Chilcote 2001, 2002).

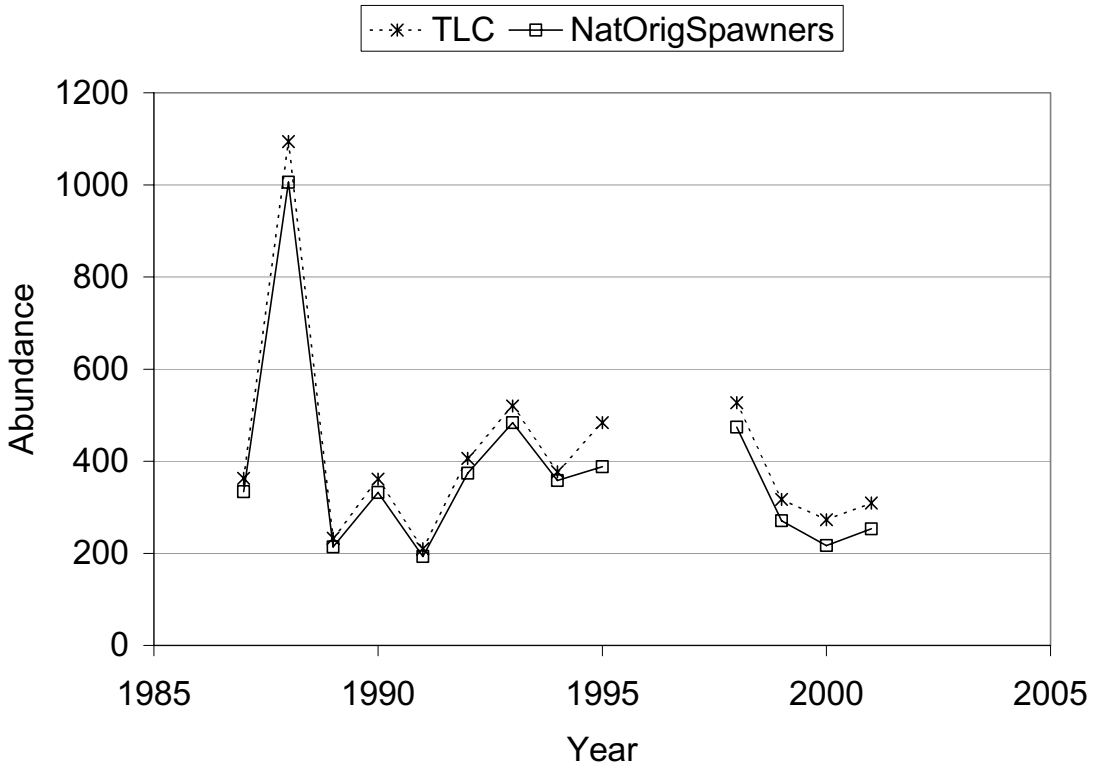


Figure B.2.3.3. Touchet River steelhead escapement estimates. Estimates based on spawning ground surveys upstream of Dayton, WA (James & Scheeler 2001).

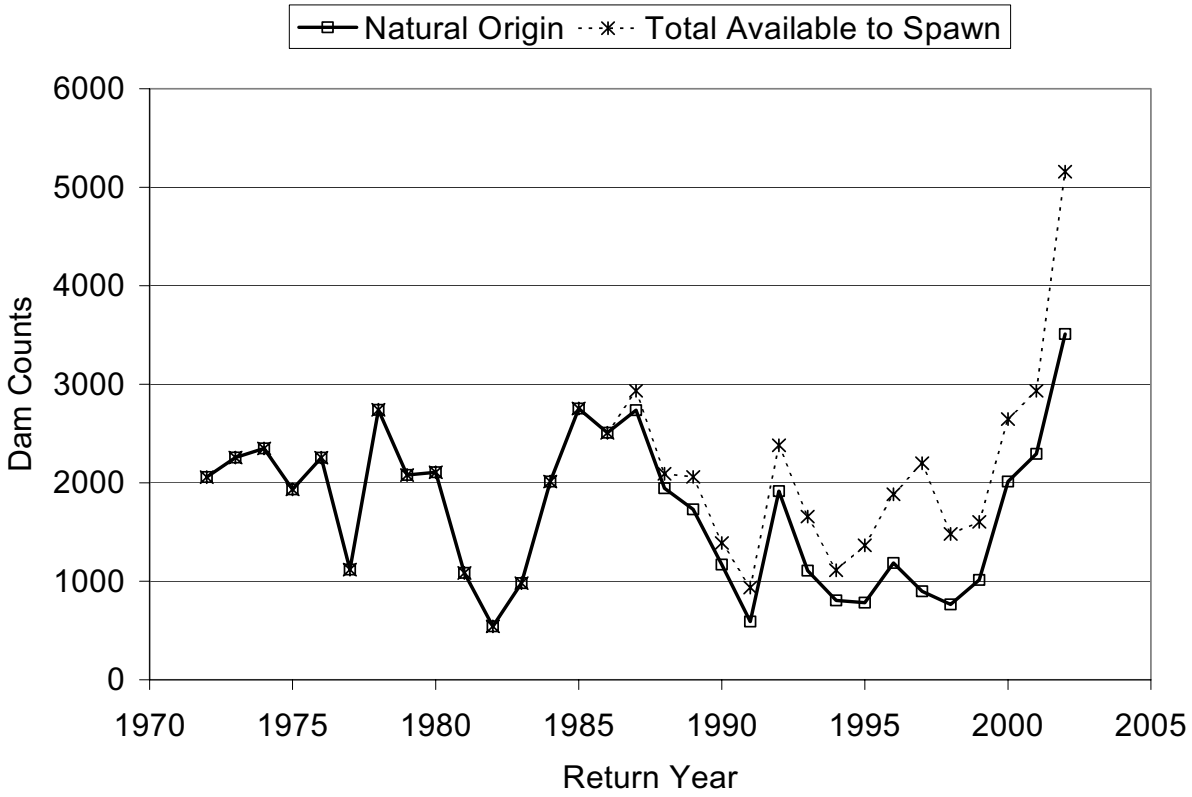


Figure B.2.3.4. Umatilla River steelhead counts at Three Mile Dam (Chilcote 2001).

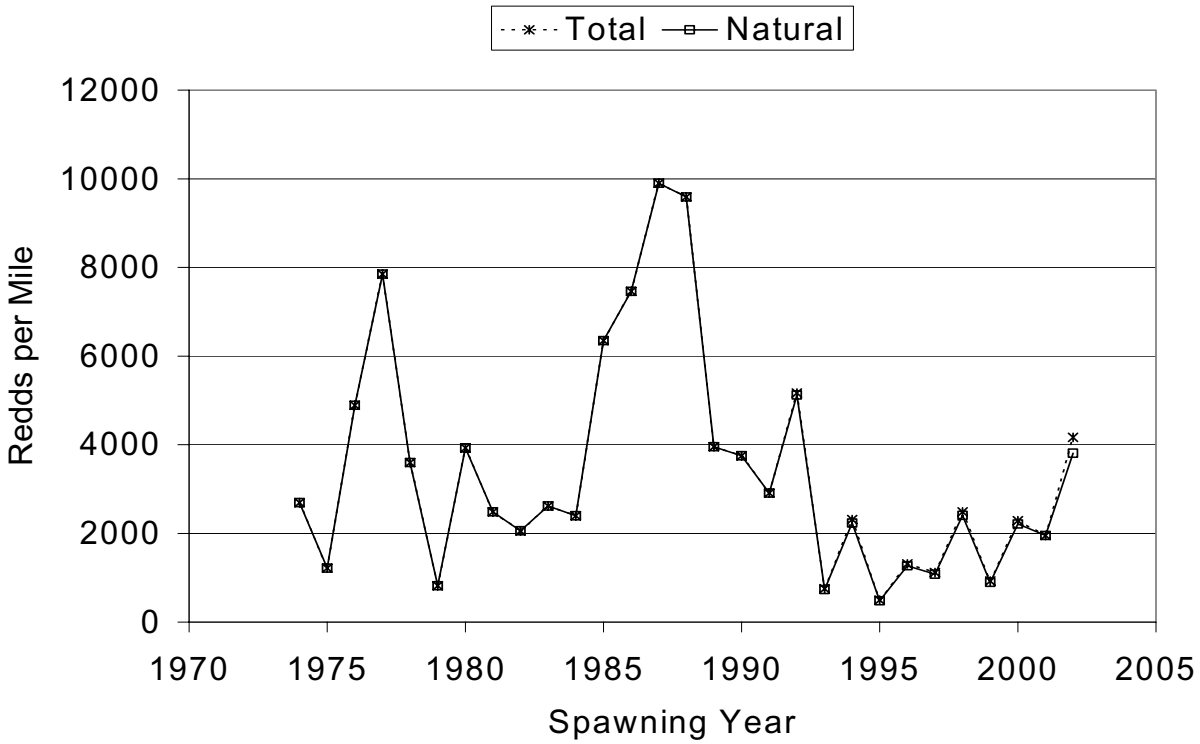


Figure B.2.3.5. Upper John Day steelhead estimates expanded from annual redd counts (Chilcote 2002).

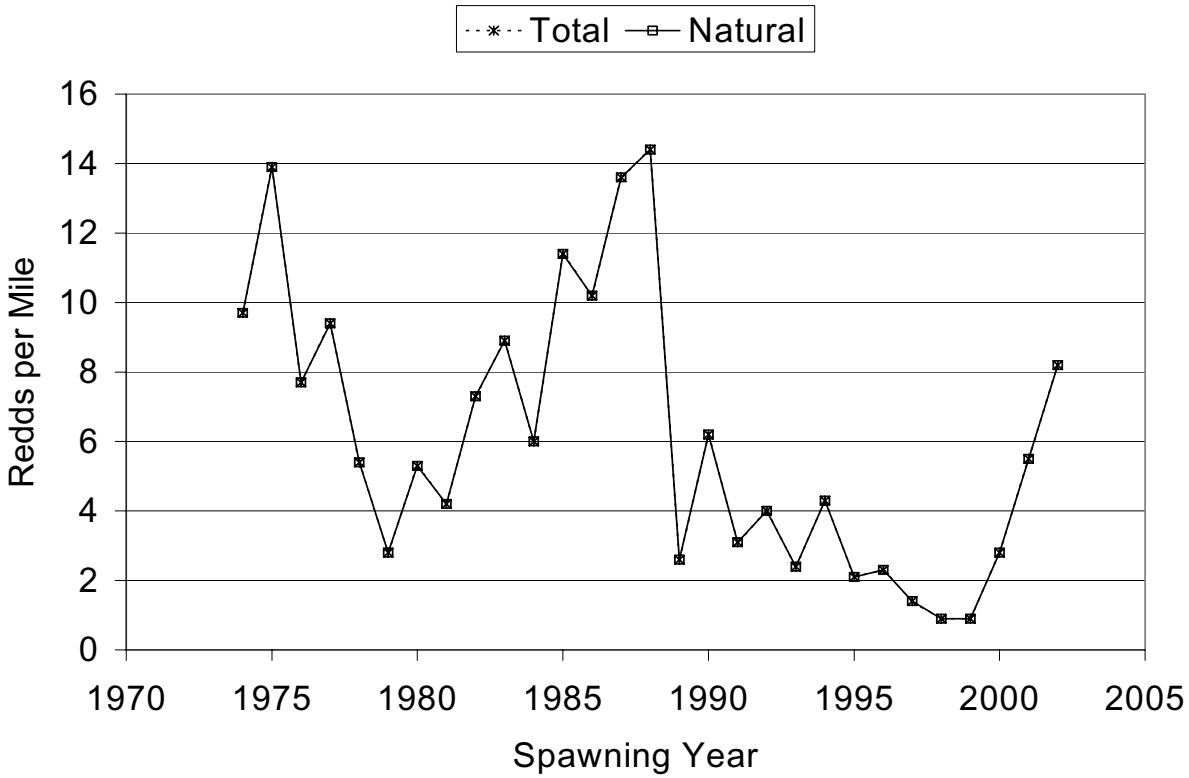


Figure B.2.3.6. South Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

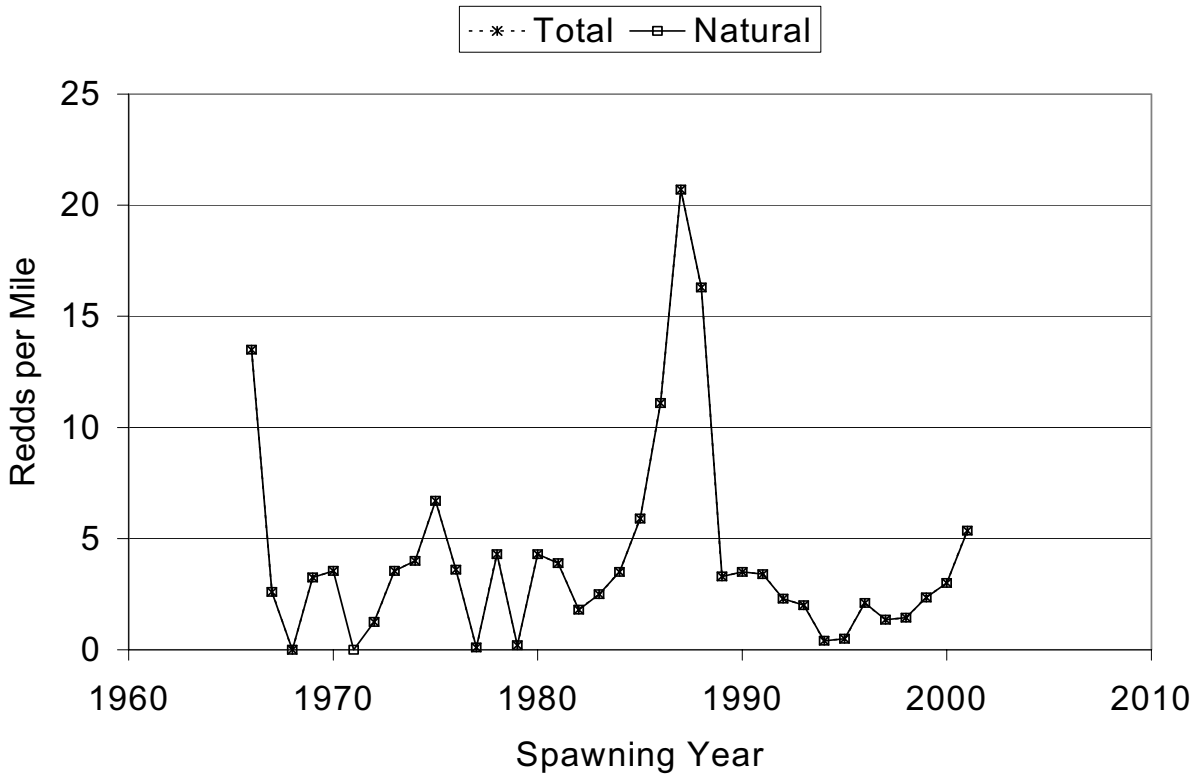


Figure B.2.3.7. Lower Mainstem John Day steelhead redds per mile from index areas (Chilcote 2001).

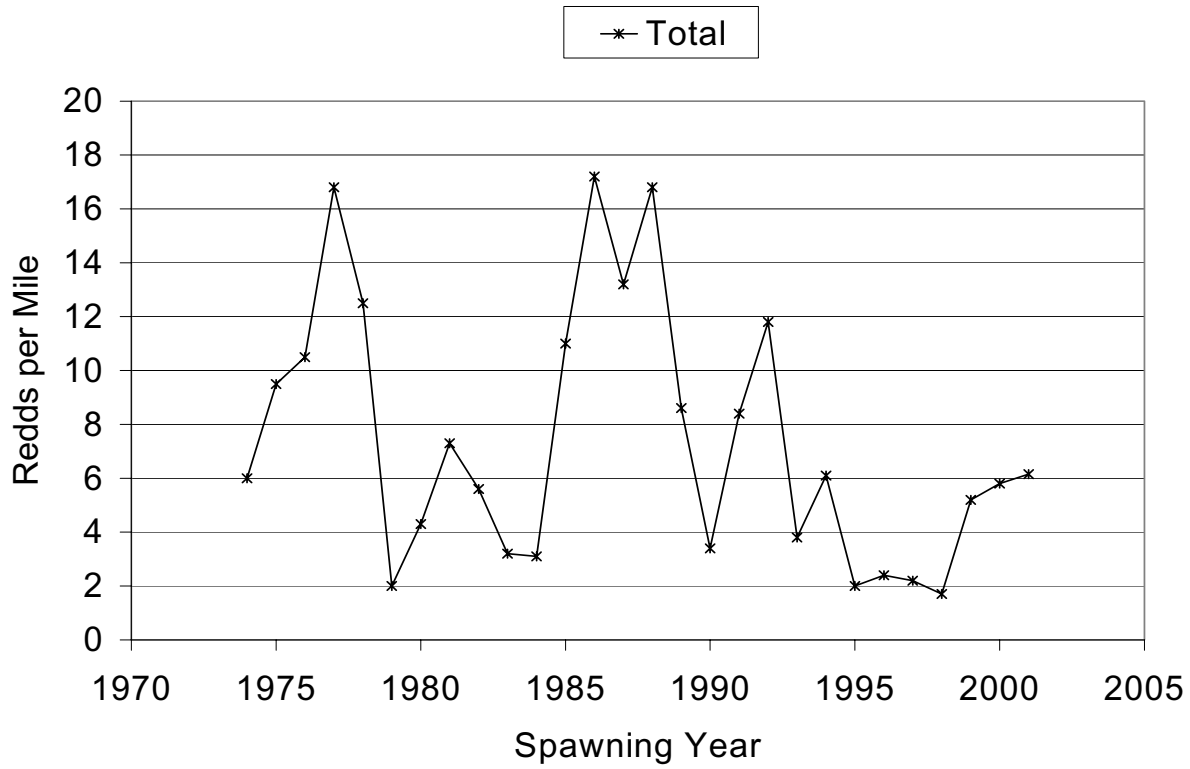


Figure B.2.3.8. Middle Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

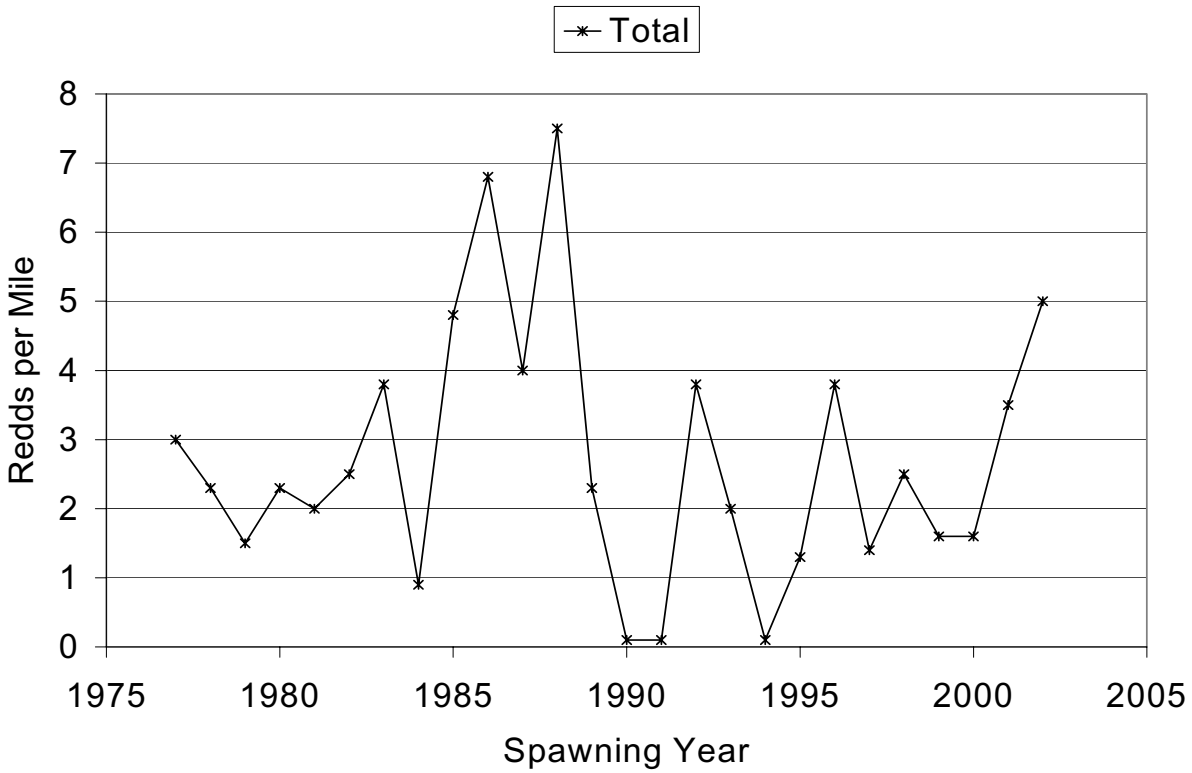


Figure B.2.3.9. Upper North Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

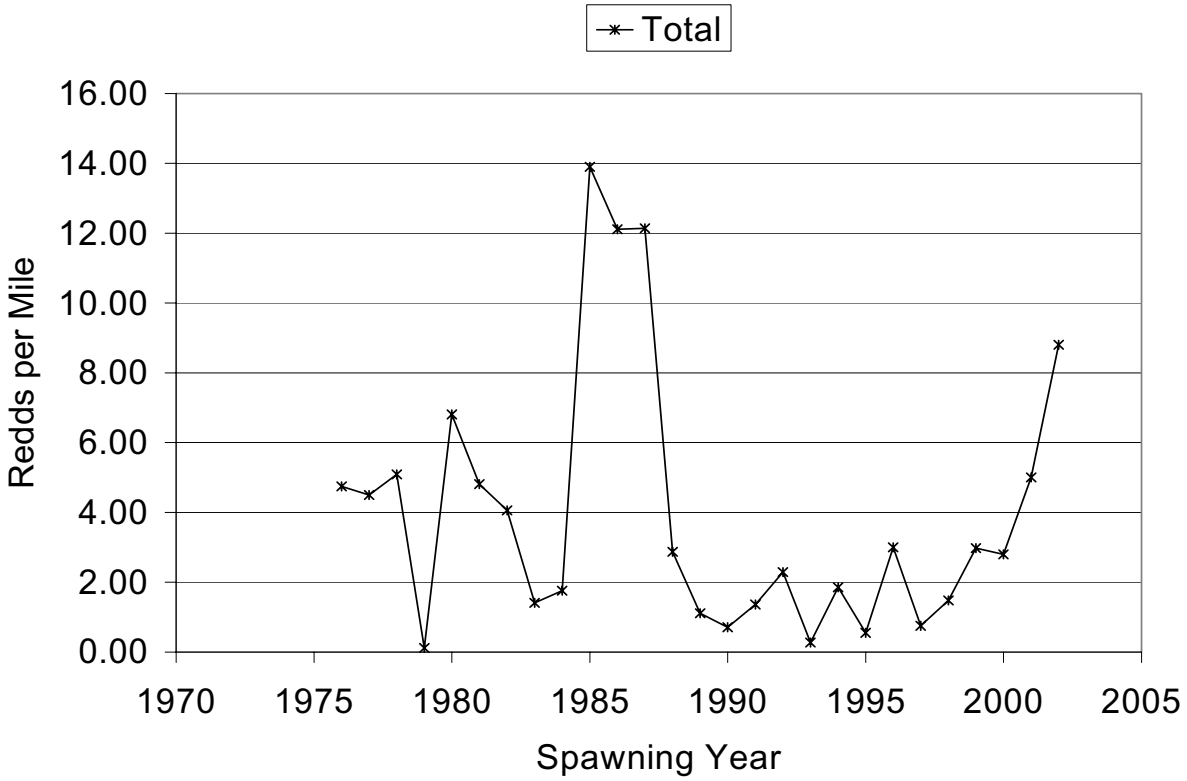


Figure B.2.3.10. Lower North Fork John Day steelhead redds per mile from index areas (Chilcote 2001).

B.2.4 LOWER COLUMBIA RIVER STEELHEAD

B.2.4.1 Summary of Previous BRT Conclusions

The status of Lower Columbia River steelhead was initially reviewed by NMFS in 1996 (Busby et al. 1996), and the most recent review occurred in 1998 (NMFS 1998a). In the 1998 review, the BRT noted several concerns for this ESU, including the low abundance relative to historical levels, the universal and often drastic declines observed since the mid-1980s, and the widespread occurrence of hatchery fish in naturally spawning steelhead populations. Analysis also suggested that introduced summer steelhead may negatively affect winter native winter steelhead in some populations. A majority of the 1998 BRT concluded that steelhead in the lower Columbia ESU were at risk of becoming endangered in the foreseeable future.

Current Listing Status: threatened

B.2.4.2 New Data and Update Analyses

New data available for this update included: recent spawner data, additional data on the fraction of hatchery-origin spawners, recent harvest rates, updated hatchery release information, and a compilation of data on resident *O. mykiss*. For many of the Washington chinook salmon populations, the Washington Department of Fish and Wildlife (WDFW) has conducted analyses using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). The EDT model attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/dungenesswc/EDT-primer.pdf). New analyses for this update include the designation of demographically independent populations, recalculation of previous BRT metrics with additional years' data, estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish, and estimates of current and historically available kilometers of stream.

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for Lower Columbia River steelhead, The Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of 17 winter-run populations and six summer-run populations for a total of 23 populations (Figures B.2.4.1 and B.2.4.2). The populations identified in Myers et al. are used as the units for the new analyses in this report.

The WLC-TRT partitioned Lower Columbia River steelhead populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2003). Analysis by the WLC-TRT suggests that a viable ESU would need multiple viable populations in each of these strata. The strata and associated populations are identified in Table B.2.4.1.

Table B.2.4.1. Historical population structure and abundance statistics for Lower Columbia River steelhead populations. The populations are partitioned into ecological zones and major life-history types. The ecological zones are based on ecological community and hydro dynamic patterns and life-history types are based on traits related to run timing. Time series used for the summary statistics are referenced in Appendix B.5.4.

Life History	Ecological Zone	Population	Years of Data for Recent Means	Recent Geometric Mean Total Spawners	Recent Arithmetic Mean Total Spawners	Recent Arithmetic Mean Percent Hatchery-origin Spawners
Winter Run	Cascade	Cispus River Winter Run	2002	2,787	2,787	73%
		Tilton River Winter Run				
		Upper Cowlitz River Winter Run				
		Lower Cowlitz River Winter Run	No Data			
		Coweeman River Winter Run	1998-2002	466	490	50%
		South Fork Toutle River Winter	1998-2002	504	5034	2%
		North Fork Toutle River Winter	1998-2002	196	207	0%
		Kalama River Winter Run	1998-2002	726	797	0%
		North Fork Lewis Winter Run	No Data			
		East Fork Lewis Winter Run	Index Data only; no abundance means available			
		Salmon Creek Winter Run	No Data			
		Washougal River Winter Run	1998-2002	323	376	0%
		Clackamas River Winter Run	1997-2001	560	717	41%
		Sandy River Winter Run	1997-2001	977	997	42%
	Gorge	Lower Gorge Tributaries Winter	No Data			
		Upper Gorge Tributaries Winter	No Data			
		Hood River Winter Run	1996-2000	756	792	52%
Summer Run	Cascade	Kalama River Summer Run	1999-2003	474	633	32%

		North Fork Lewis Summer Run	No Data			
		East Fork Lewis Summer Run	1999-2003	434	514	25%
		Washougal River Summer Run	1999-2003	264	313	8%
	Gorge	Wind River Summer Run	1999-2003	472	535	5%
		Hood River Summer Run	1996-2000	931	1,003	83%

Abundance and trends

References for abundance time series and related data are in Appendix B.5.4. Recent abundance of total spawners, and recent fraction of hatchery-origin spawners for Lower Columbia River steelhead populations are summarized in Table B.2.4.1. The abundance means in Table B.2.4.1 are for total spawners and include both natural and hatchery-origin fish. Natural-origin fish had parents that spawned in the wild as opposed to hatchery-origin fish whose parents were spawned in a hatchery. A number of the populations have a substantial fraction of hatchery-origin spawners in the spawning areas and are hypothesized to be sustained largely by hatchery production. Exceptions are the Kalama, the North Fork Toutle, the South Fork Toutle, and East Fork Lewis winter-run populations, which have few hatchery fish spawning on the natural spawning areas. These populations have relatively low recent mean abundance estimates, with the largest being the Kalama (geometric mean of 726 spawners).

The pooled estimate of abundance for the historical Cispus, Tilton and Upper Cowlitz populations has the highest recent total spawner abundance in the ESU, but also the largest fraction of hatchery-origin spawners. The hatchery-origin spawners are part of a reintroduction program to establish steelhead above Cowlitz Falls dam, the upper most of impassable three dams on the mainstem Cowlitz (Serl and Morrill 2002). Adults are collected below the most downstream dam (Mayfield) and trucked above Cowlitz Falls. Downstream survival of juvenile steelhead though the dams and reservoirs is considered negligible, so juveniles are collected at Cowlitz Falls and trucked downstream. The current collection efficiency of juveniles at Cowlitz Falls is considered too low for the reintroduction to be self-sustaining (Rawding 2003 pers. com.).

Where data are available, the abundance time series information for each of the populations is presented in Figures B.2.4.3.-B.2.4.23. Two types of time series figures are presented. The first type of figure plots abundance over time (Figures B.2.4.3, B.2.4.5, B.2.4.7, B.2.4.9, B.2.4.11, B.2.4.13, B.2.4.15-B.2.4.19, B.2.4.21, and B.2.4.23). Where possible, two lines are presented on the abundance figure, where one line is the total number of spawners (or total count at a dam) and the other line is the number of fish of natural origin. In some cases, data were not available to distinguish between natural and hatchery-origin spawners, so only total spawner (or dam count) information is presented. This type of figure can give a sense of the levels of abundance, overall trend, patterns of variability, and the fraction of hatchery-origin spawners.

The second type of time-series figure presents the total number of spawners (natural and hatchery origin) and the number of preharvest recruits produced by those spawners over broodyear (Figures B.2.4.4, B.2.4. 6, B.2.4.8, B.2.4.10, B.2.4.12, B.2.4.14, B.2.4.20, B.2.4.22, B.2.4.24). Dividing the number of preharvest recruits by the number of spawners for the same time period would yield an estimate of the preharvest recruits per spawner. This type of figure requires harvest and age structure information, and therefore, could be produced for only a limited number of populations. This type of figure can indicate if there have been changes in preharvest recruitment and the degree to which harvest management has the potential to recover populations. If the preharvest recruitment line is consistently below the spawner line, it indicates that the population would not be replacing itself, even in the absence of all harvest.

Summary statistics on population trends and growth rate are presented in Tables B.2.4.2-B.2.4.5 and in Figures B.2.4.25- B.2.4.27. The methods for estimating trends and growth rate (λ) are described in the general methods section. The majority of populations have a long-term trend less than one, indicating the population is in decline. In addition, there is a high probability for most populations that the true trend/growth rate is less than one (Table B.2.4.3). When growth rate is estimated, assuming that hatchery-origin spawners have a reproductive success equal to that of natural-origin spawners, all of the populations have a negative growth rate except the North Fork Toutle winter run, which had very few hatchery-origin spawners (Figure B.2.4.23). The North Fork Toutle population is recovering from the eruption of Mt. St. Helens in 1980 and is still at low abundance (recent mean of 196 spawners). The potential reasons for these declines have been cataloged in previous status reviews and include habitat degradation, deleterious hatchery practices, and climate-driven changes in marine survival.

Rawding (2003) suggests that marine conditions have been a major factor driving the decline observed in the available time series and that marine survival is largely responsible for the increases observed in the last few years. He poses as an important question: What will happen to Lower Columbia River steelhead when the ocean cycles to less productive regimes again? This general issue is discussed in the introduction to the update reports, as it applies to many ESUs.

Table B.2.4.2. Long-term trend and growth rate for a subset of Lower Columbia steelhead populations for which adequate data are available (95% C.I. are in parentheses). The long-term analysis used the entire data set. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	Population	Years for Trend and λ	Trend of Total Spawners	Median Growth Rate (λ)	
				Hatchery = 0	Hatchery = Wild

Winter	Coweeman	1987-2002	0.916 (0.847-0.990)	0.908 (0.792-1.041)	0.782 (0.678-0.903)
	South Fork Toutle	1984-2002	0.917 (0.876-0.961)	0.938 (0.830-1.059)	0.933 (0.821-1.061)
	North Fork Toutle	1989-2002	1.135 (1.038-1.242)	1.062 (0.915-1.233)	1.062 (0.915-1.233)
	Kalama	1977-2002	0.998 (0.973-1.023)	1.010 (0.913-1.117)	0.916 (0.824-1.019)
	Clackamas	1958-2001	0.979 (0.966-0.993)	0.971 (0.901-1.047)	0.949 (0.877-1.027)
	Sandy	1978-2001	0.940 (0.919-0.960)	0.945 (0.850-1.051)	0.828 (0.741-0.925)
Summer	Kalama	1977-2003	0.928 (0.889-0.969)	0.981 (0.889-1.083)	0.712 (0.642-0.790)
	Washougal	1986-2003	0.991 (0.942-1.043)	1.003 (0.884-1.138)	0.996 (0.872-1.138)
	Wind	1989-2003	0.973 (0.921-1.028)	0.983 (0.853-1.134)	0.937 (0.807-1.089)

Table B.2.4.3. Short-term trend and growth rate for a subset of Lower Columbia steelhead populations for which adequate data are available (95% C.I. are in parentheses). Short-term data sets include data from 1990 to the most recent available year. The trend estimate is for total spawners and includes both natural-origin and hatchery-origin fish. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural-origin fish.

Run	**Population**	**Years for Trend**	**Trend of Total Spawners**	**Median Growth Rate (λ)**	
				Hatchery = 0	**Hatchery = Wild**
Winter	Coweeman	1990-2002	0.941 (0.818-1.083)	0.920 (0.803-1.055)	0.787 (0.682-0.909)
	South Fork Toutle	1990-2002	0.939 (0.856-1.130)	0.933 (0.826-1.054)	0.929 (0.817-1.056)
	North Fork Toutle	1990-2002	1.086 (0.999-1.018)	1.038 (0.894-1.206)	1.038 (0.894-1.206)
	Kalama	1990-2002	1.004 (0.923-1.091)	0.984 (0.890-1.088)	0.922 (0.829-1.025)
	Clackamas	1990-2001	0.914 (0.806-1.036)	0.875 (0.812-0.943)	0.830 (0.767-0.898)
	Sandy	1990-2001	0.889 (0.835-0.946)	0.866 (0.797-0.985)	0.782 (0.700-0.874)
Summer	Kalama	1990-2003	0.855 (0.756-0.968)	0.900 (0.816-0.994)	0.664 (0.598-0.737)
	Washougal	1990-2003	1.024 (0.951-1.104)	1.029 (0.907-1.168)	0.960 (0.841-1.097)

	Wind	1990-2003	0.989 (0.931-1.049)	0.995 (0.863-1.148)	0.903 (0.777-1.049)

Table B.2.4.4. Probability that the long-term abundance trend or growth rate of a subset of Lower Columbia River steelhead populations is less than one. In the "Hatchery = 0" columns, the hatchery-origin fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	Population	Years for Trend and λ	Prob. Trend <1	Prob. λ < 1	
				Hatchery = 0	Hatchery = Wild
Winter	Coweeman	1987-2002	0.985	0.936	1.000
	South Fork Toutle	1984-2002	0.999	0.884	0.899
	North Fork Toutle	1989-2002	0.005	0.063	0.063
	Kalama	1977-2002	0.574	0.405	0.971
	Clackamas	1958-2001	0.998	0.784	0.918
	Sandy	1978-2001	1.000	0.993	1.000
Summer	Kalama	1977-2003	0.999	0.613	1.000
	Washougal	1986-2003	0.644	0.476	0.526
	Wind	1989-2003	0.848	0.639	0.889

Table B.2.4.5. Probability that the long-term abundance trend or growth rate of a subset of Lower Columbia River steelhead populations is less than one. In the "Hatchery = 0" columns, the hatchery-origin fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery-origin fish are assumed to have reproductive success equivalent to that of natural-origin fish.

Run	Population	Years for Trend	Prob. Trend <1	Prob. λ < 1	
				Hatchery = 0	Hatchery = Wild
Winter	Coweeman	1990-2002	0.822	0.851	0.995
	South Fork Toutle	1990-2002	0.919	0.797	0.812
	North Fork Toutle	1990-2002	0.026	0.135	0.135
	Kalama	1990-2002	0.463	0.593	0.846
	Clackamas	1990-2001	0.929	0.849	0.929
	Sandy	1990-2001	0.999	0.991	1.000
Summer	Kalama	1990-2003	0.991	0.849	1.000
	Washougal	1990-2003	0.249	0.349	0.757
	Wind	1990-2003	0.659	0.538	0.989

EDT-based estimates of historical abundance—The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of the Lower Columbia River chinook populations using the Ecosystem Diagnosis and Treatment (EDT) model (Busack and Rawding 2003). WDFW populated this model with estimates of historical habitat condition, which produced the estimates of average historical abundance shown in Table B.2.4.6. There is a great deal of

unquantified uncertainty in the EDT historical abundance estimates, which should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas that were historically accessible but currently blocked by large dams are omitted from the analyses and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Table B.2.4.6. EDT based estimates of historical abundance for a subset of Lower Columbia River steelhead populations.

Life History	Population	EDT Estimate of Historical Abundance
Winter Run	Coweeman River Winter Run	2,243
	Lower Cowlitz River Winter Run	1,672
	South Fork Toutle River Winter	2,627
	North Fork Toutle River Winter	3,770
	Kalama River Winter Run	554
	North Fork Lewis Winter Run	713
	East Fork Lewis Winter Run	3,131
	Salmon Creek Winter Run	
	Washougal River Winter Run	2,497
	Lower Gorge Tributaries Winter	793
	Upper Gorge Tributaries Winter	243
	Hood River Winter Run	
Summer Run	Kalama River Summer Run	3,165
	East Fork Lewis Summer Run	422
	Washougal River Summer Run	1,419
	Wind River Summer Run	2,288

Loss of habitat from barriers—An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the Lower Columbia River (Table B.2.4.7). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. Barriers with passage limited to trap-and-haul are considered impassible for this analysis. This approach will over estimate the number of usable stream km as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations, the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table B.2.4.7. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0.5% and 4% (summer) and 0.5% and 6% (winter). The current to historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat	Potential Historical Habitat (km)	Current to Historical Habitat Ratio
Cispus River Winter Run	0	87	0%
Coweeman River Winter Run	85	102	84%
Lower Cowlitz River Winter Run	542	674	80%
Upper Cowlitz River Winter Run	6	358	2%
Tilton River Winter Run	0	120	0%
South Fork Toutle River Winter	82	92	8%
North Fork Toutle River Winter	209	330	63%
Kalama River Winter Run	112	122	92%
North Fork Lewis Winter Run	115	525	22%
East Fork Lewis Winter Run	239	315	76%
Salmon Creek Winter Run	222	252	88%
Washougal River Winter Run	122	232	53%
Clackamas River Winter Run	919	1,127	82%
Sandy River Winter Run	295	386	76%
Lower Gorge Tributaries Winter	46	46	99%
Upper Gorge Tributaries Winter	31	31	100%
Hood River Winter Run	138	138	99%
Kalama River Summer Run	49	54	90%
North Fork Lewis Summer Run	78	83	94%
East Fork Lewis Summer Run	87	364	24%
Washougal River Summer Run	181	236	77%
Wind River Summer Run	84	164	51%
Hood River Summer Run	36	41	90%
Total	3,678	5,879	63%

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident *O. mykiss* for this ESU and found no quantitative estimates of abundance for resident *O. mykiss* in any LCR population. However, expert opinion on the distribution and relative abundance of resident *O. mykiss* is available. Expert opinion suggests that resident *O. mykiss* numerically dominate the Wind River Basin, and the West Fork of the Hood basin. However they are considered less common in other portions of the Hood basin. Residents are considered common in the Collowash subbasin of the Clackamas, though rare or possibly absent in other parts of the basin below natural barriers. Resident *O. mykiss* are considered abundant above the Bull Run dams (1929) in the Sandy basin, Merwin Dam (1931) in the Lewis basin and Mayfield Dam (1963) in the Cowlitz basin, but are rare or absent elsewhere in these basins. We are not aware of specific information relevant to the ESU status of Case 3 resident populations above the dams in the Cowlitz, Lewis, or Sandy Rivers. Resident *O. mykiss* are probably common in the upper portions of the Kalama and Washougal basins, but rare in the lower portions. Resident *O. mykiss* are considered absent from all the smaller lower Columbia tributaries that have small patches of spawning anadromous *O. mykiss*. Cutthroat trout, *Oncorhynchus clarki,* tend not to co-occur with resident *O. mykiss* and appear to have historically been the predominant resident trout species in many of the lower Columbia tributaries.

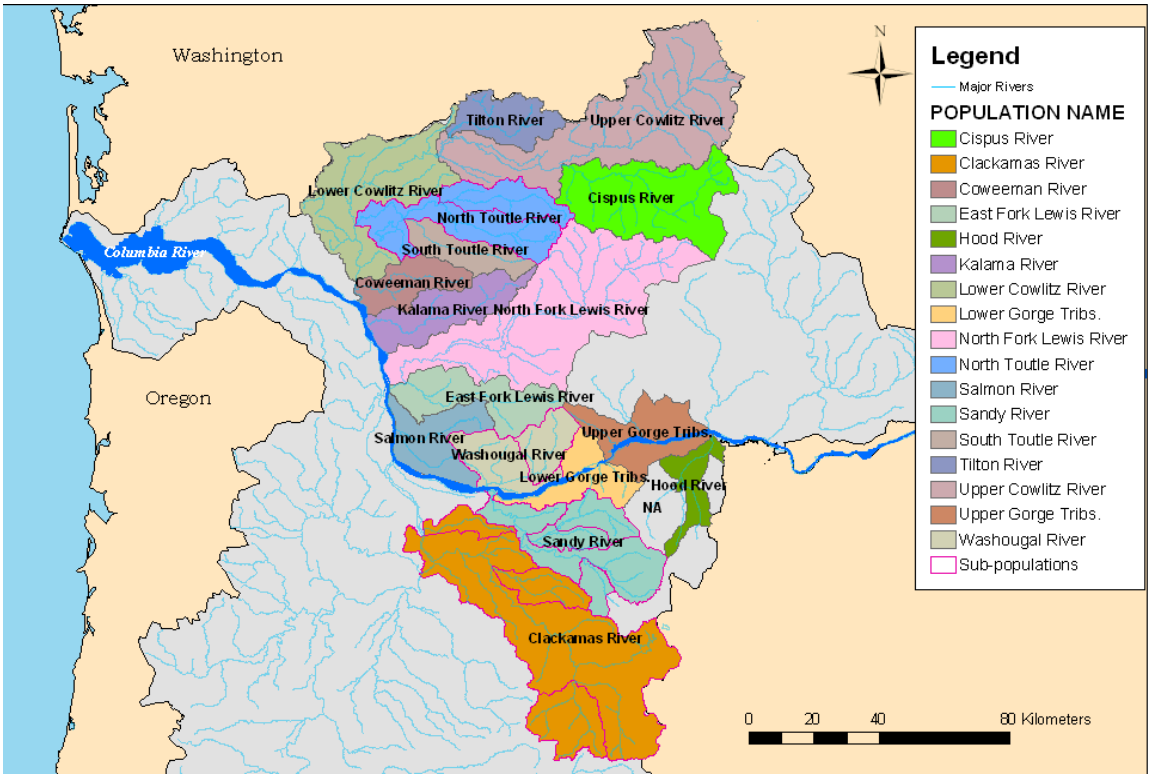


Figure B.2.4.1. Historical populations of winter steelhead in the Lower Columbia ESU (Myers et al. 2002).

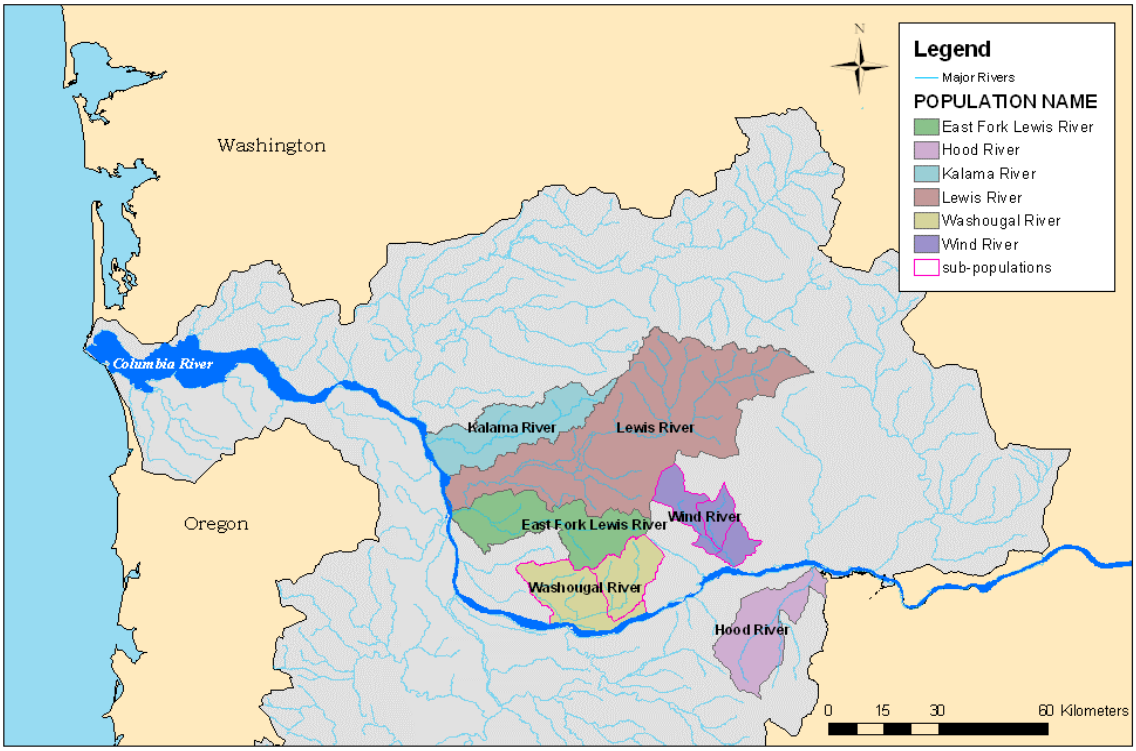


Figure B.2.4.2. Historical populations of summer steelhead in the Lower Columbia ESU (Myers et al. 2002).

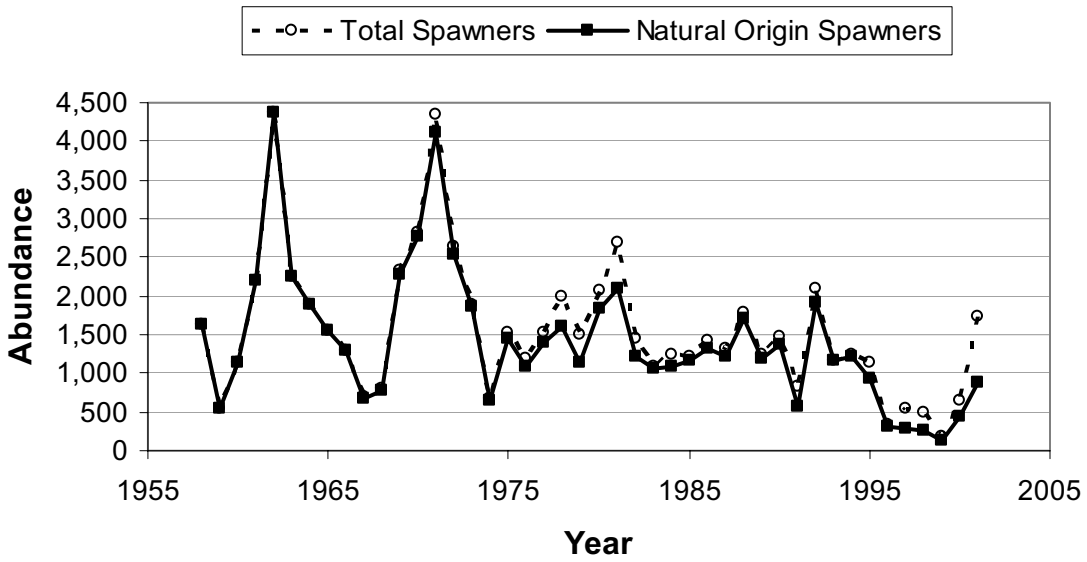


Figure B.2.4.3. Winter steelhead abundance at North Fork dam on Clackamas River (data from Cramer 2002).

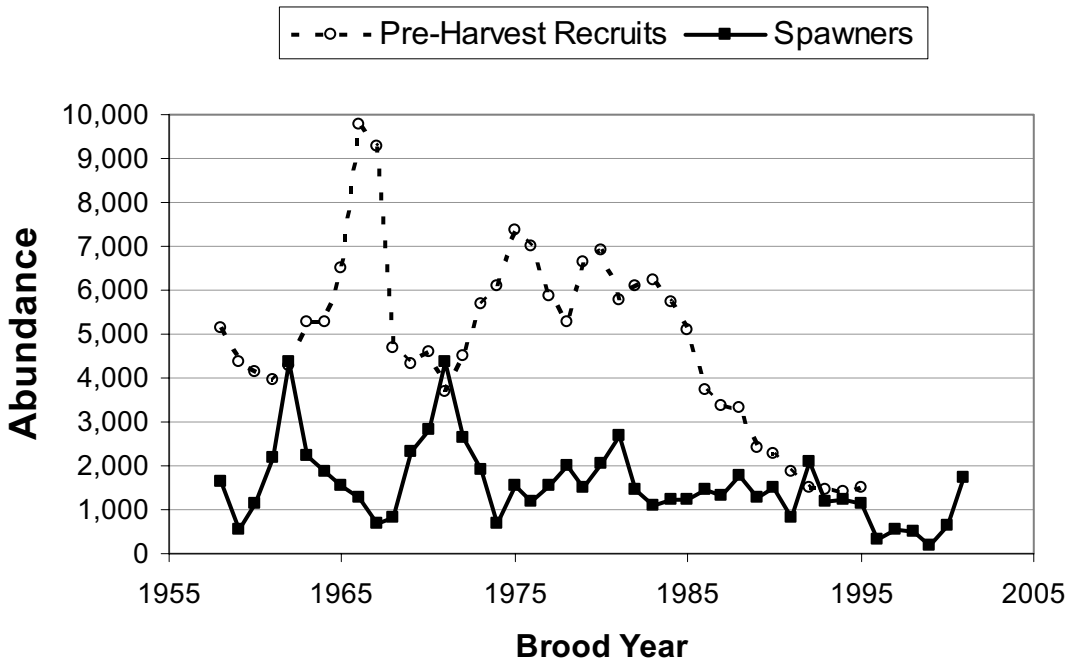
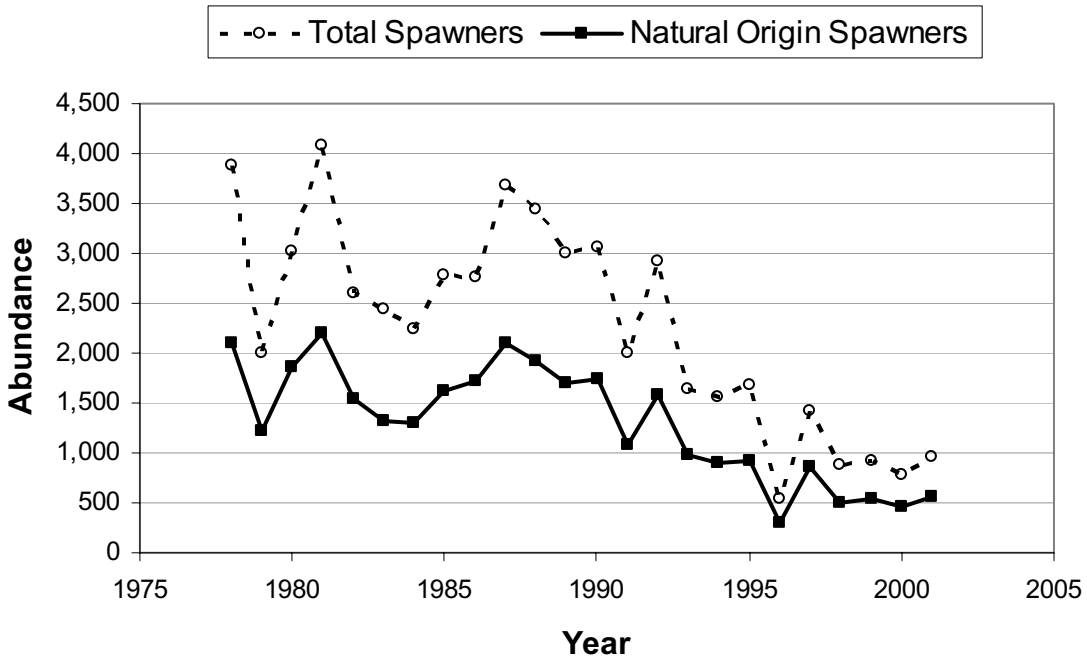
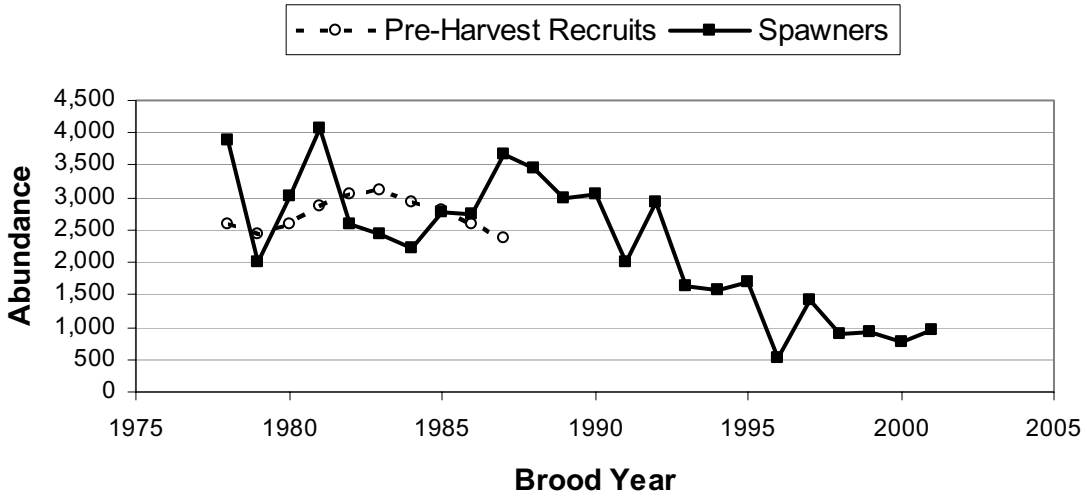


Figure B.2.4.4. Preharvest recruits and spawners for winter steelhead estimated from counts at North Fork Dam on the Clackamas River.



B.2.4.5. Winter steelhead abundance at Marmot dam on the Sandy River (data from Cramer 2002).



B.2.4.6. Preharvest recruits and spawners for winter steelhead estimated from counts at Marmot Dam on the Sandy River.

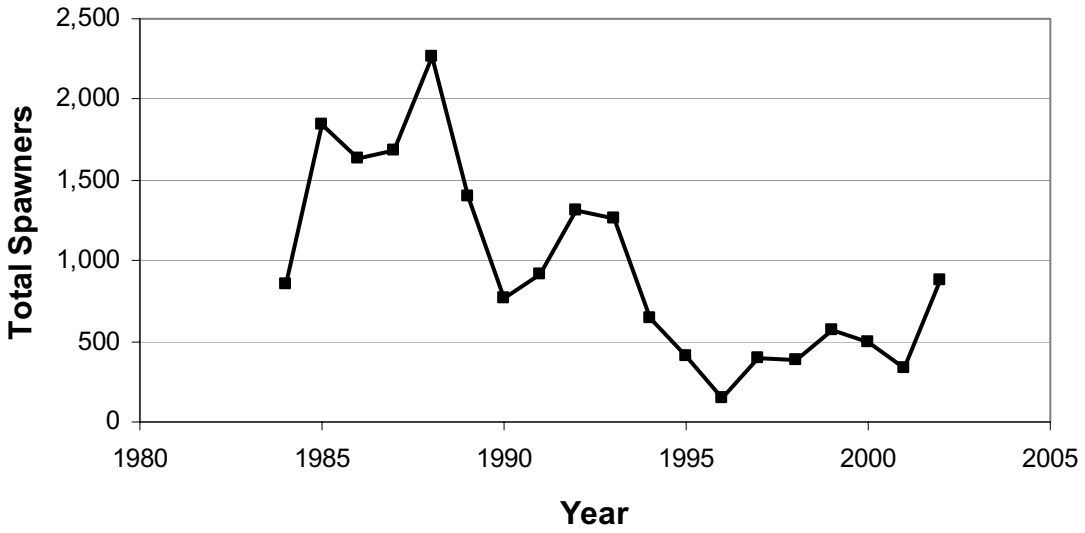


Figure B.2.4.7. Estimate of winter steelhead spawner abundance in the South Fork Toutle River. It is estimated that approximately 2% of the total spawners may be of natural origin.

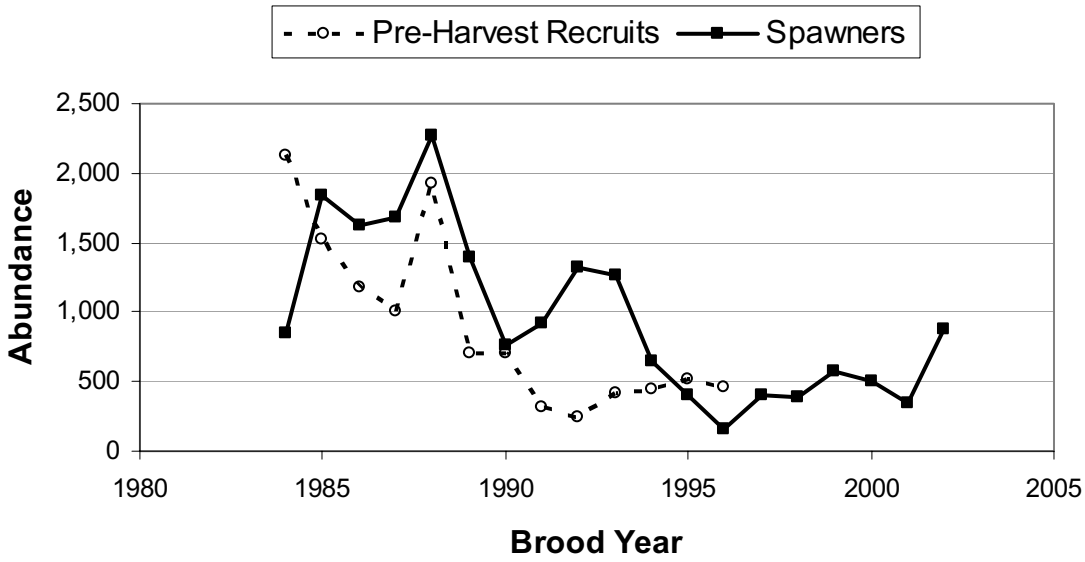


Figure B.2.4.8. Estimate of winter steelhead preharvest recruits and spawners in the South Fork Toutle River.

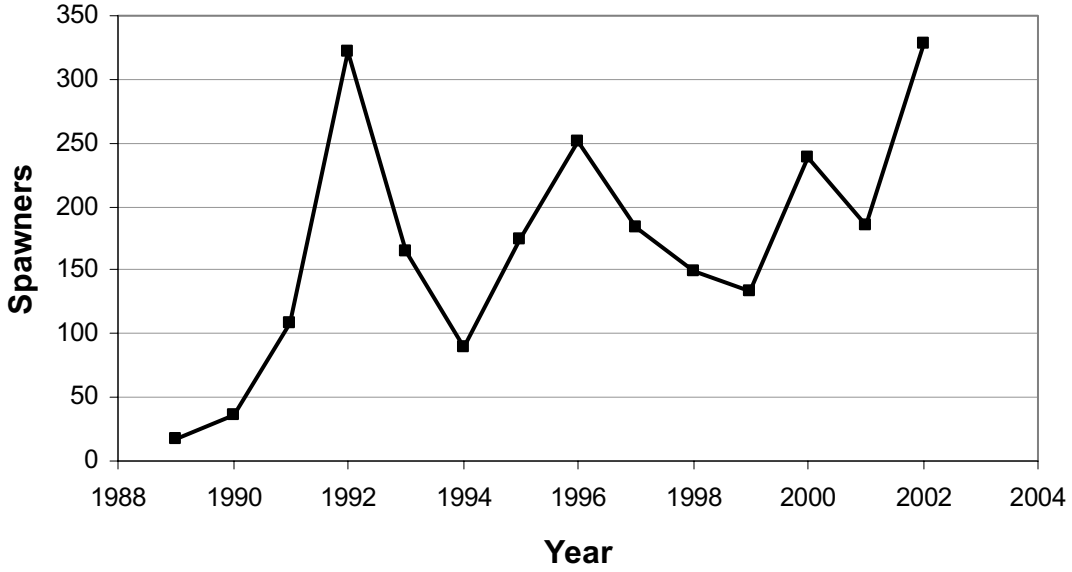


Figure B.2.4.9. Estimate of winter steelhead abundance in the North Fork Toutle. There are estimated to be no hatchery-origin spawners in the North Fork Toutle population.

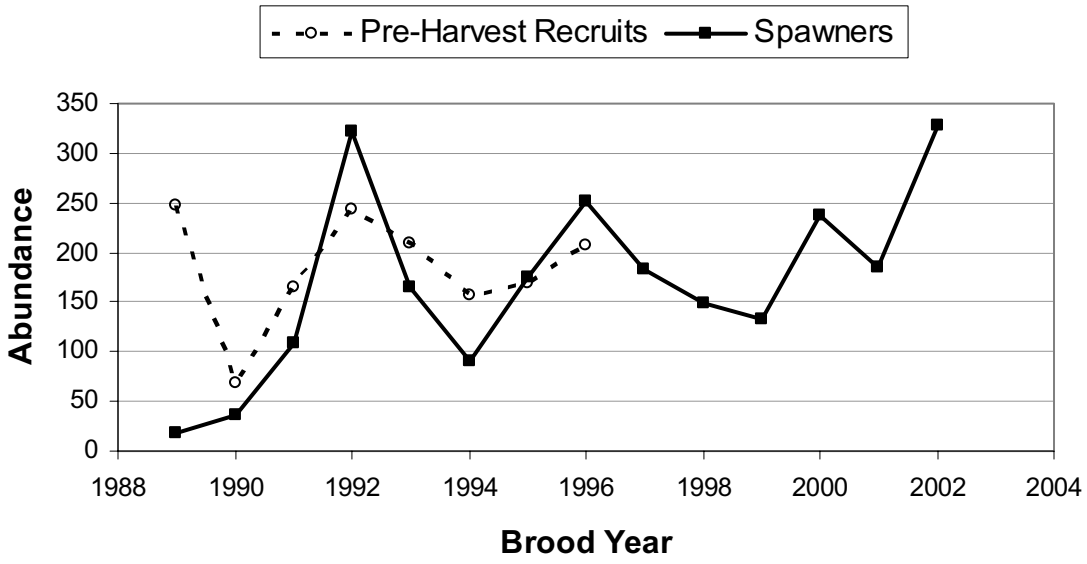
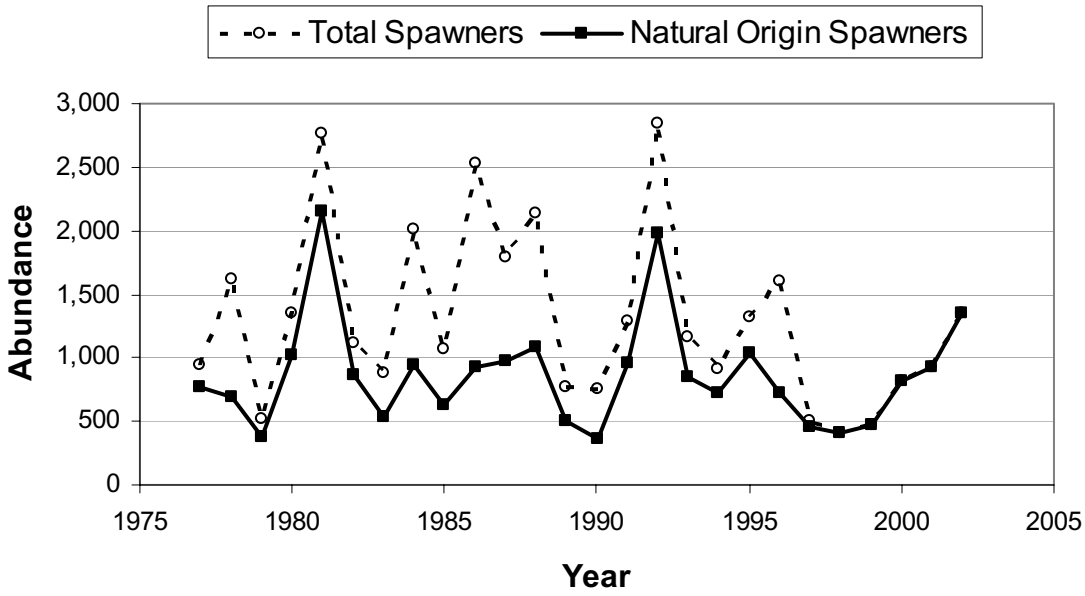


Figure B.2.4.10. Estimate of winter steelhead preharvest recruits and spawners in the North Fork Toutle River.



B.2.4.11. Estimate of winter steelhead abundance in the Kalama River.

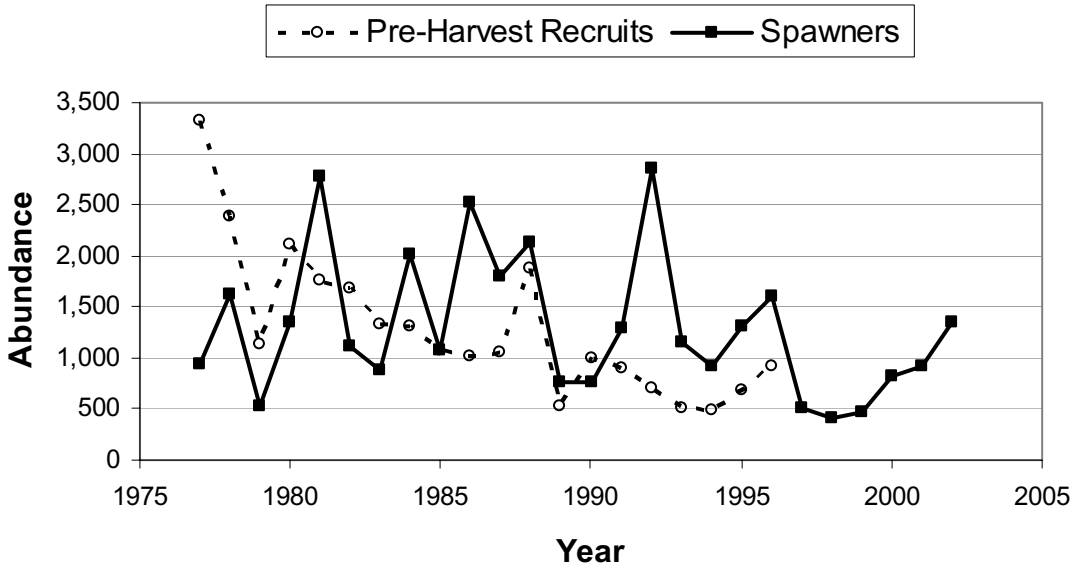
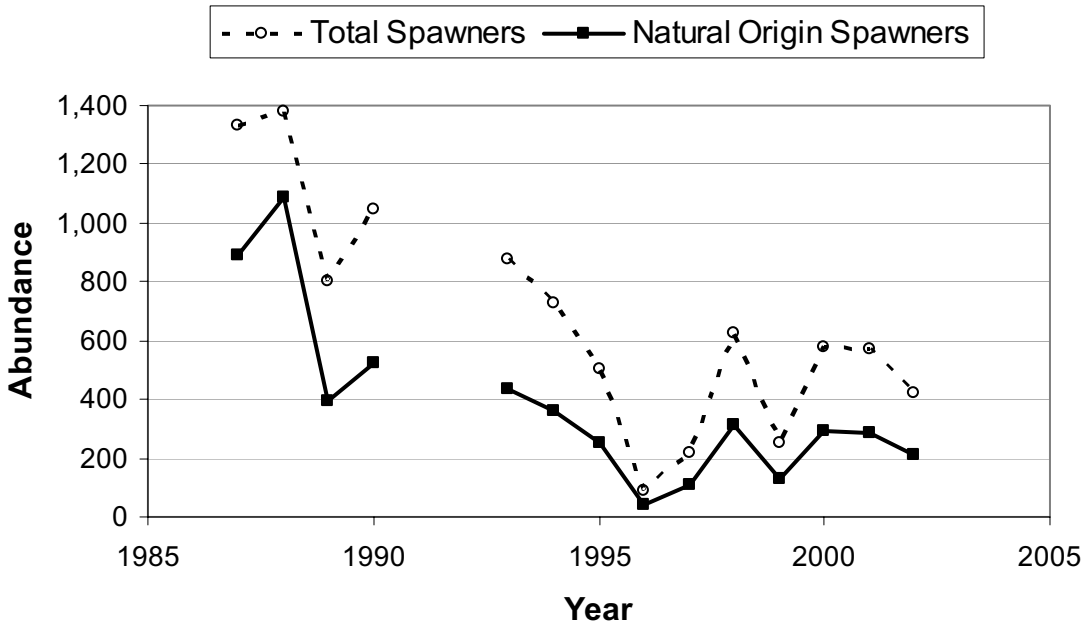


Figure B.2.4.12. Estimate of winter steelhead preharvest recruits and spawners in the Kalama River.



B.2.4.13. Estimate of winter steelhead abundance in the Coweeman River.

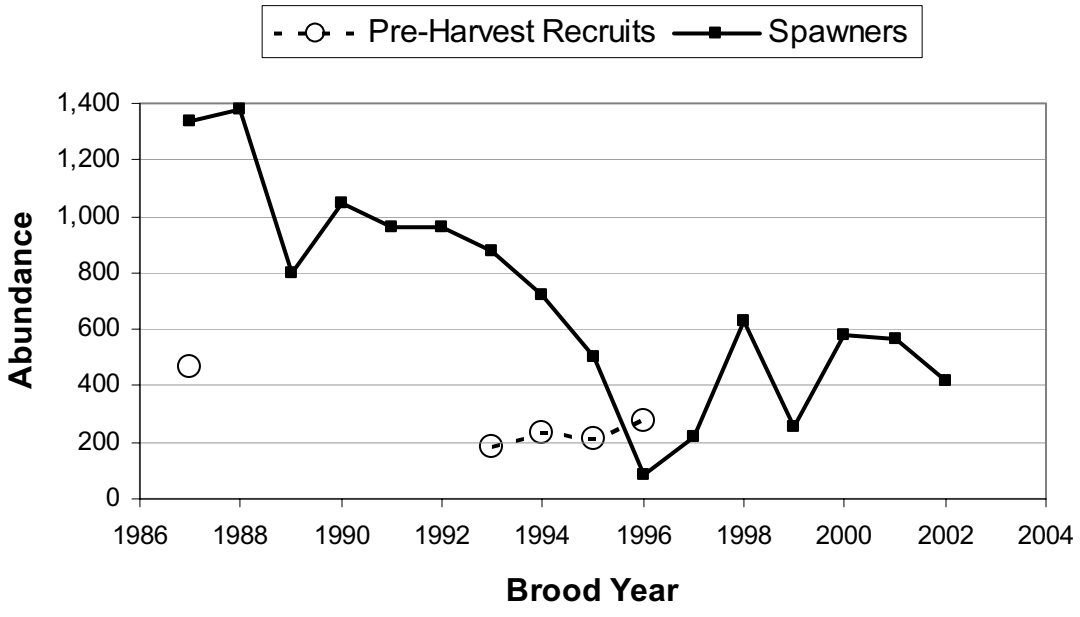


Figure B.2.4.14. Estimate of winter steelhead preharvest recruits and spawners in the Coweeman River.

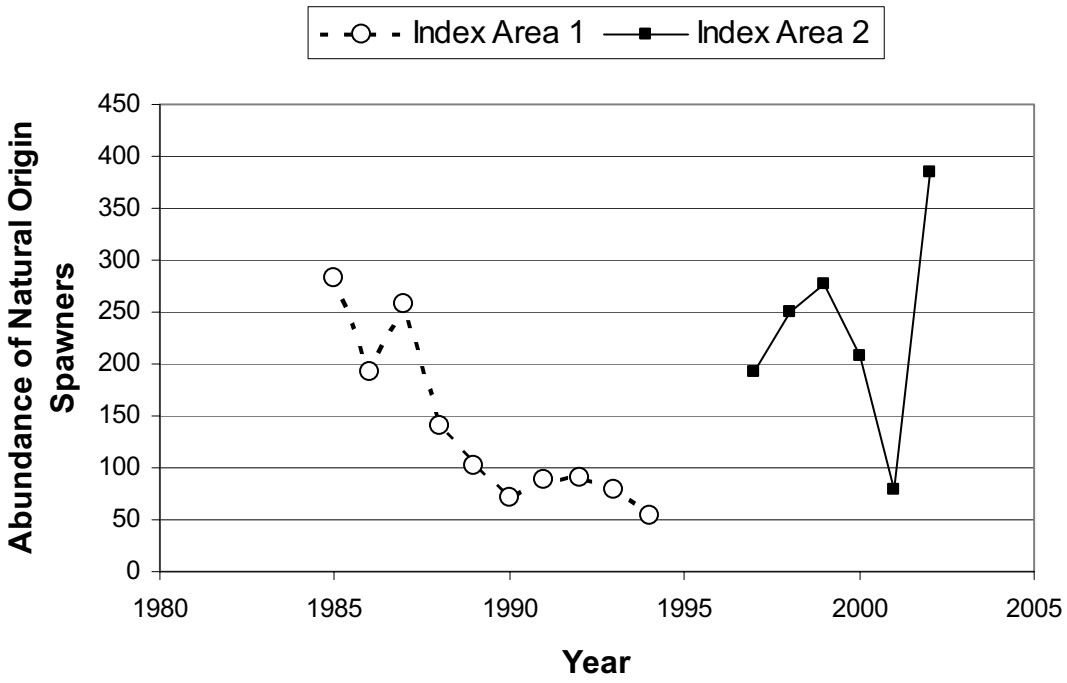


Figure B.2.4.15. Index counts of natural-origin winter steelhead in the East Fork of the Lewis River. The two indexes are for different areas and cannot be directly compared and cannot be used to create a more continuous time trend.

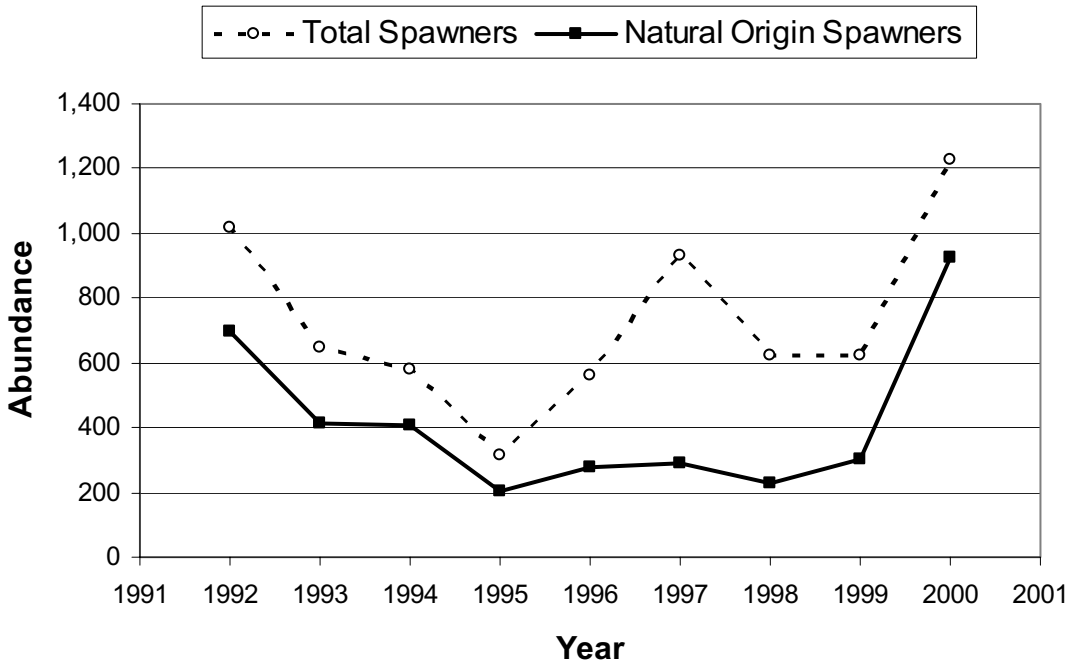


Figure B.2.4.16. Estimate of winter steelhead abundance in the Hood River.

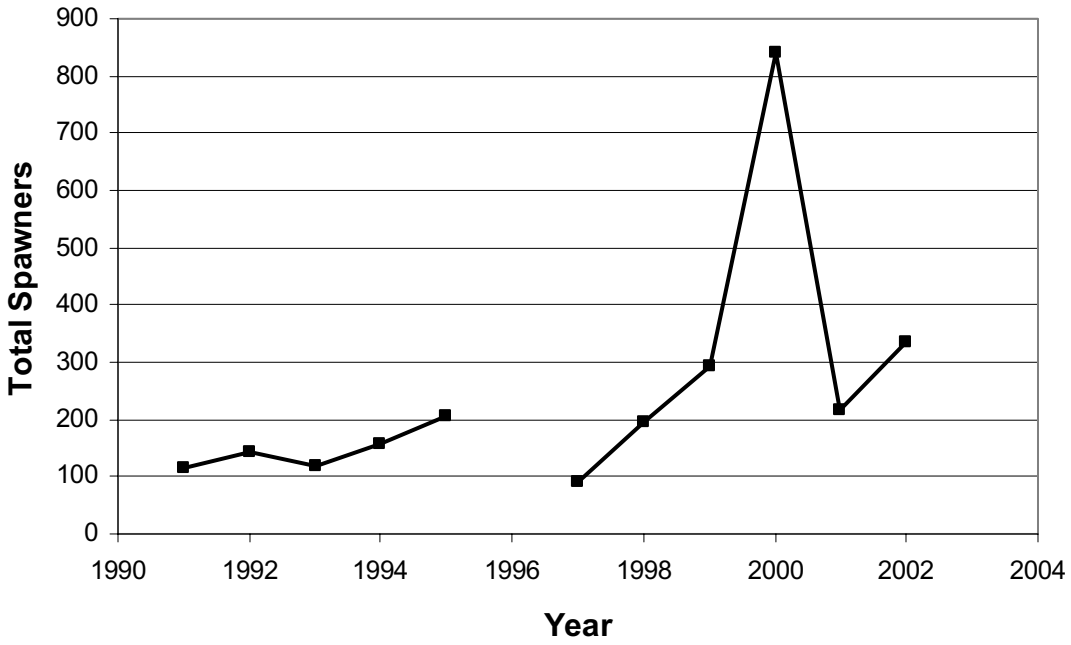
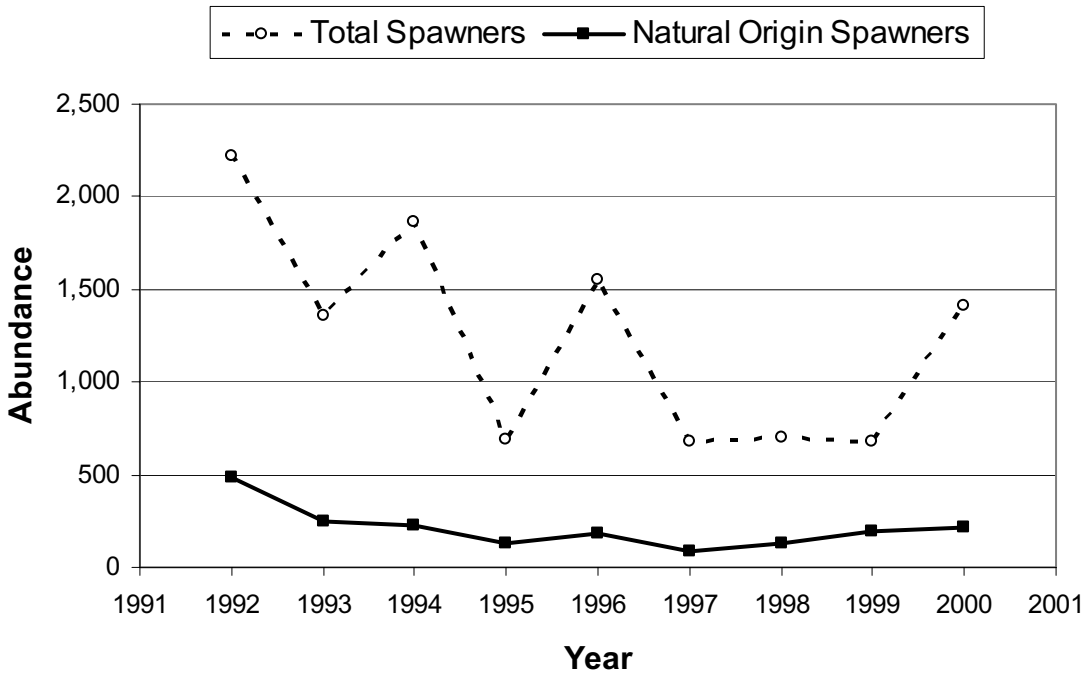
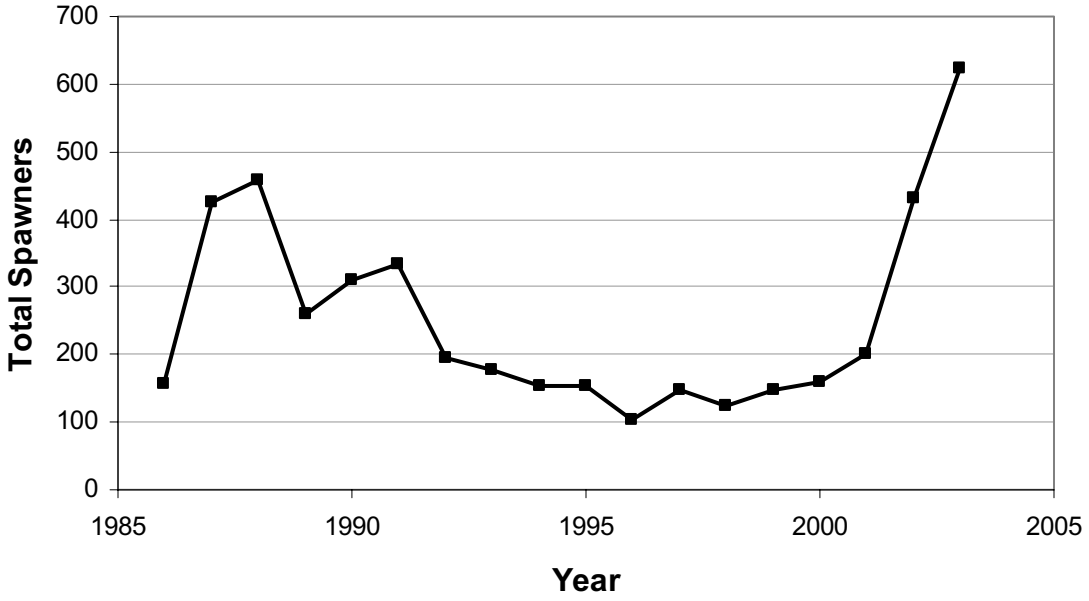


Figure B.2.4.17. Estimate of winter steelhead abundance in the Washougal River. The percent of hatchery-origin spawners is considered minimal.



B.2.4.18. Estimate of summer steelhead abundance in the Hood River.



B.2.4.19. Estimate of the total summer steelhead abundance in the Washougal River. The fraction of hatchery-origin fish is minimal (avg. approx. 3%)

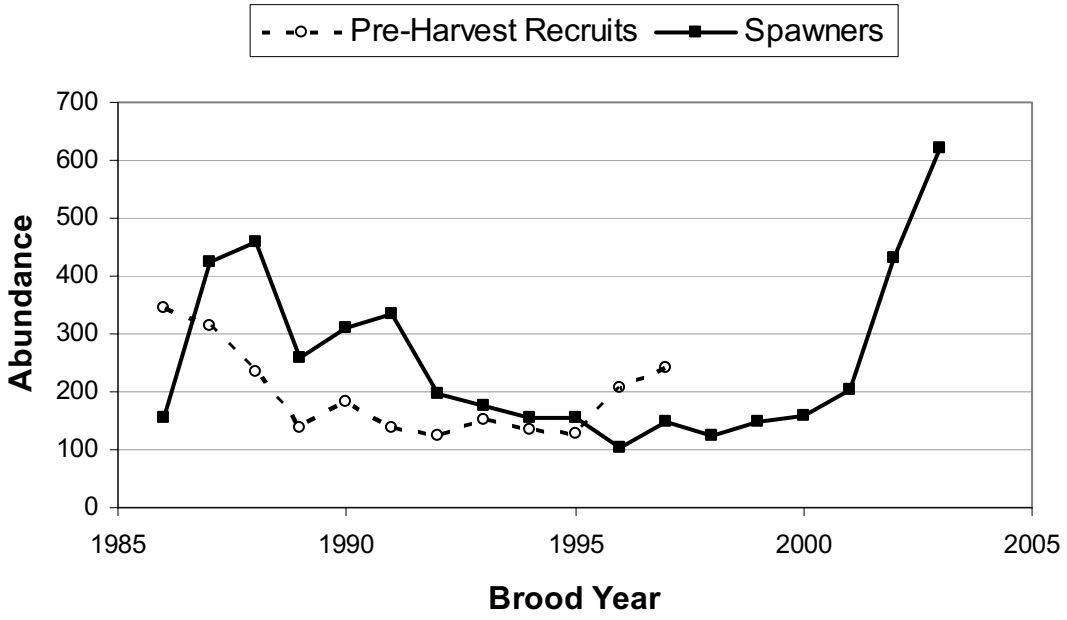
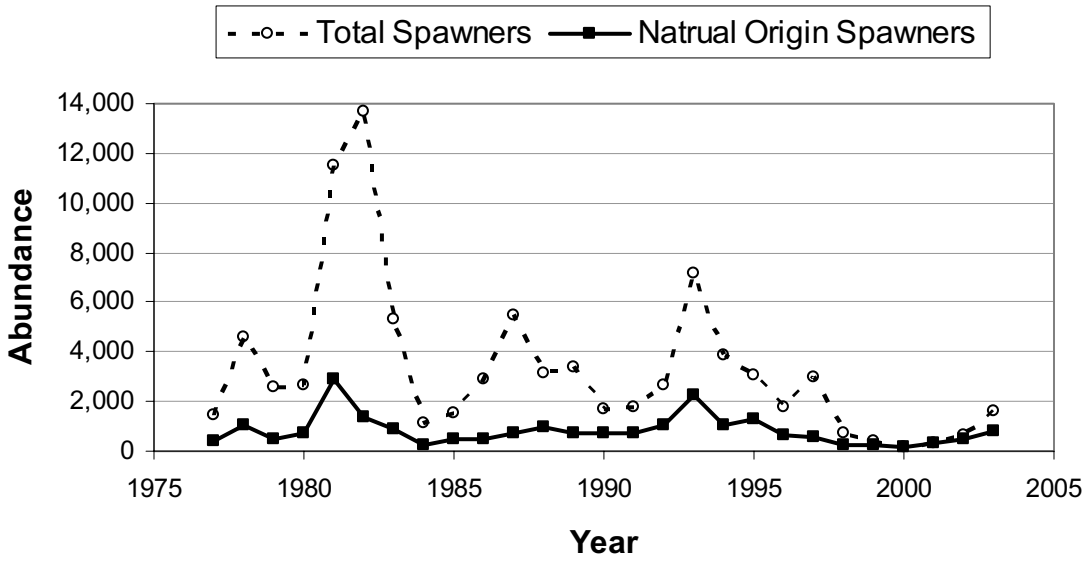


Figure B.2.4.20. Estimate of summer steelhead preharvest recruits and spawners in the Washougal River.



B.2.4.21. Estimate of summer steelhead abundance in the Kalama River.

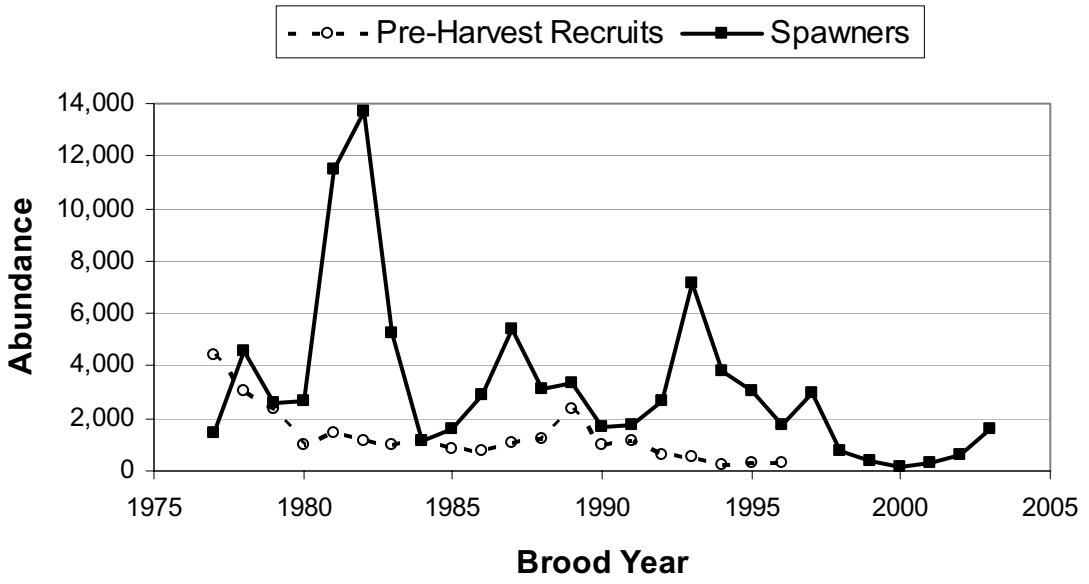


Figure B.2.4.22. Estimate of summer steelhead preharvest recruits and spawners in the Kalama River.

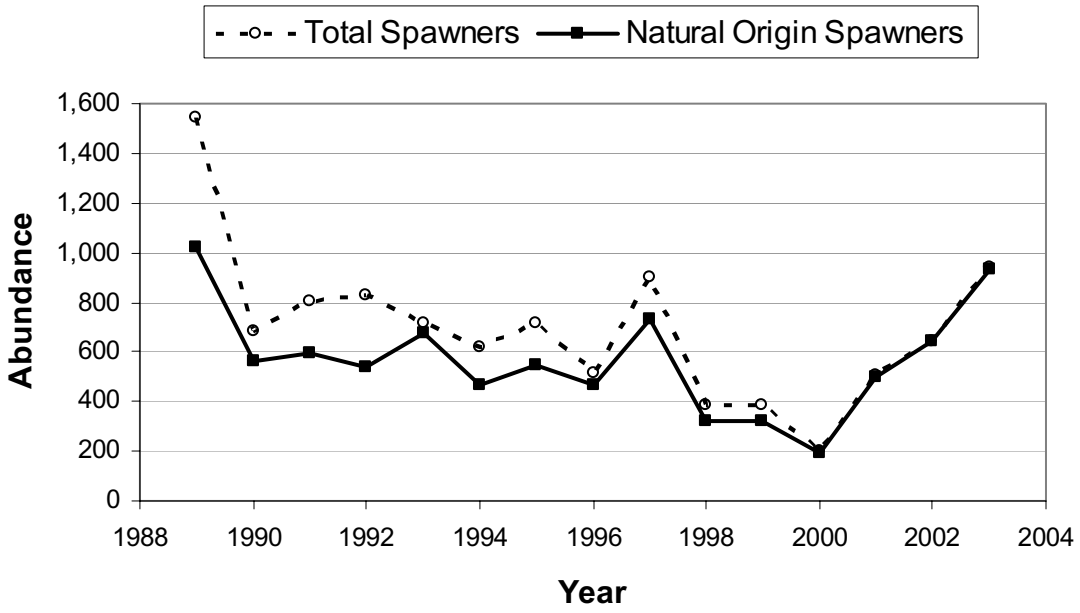


Figure B.2.4.23. Estimate of summer steelhead abundance in the Wind River.

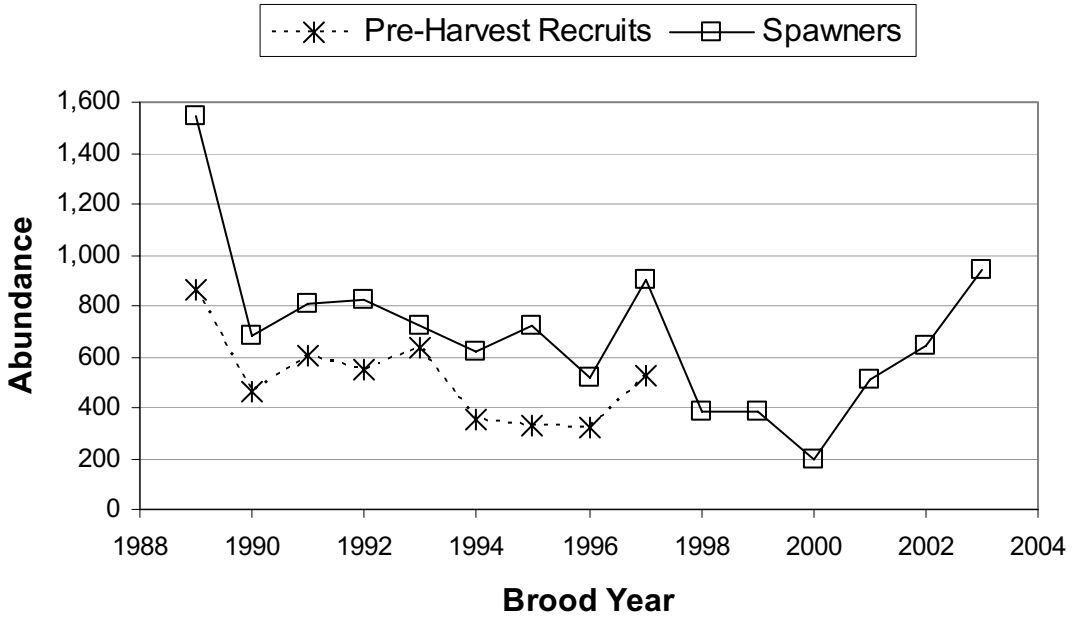


Figure B.2.4.24. Estimate of summer steelhead preharvest recruits and spawners in the Washougal River.

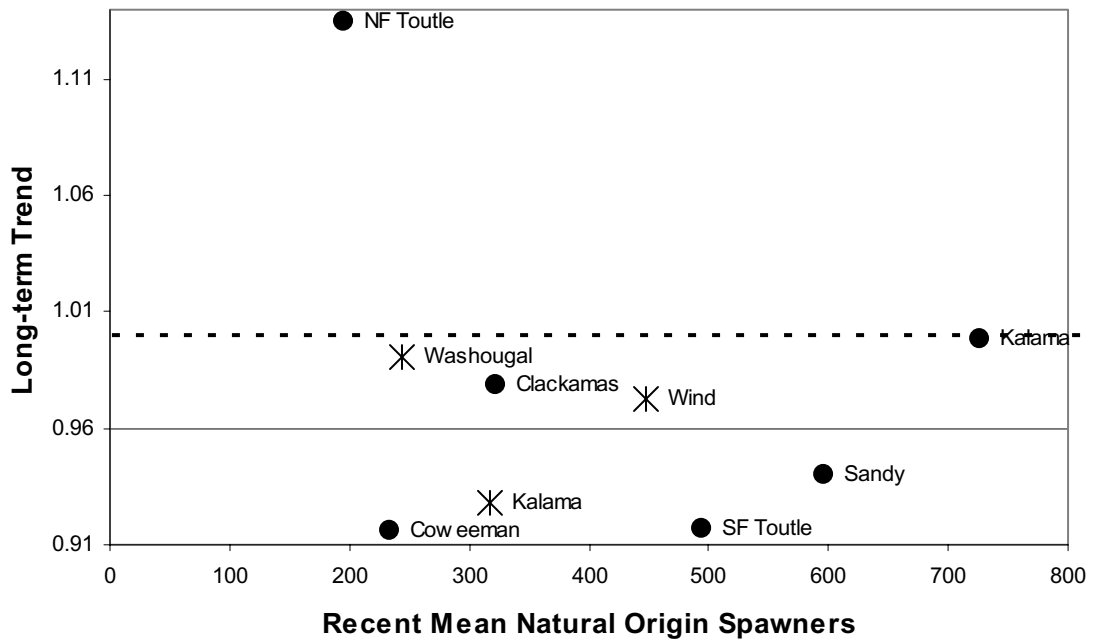


Figure B.2.4.25. Long-term trend vs. 5-year geometric mean abundance of natural-origin spawners. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

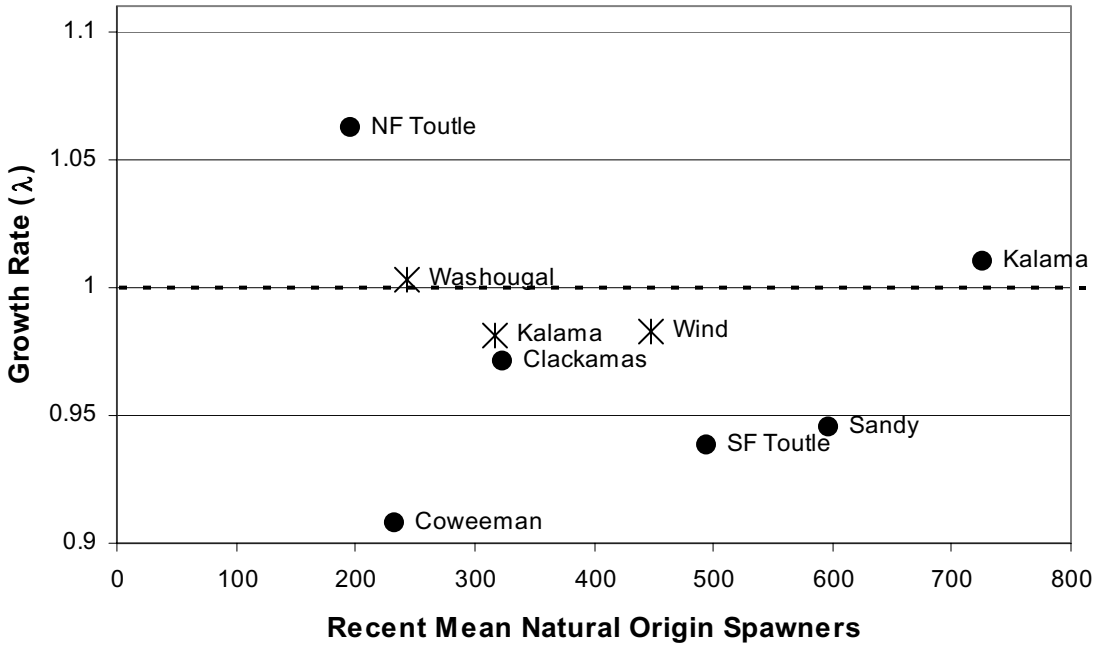


Figure B.2.4.26. Long-term growth rate vs. 5-year geometric mean abundance of natural-origin spawners. The growth rate is estimated assuming the reproductive success of hatchery-origin spawners is zero. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

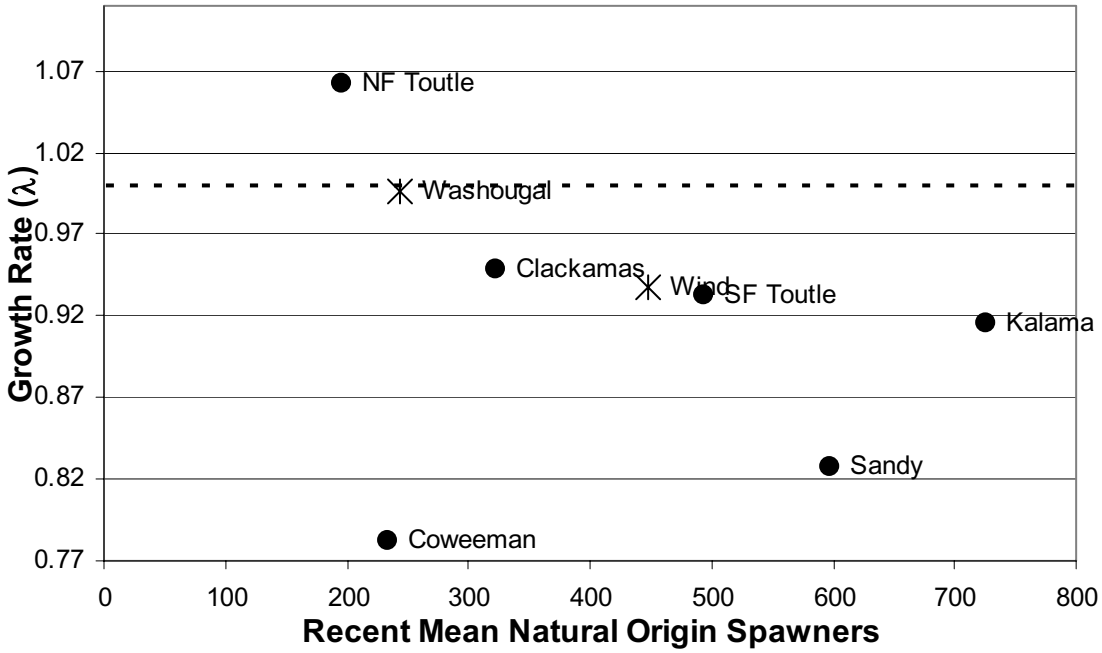


Figure B.2.4.27. Long-term growth rate vs. 5-year geometric mean abundance of natural-origin spawners. The growth rate is estimated assuming the reproductive success of hatchery-origin spawners is equivalent to that of natural-origin spawners. The "*" symbol indicates summer run populations. The dash line indicates a flat trend of 1.

B.2.5. UPPER WILLAMETTE RIVER STEELHEAD

B.2.5.1. Summary of Previous BRT Conclusions

The status of Upper Willamette River steelhead was initially reviewed by NMFS in 1996 (Busby et al. 1996) and the most recent review occur in 1999 (NMFS 1999). In the 1999 review, the BRT noted several concerns for this ESU, including the relatively low abundance and steep declines since 1988. The previous BRT was also concerned about the potential negative interaction between non-native summer steelhead and wild winter steelhead. The previous BRT considered the loss of access to historical spawning grounds because of dams a major risk factor. The 1999 BRT reached a unanimous decision that the Upper Willamette River steelhead ESU was at risk is of becoming endangered in the foreseeable future.

Current Listing Status: threatened

B.2.5.2 New Data and Updated Analyses

New data for Upper Willamette River steelhead include redd counts and dam/weir counts through 2000, 2001, or 2002 and estimates of hatchery fraction and harvest rates through 2000. New analyses for this update include the designation of demographically independent populations, and estimates of current and historically available kilometers of stream.

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for Upper Willamette River steelhead, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. hypothesized that the ESU historically consisted of at least four populations (Mollala, North Santiam, South Santiam and Calapooia) and possibly a fifth (Coast Range) (Figure B.2.5.1). There is some uncertainty about the historical existence of a population in the coast range. The populations identified in Myers et al. are used as the units for the new analyses in this report.

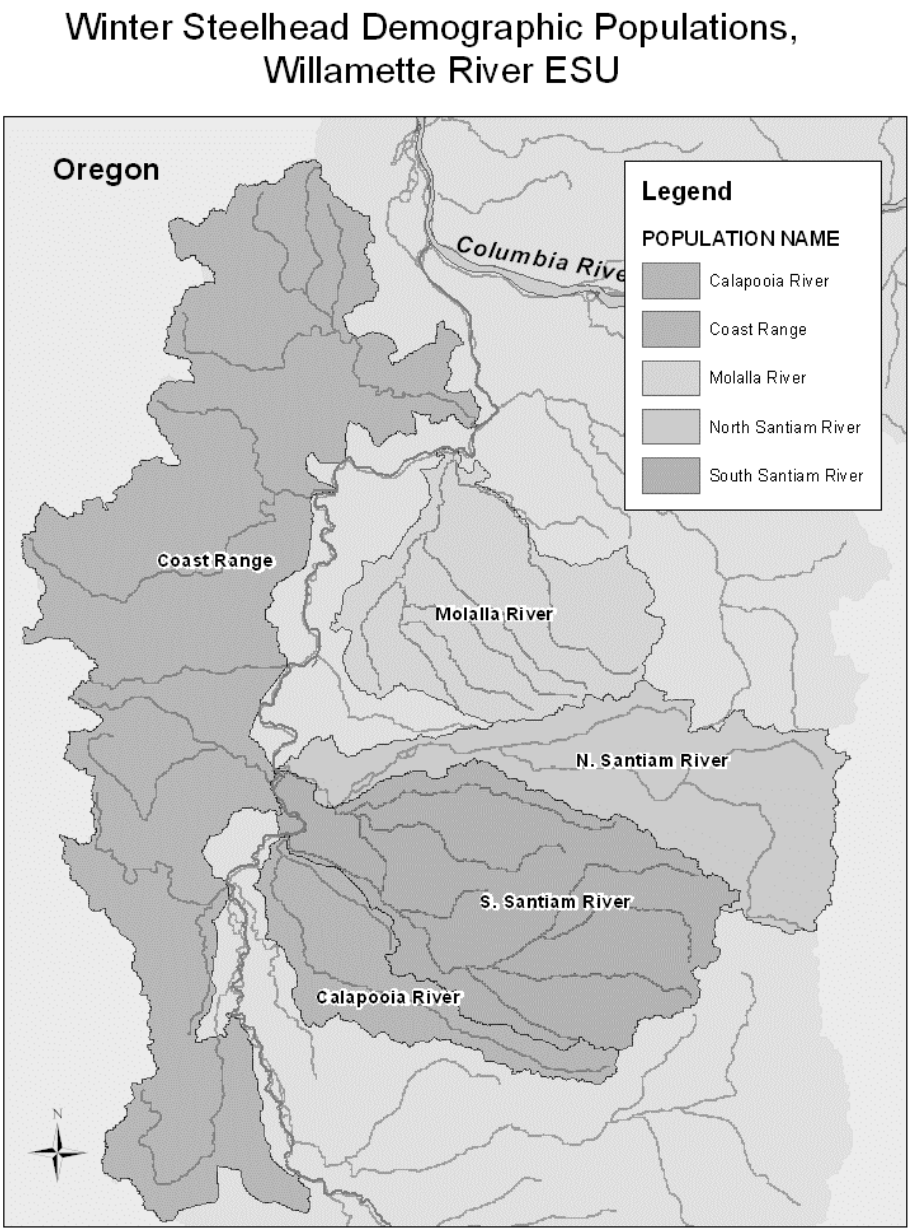


Figure B.2.5.1. Map of historical Upper Willamette River steelhead populations.

Abundance and trends

Willamette Falls - The number of winter steelhead passing over Willamette Falls from 1971 to 2002 is shown in Figure B.2.5.2. All steelhead in the ESU must pass Willamette Falls. Two groups of winter steelhead currently exist in the upper Willamette. The "late-run" winter steelhead exhibit the historical phenotype adapted to passing the seasonal barrier at Willamette Falls. The falls were laddered and hatchery "early-run" winter steelhead fish were released above the falls. The early-run fish were derived from Columbia Basin steelhead outside the Willamette and are considered non-native. The release of winter-run hatchery steelhead has recently been discontinued in the Willamette (Table B.2.5.1), but some early-run winter

steelhead are still returning from the earlier hatchery releases and from any natural production of the early-run fish that has been established. One line on the graph of winter steelhead at Willamette Falls shows the combined early and late returns and the other line shows only the native late run. Non-native summer run hatchery steelhead are also released into the upper Willamette, but are not graphed. The geometric mean of late returning steelhead passing Willamette Falls over the years 1998-2002 is 5,819 steelhead and the arithmetic mean over the same period is 6,765 steelhead.

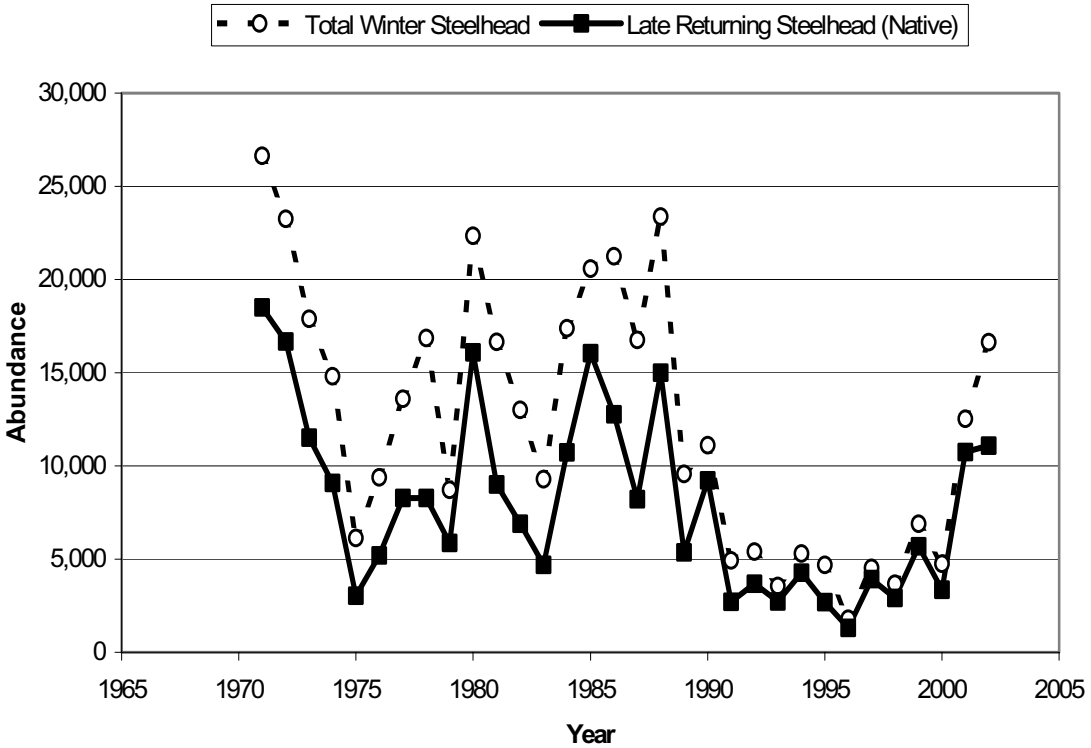


Figure B.2.5.2. Counts of winter steelhead at Willamette Falls.

Table B.2.5.1. The stocking of winter-run steelhead in the Willamette River has been discontinued. However, winter-run hatchery fish were still returning over the period of the available time series and summer run steelhead continue to be stocked in the Willamette. This table shows the last year of winter run releases in each of the basins.

Population	Last Year Winter Run Steelhead Released
Mollala River	1999
North Santiam River	1998
South Santiam River	1989
Calapooia River	No hatchery

The available time series data for individual Upper Willamette River steelhead populations consist of redd count index surveys, one dam count (Foster dam) and one hatchery trap count (Minto Trap). At one time, ODFW applied an algorithm involving the redd surveys and the length of available stream miles to apportion the fish passing Willamette Falls into

individual populations. This approach appears to have been dropped in 1997 and there are currently no estimates of the absolute total numbers of spawners in the individual populations. The status of individual populations is discussed below.

Table B.2.5.2. Trends in redds per mile surveys of Upper Willamette River winter steelhead populations. The long-term trends use the entire data set and the short-term trends use data from 1990 through the most recent year. The 95% confidence intervals are in parentheses.

Population	Years of Data	Long-term Trend in Redds per Mile	Probability Long-term Trend < 1	Short-term Trend in Redds per Mile	Probability Short-term Trend < 1
Mollala	1980-2000	0.947 (0.918-0.977)	0.999	0.972 (0.867-1.090)	0.705
North Santiam	1980-2001	0.941 (0.906-0.977)	0.999	0.962 (0.845-1.095)	0.740
South Santiam	1980-2001	0.936 (0.904-0.970)	1.000	0.917 (0.811-1.037)	0.926
Calapooia	1980-2001	0.968 (0.933-1.003)	0.964	1.053 (0.935-1.149)	0.229

Molalla—A time series of redd-per-mile data from the Molalla shows a declining trend from 1980-2000 (Table B.2.5.2 and Figure B.2.5.3). Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9, and the estimated harvest rate in Figure B.2.5.10. The populations shows a declining trend over the available time series.

North Santiam—A time series of redd-per-mile data from the North Santiam show a declining trend from 1980-2001 (Figure B.2.5.4). A time series also exists the Minto trap on the North Santiam (Figure B.2.5.5). Minto is a hatchery acclimation-and-release site, so it is assumed that the majority of fish trapped at this site over the time series are of hatchery origin. Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9 and the estimated harvest rate in Figure B.2.5.10.

South Santiam—Counts of winter steelhead at Foster Dam (RKm 77) from 1967 to 2002 are shown in Figure B.2.5.6. A hatchery program was initiated in the 1980s and hatchery-origin fish were identified at the dam facility. Redd surveys are also conducted below Foster Dam (Figure B.2.5.7). Estimates of the fraction of hatchery-origin spawners for this population below Foster Dam are shown in Figure B.2.5.9, and the estimated harvest rate in Figure B.2.5.10.

Calapooia—A time series of redd-per-mile data from the Calapooia shows a declining trend from 1980-2001 (Figure B.2.5.8). Estimates of the fraction of hatchery-origin spawners for this population are shown in Figure B.2.5.9 and the estimated harvest rate in Figure B.2.5.10.

West Side Tributaries—No time series or current counts of spawner abundance for the west side tributaries population are available. It is questionable if there was ever a self-sustaining steelhead population in the west side. There is assumed to be little, if any, natural production of steelhead in these tributaries.

Loss of habitat from barriers

An analysis was conducted by Steel and Sheer (2003) to assess the number of stream km historically and currently available to salmon populations in the Upper Willamette River ESU (Table B.2.5.3). Stream km usable by salmon are determined based on simple gradient cut offs, and on the presence of impassable barriers. This approach will over estimate the number of usable stream km as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is greatly reduced from the historical condition.

Table B.2.5.3. Historical populations of Upper Willamette River spring chinook and loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient and 0.5% and 6%. The current-to-historical habitat ratio is the percent of the historical habitat that is currently available.

Population	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio
Mollala River	524	827	63
North Santiam River	210	347	61
South Santiam River	581	856	68
Calapooia River	203	318	64
West side Tributaries	1,376	2,053	67

Resident *O. mykiss* considerations

The available information on resident *O. mykiss* populations within the ESU is summarized in Table B.2.1.3 and Appendix B.5.1 and provides a broad overview of the distribution of Case 1, 2, and 3 resident populations within the ESU. See the section on Resident Fish in the Introduction section to the main body of this report for an explanation of the three cases and their relevance to ESU determinations. The section on Resident Fish in section B.1 of this steelhead report discusses how resident fish are considered in risk analyses.

Kostow (2003) has reviewed information on the abundance and distribution of resident *O. mykiss* for this ESU and found no quantitative estimates of abundance for resident *O. mykiss* in any UW population. However, expert opinion indicates that resident *O. mykiss* are rare in this ESU. Cutthroat trout (*Oncorhynchus clarki)* are found through much of the Willamette River Basin and tend not to co-occur with resident *O. mykiss*. Resident *O. mykiss* in the Middle Fork Willamette and McKenzie River might normally be considered to be Case 1 because there are no obvious barriers to anadromous access to these areas. Nevertheless, there is no evidence that steelhead historically inhabited these basins, and the resident fish in these basins are morphologically distinctive (being known locally as "McKenzie redsides; Kostow 2003). These upper basin resident fish are also genetically quite different from Upper Willamette ESU

steelhead (NMFS unpublished data), and they are not considered part of the Upper Willamette River ESU (cite FR notice; status review or update memo)

Resident or residualized rainbow trout are found above the dams on the North and South Santiam Rivers; historically, these areas were the primary production areas for steelhead in this ESU. We are not aware of specific information relevant to the ESU status of these Case 3 resident populations. Resident *O. mykiss* are found in the numerous small waterfalls that exist in the headwater regions of this ESU.

B.2.5.3. ESU Summary

Based on the updated information provided in this report, the information contained in previous Upper Willamette River steelhead ESU status reviews, and preliminary analyses by the WLC-TRT, we could not conclusively identify a single population that is naturally self-sustaining. All populations are relatively small, with the recent mean abundance of the entire ESU at less than 6,000. Over the period of the available time series, most of the populations are in decline. The recent elimination of the winter-run hatchery production will allow estimation of the naturally productivity of the populations in the future, but the available time series are confounded by the presence of hatchery-origin spawners. On a positive note, the counts all indicate an increase in abundance in 2001, likely at least partly as a result of improved marine conditions. The issue of changing marine conditions is discussed in the introduction to this update report, as it is an issue for may ESUs.

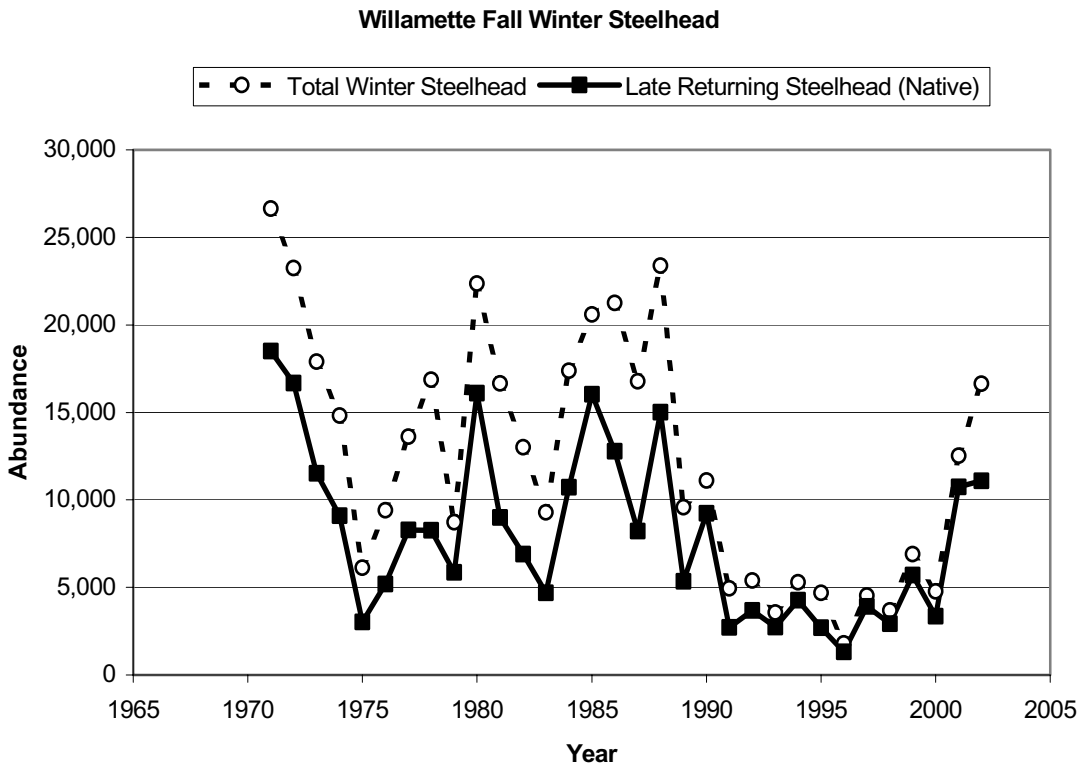


Figure B.2.5.2. Counts of winter steelhead at Willamette Falls.

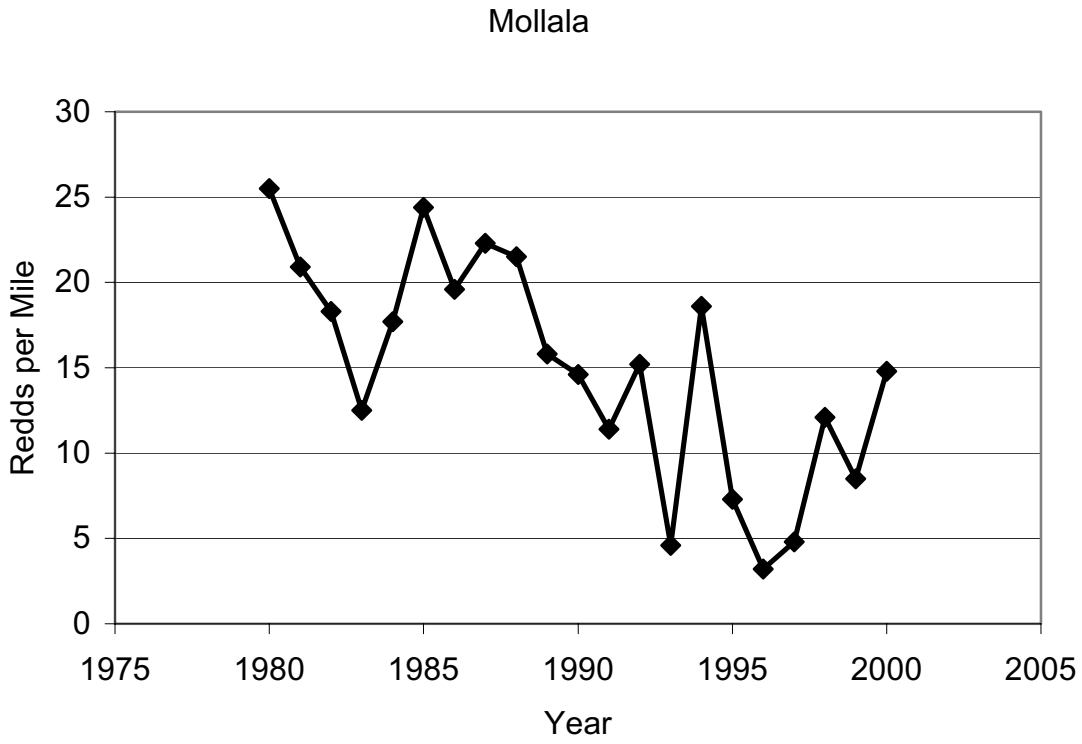


Figure B.2.5.3. Redd surveys of winter steelhead in the Molalla.

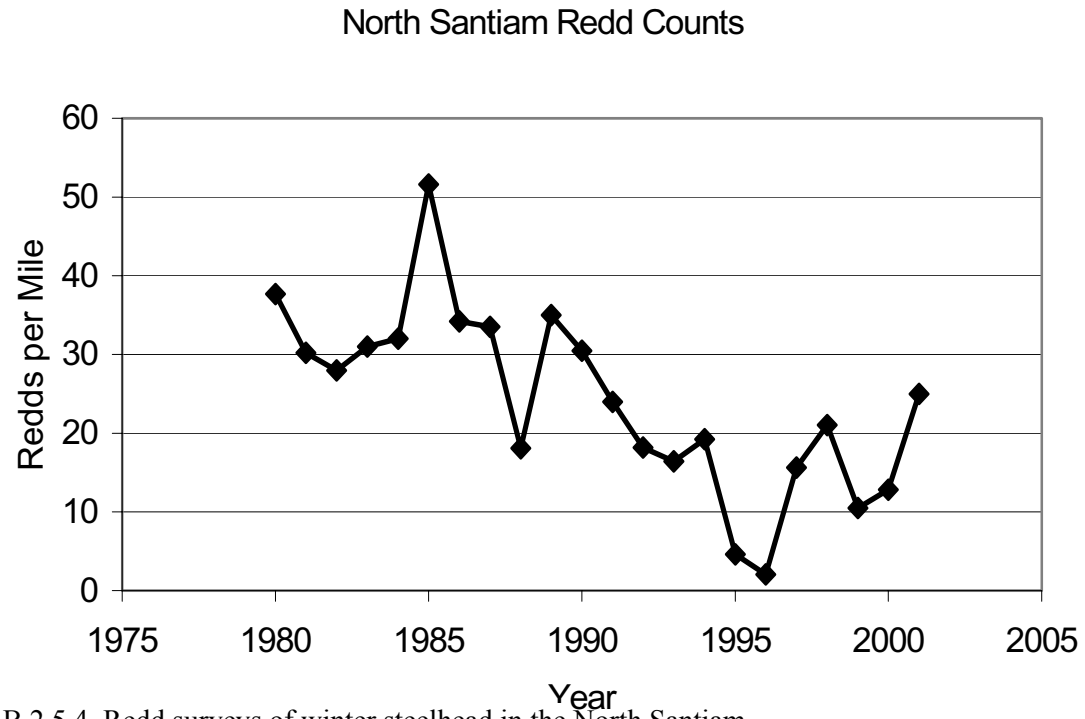


Figure B.2.5.4. Redd surveys of winter steelhead in the North Santiam.

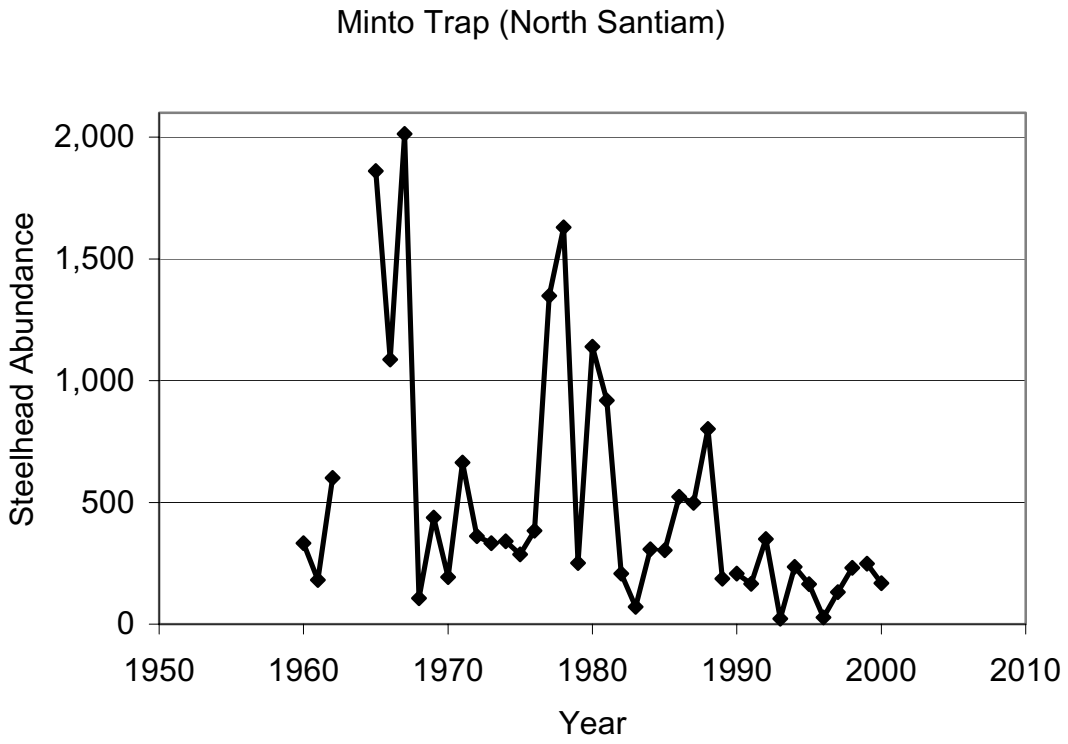
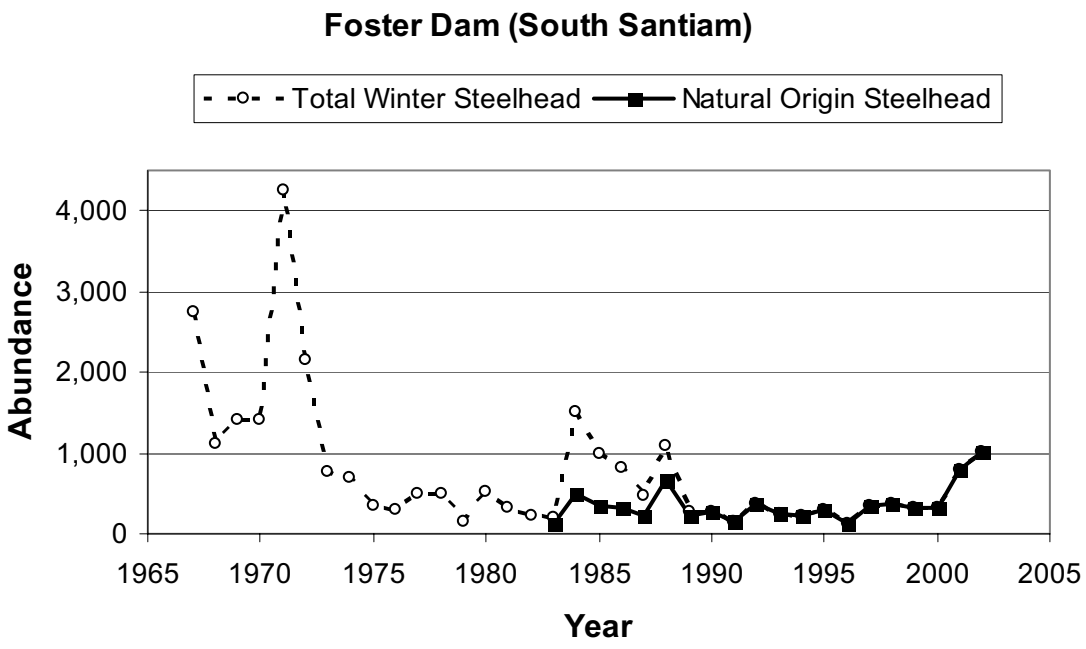


Figure B.2.5.5. Counts of winter steelhead at the Minto trap on the North Santiam. Minto is a hatchery-acclimation pond and release site.



B.2.5.6. Counts of winter steelhead at Foster Dam on the South Santiam (RKm 77).

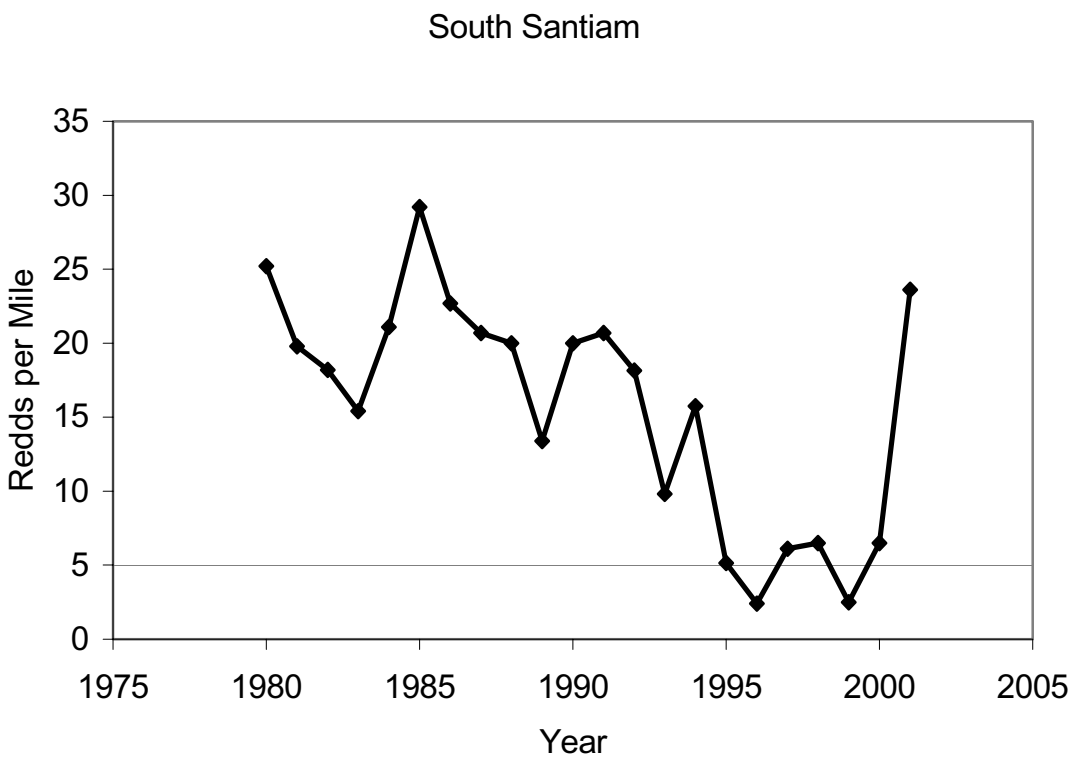


Figure B.2.5.7. Redd surveys of winter steelhead in the South Santiam below Foster Dam.

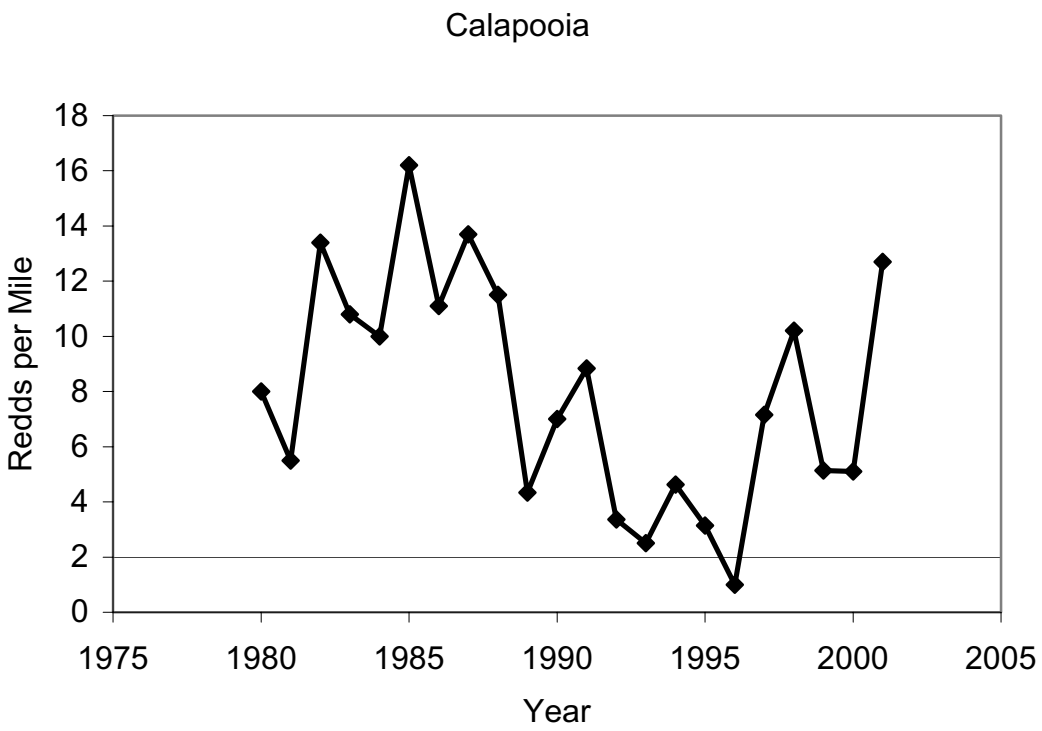


Figure B.2.5.8. Redd surveys of winter steelhead in the Calapooia River.

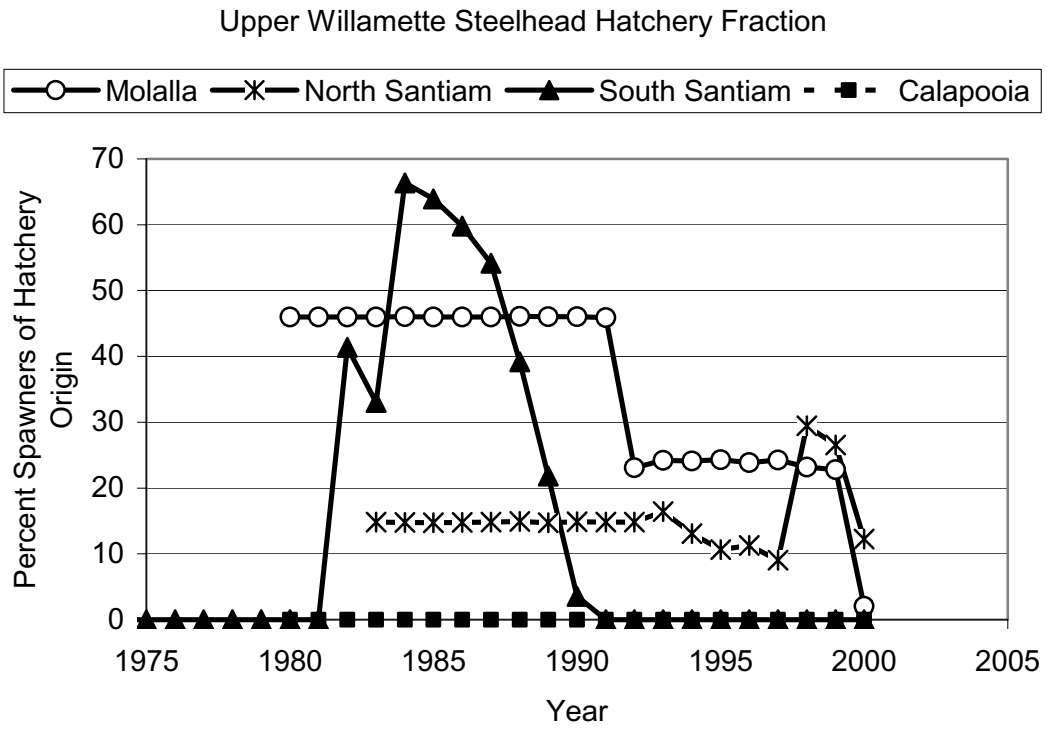


Figure B.2.5.9. Estimates of the fraction of hatchery-origin spawners in populations of UW winter steelhead (Chilcote 2001). Winter steelhead are not currently released into the UW.

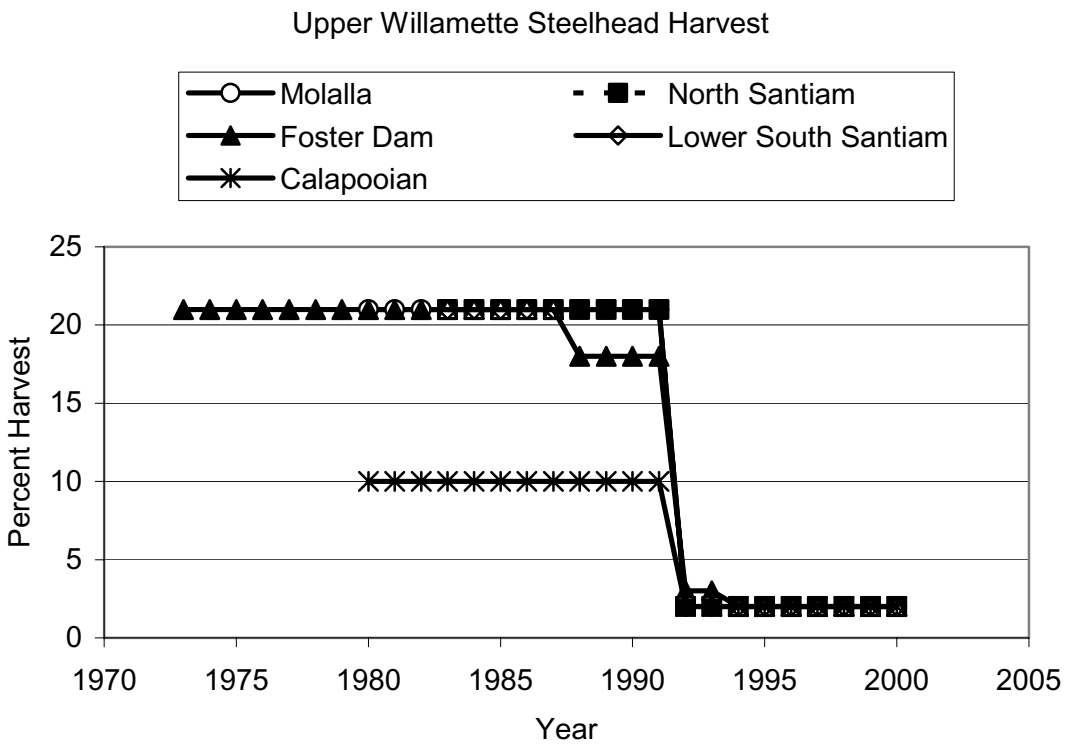


Figure B.2.10. Estimates of the harvest rate on populations of UW winter steelhead (Chilcote 2001).

B.2.6 NORTHERN CALIFORNIA STEELHEAD ESU

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.6.1 Summary of Previous BRT Conclusions

The Northern California ESU was determined to inhabit coastal basins from Redwood Creek (Humboldt County) southward to the Gualala River (Mendocino County), inclusive (Busby et al. 1996). Within this ESU, both summer-run[2], winter-run, and half-pounders[3] have been found. Summer-run steelhead are found in the Mad, Eel, and Redwood rivers; the Middle Fork Eel River population is their southern-most occurrence. Half-pounders are found in the Mad and Eel rivers. Busby et al. (1996) argued that when summer-run and winter-run steelhead co-occur within a basin, they were more similar to each other than either is to the corresponding run-type in other basins. Thus Busby et al. (1996) considered summer-run and winter-run steelhead to jointly comprise a single ESU.

Summary of major risks and status indicators

Risks and limiting factors—The previous status review (Busby et al. 1996) identified two major barriers to fish passage: Mathews Dam on the Mad River and Scott Dam on the Eel River. Numerous other blockages on tributaries were also thought to occur. Poor forest practices and poor land use practices, combined with catastrophic flooding in 1964, were thought to have caused significant declines in habitat quality that then persisted up to the date of the status review. These effects include sedimentation and loss of spawning gravels. Non-native Sacramento pikeminnow (*Ptychocheilus grandis*) had been observed in the Eel River basin and could be acting as predators on juvenile steelhead, depending on thermal conditions leading to niche overlap of the two species (see also Brown and Moyle 1981, 1997; Harvey et al 2002, Reese and Harvey 2002).

Status indicators—Historical estimates (pre-1960s) of steelhead abundance for this ESU have been few (Table B.2.6.1). The only time-series data are dam counts of winter-run steelhead in the upper Eel River (Cape Horn Dam, 1933-present), winter-run steelhead in the Mad River (Sweasey Dam, 1938-1963), and combined counts of summer-run and winter-run steelhead in the South Fork Eel River (Benbow Dam, 1938-75; see Figure B.2.6.1A). More recent data are snorkel counts of summer-run steelhead that were made in the middle fork of the Eel since 1966 (with some gaps in the time-series) (Scott Harris and Wendy Jones, CDFG, personal communication). Some "point" estimates of mean abundance exist—in 1963, the California

---

[2] Some consider summer-run steelhead and fall-run steelhead to be separate runs within a river while others do not consider these groups to be different. For purposes of this review, summer-run and fall-run are considered stream-maturing steelhead and will be referred to as summer steelhead (see McEwan 2001 for additional details).

[3] A half pounder is a sexually immature steelhead, usually small, that returns to freshwater after spending less than a year in the ocean (Kesner and Barnhart 1972, Everest 1973).

Department of Fish and Game made estimates of steelhead abundance for many rivers in the ESU (Table B.2.6.2). An attempt was made to estimate a mean count over the interval 1959 to 1963, but in most cases 5 years of data were not available and estimates were based on fewer years (CDFG 1965); the authors state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource" (CDFG 1965). The previous BRT (Busby et al. 1996) considered the above datasets in making their risk assessment.

Table B.2.6.1. Summary of historical abundance (average counts) for steelhead in the Northern California evolutionarily significant unit (see also Figure 1).

		Average count						
Basin	**Site**	**1930s**	**1940s**	**1950s**	**1960s**	**1970s**	**1980s**	**Reference**
Eel River	Cape Horn Dam	4,390	4,320	3,597	917	721	1,287	Grass 1995
Eel River	Benbow Dam	13,736	18,285	12,802	6,676	3,355	-	
Mad River	Sweasey Dam	3,167	4,720	2,894	1,985	-	-	

Although the data were relatively few, the data that did exist suggested the following to the BRT: 1) Population abundances were low relative to historical estimates (1930s dam counts; see Table B.2.6.1 and Figure B.2.6.1); 2) Recent trends were downward (except for a few small summer-run stocks; see Figures B.2.6.1 and B.2.6.2); and 3) Summer-run steelhead abundance was "very low." The BRT was also concerned about negative influences of hatchery stocks, especially in the Mad River (Busby et al. 1996). Finally, the BRT noted that the status review included two major sources of uncertainty: lack of data on run sizes throughout the ESU, and uncertainty about the genetic heritage of winter-run steelhead in Mad River.

Listing status

Status was formally assessed in 1996 (Busby et al. 1996), updated in 1997 (NMFS 1997) and updated again in 2000 (Adams 2000). Although other steelhead ESUs were listed as threatened or endangered in August 1997, the National Marine Fisheries Service (NMFS) allowed steelhead in the Northern California ESU to remain a candidate species pending an evaluation of state and federal conservation measures. There was a "North Coast Steelhead Memorandum of Agreement" (MOA) with the State of California, which listed a number of proposed actions, including a change in harvest regulations, a review of California hatchery practices, implementation of habitat restoration activities, implementation of a comprehensive monitoring program, and numerous revisions to rules on forest-practices. These revisions would be expected to improve forest condition on non-federal lands. In March 1998 the NMFS announced its intention to reconsider the previous no-listing decision. On 6 October 1999 the California Board of Forestry failed to take action on the forest practice rules, and the NMFS Southwest Region (SWR) regarded this failure as a breach of the MOA, despite the fact that other state agencies, such as the California Department of Fish and Game, had complied with the MOA. The Northern California ESU was listed as threatened in June 2000.

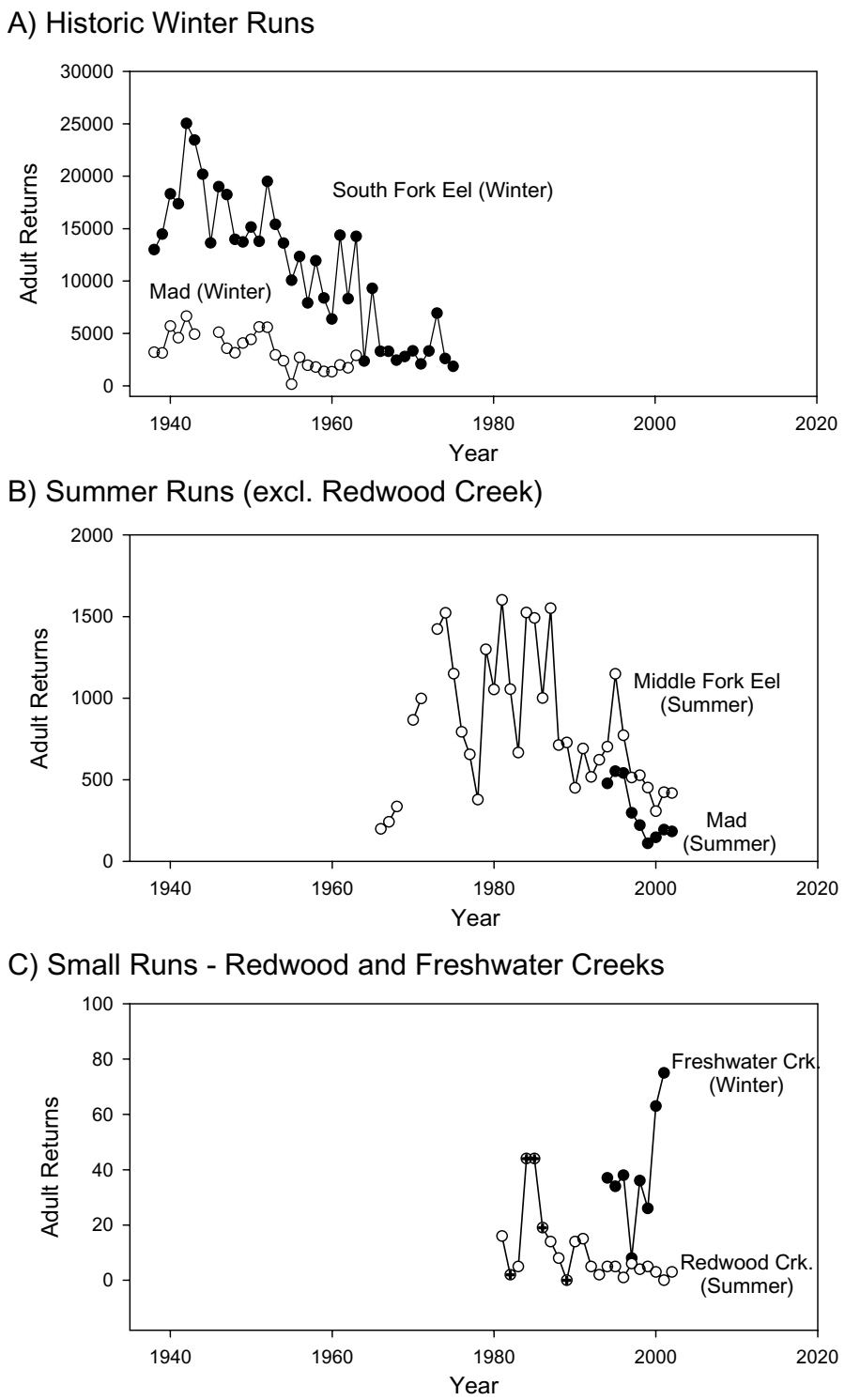


Figure B.2.6.1. Time-series data for the North-Central California Steelhead ESU. A) Historical data from winter runs on the Mad River and South Fork Eel. B) Summer-run on the Middle Fork Eel and Mad River. C) Summer-run steelhead in Redwood Creek, and winter-run steelhead in Freshwater Creek, Humboldt County. Symbols with crosses represent minimum estimates. Note the three different scales of the *y*-axis.

Table B.2.6.2. Historical estimates of number of spawning steelhead for California rivers in the Northern California ESU and Central California Coast ESU (data from CDFG 1965). Estimates are considered by CDFG (1965) to be notably uncertain.

ESU	Stream	1963
Northern California		
	Redwood Creek	10,000
	Mad River	6,000
	Eel River (total)	82,000
	Eel River	(10,000)
	Van Duzen River (Eel)	(10,000)
	South Fork Eel River	(34,000)
	North Fork Eel River	(5,000)
	Middle Fork Eel River	(23,000)
	Mattole River	12,000
	Ten Mile River	9,000
	Novo River	8,000
	Big River	12,000
	Navarro River	16,000
	Garcia River	4,000
	Gualala River	16,000
	other Humboldt County stream	3,000
	other Mendocino County streams	20,000
	Total	198,000
Central California Coast		
	Russian River	50,000
	San Lorenzo River	19,000
	other Sonoma County streams	4,000
	other Marin County steams	8,000
	other San Mateo County streams	8,000
	other Santa Cruz County streams	5,000
	Total	94,000

B.2.6.2 New Data and Updated Analyses

There are four significant sets of new information regarding status: 1) Updated time-series data exist for the middle fork of the Eel River (summer-run steelhead; snorkel counts. See Figure B.2.6.1B); 2) There are new data-collection efforts initiated in 1994 in the Mad River (summer-run steelhead; snorkel counts--Figure B.2.6.1B) and in Freshwater Creek (winter-run steelhead; weir counts--Figure B.2.6.1C; Freshwater Creek is a small stream emptying into Humboldt Bay; 3) Numerous reach-scale estimates of juvenile abundance have been made extensively throughout the ESU; and 4) Harvest regulations have been substantially changed since the last status review. Analyses of this information are described below.

Updated Eel River data

The time-series data for the Middle Fork of the Eel River are snorkel counts of summer-run steelhead, made for fish in the holding pools of the entire mainstem of the middle fork (Scott Harris and Wendy Jones, CDFG, pers. comm.). Most adults in the system are thought to oversummer in these holding pools. An estimate of λ over the interval 1966 to 2002 was made using the method of Lindley (in press; random-walk-with-drift model fitted using Bayesian assumptions). The estimate of λ is 0.98, with a 95% confidence interval of [0.93, 1.04] (see Table B.2.6.3)[4]. The overall trend in the data is downward in both the long- and the short-term (Figure B.2.6.1B).

New time-series

The Mad River time-series consists of snorkel counts for much of the mainstem below Ruth Dam. Some counts include the entire mainstem; other years include only data from land owned by Simpson Timber Company. In the years with data from the entire mainstem, fish from Simpson Timber land make up at least 90% of the total count. The time-series from Freshwater Creek is composed of weir counts. Estimates of λ were not made for either time-series because there were too few years of data to make meaningful estimates.

Vital statistics for these and other existing time-series are given in Table B.2.6.3; trend versus abundance is plotted in Figure B.2.6.2.

[4] Note that Lindley (in press) defines $\lambda \approx \exp(\mu + \sigma^2/2)$, whereas Holmes (2001) defines $\lambda \approx \exp(\mu)$; see the Lindley (in press) for meaning of the symbols.

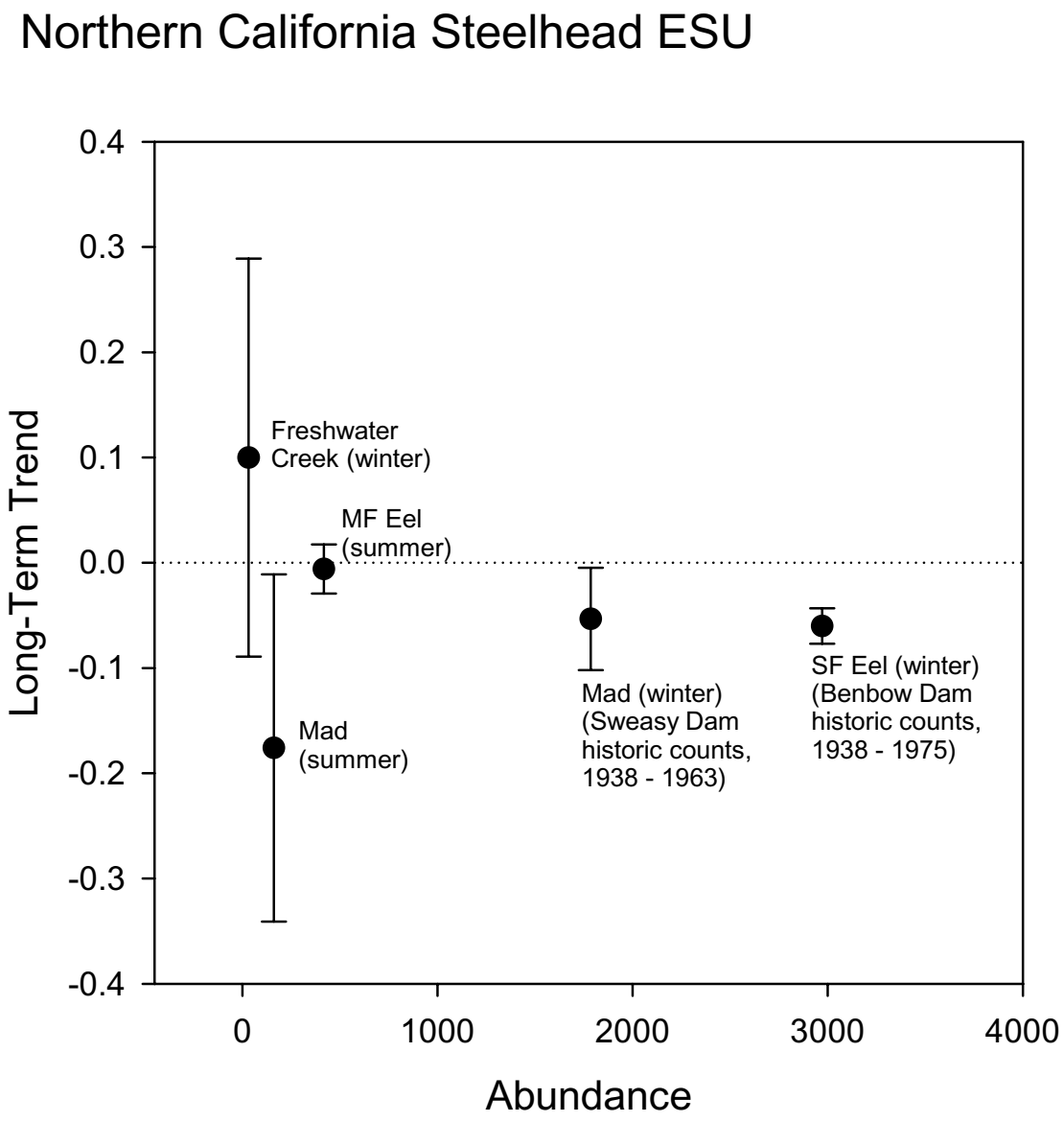


Figure B.2.6.2. Trends versus abundance for the time-series data from Figure B.2.6.1. Note that neither set of dam counts (Sweasy Dam, Benbow Dam) has any recent data. Vertical bars are 95% confidence intervals.

Table B.2.6.3. Summary of time-series data for listed steelhead ESUs on the California Coast.

Population	Span of time series	5-Year Means[5]			Lambda[6]	Long-term trend (95% conf. int.)	Short-term trend (95% conf. int.)
		Rec.	Min.	Max.			
Northern California ESU (threatened)							
M.Fk. Eel Riv. (summer-run)	'66-'02	418	384	1,246	0.98 (0.93, 1.04)	-0.006 (-0.029, 0.017)	-0.067 (-0.158, 0.024)
Mad River (summer-run)	'94-'02	162	162	384	Insufficient data	-0.176 (-0.341, -0.012)	-0.176 (-0.341, -0.121)
Freshwater Crk. (winter-run)	'94-'01	32	25	32	Insufficient data	0.099 (-0.289, 0.489)	0.099 (-0.289, 0.489)
Redwood Crk. (summer-run)	'81-'02	3	Fig. B.2.6.1[7]		Insufficient data	See Fig. B.2.6.1	-0.775 (-1.276, -0.273)
S.Fk. Eel Riv. (winter-run)[8]	'38-'75		2,743	20,657	0.98 (0.92, 1.02)	-0.060 (-0.077, -0.043)	No recent data
Mad Riv. (winter-run)[9]	'38-'63		1,140	5,438	1.00 (0.93, 1.05)	-0.053 (-0.102, -0.005)	No recent data
Central California ESU (threatened)							
No data							
South-Central California ESU (threatened)							
Carmel River (winter-run)	'62-'02	611	1.13	881	Insufficient data	0.488 (0.442, 0.538)[10]	0.488 (0.442, 0.538)
Southern California ESU (endangered)							
Santa Clara R. (winter-run)[11]	'94-'97	1.0			Insufficient data		

[5] Geometric means. The value 0.5 was used for years in which the count was zero.
[6] Lambda calculated using the method of Lindley (In press). Note that a population with lambda greater than 1.0 can nevertheless be declining, due to environmental stochasticity.
[7] Certain years have minimum run sizes, rather than unbiased estimates of run size, rendering the time series unsuitable for some of the estimators.
[8] Historical counts made at Benbow Dam.
[9] Historical counts made at Sweasy Dam.
[10] Early data (pre 1988) have exceptionally high observation error and were not used in calculations.
[11] Recent abundance is a 4-year mean.

Juvenile data

Data on juvenile abundance were collected at numerous sites using a variety of methods (contact NMFS SW Fisheries Science Ctr. for attributions of datasets). Many of the methods involve the selection of reaches thought to be "typical" or "representative" steelhead habitat; other reaches were selected because they were thought to be typical coho habitat, and steelhead counts were made incidentally to coho counts. In general, the field crew made electro-fishing counts (usually multiple-pass, depletion estimates) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

Because there are so few adult data on which to base a risk assessment of this ESU, we chose to analyze these juvenile data. However, we note that they have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems; non-random sampling of populations within the ESU; and a general lack of estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.6.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

To estimate a trend from the juvenile data, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum number of observations per time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The general lack of data on this ESU prompted us to consider these datasets despite their brevity.

This procedure resulted in 10 independent populations for which a trend was estimated. Both upward and downward trends were observed (Figure B.2.6.3). We tested the null hypothesis that abundances were stable or increasing. It was not rejected (H_o: slope ≥ 0; $p < 0.32$ via one-tailed *t*-test against expected value). However, it is important to note that a significance level of 0.32 implies a probability of 0.32 that the ESU is stable or increasing, and a probability of $1 - 0.32 = 0.68$ that the ESU is declining; thus the odds are more than 2:1 that the ESU has been declining during the past 6 years. This conclusion requires the assumption that the assessed populations 1) are indeed independent populations rather than plausibly independent populations, and 2) were randomly sampled from all populations in the ESU (in fact they were "haphazardly" sampled).

Table B.2.6.4. Interpretation of data on juvenile trends.

		Inference made about adult trends		
		Increasing	**Level**	**Decreasing**
Observed juvenile trends	Increasing	Possible, if no density-dependence in the smolt/oceanic phase. The most parsimonious inference.	Possible, if density-dependence occurs in the juvenile over-wintering phase, or in the smolt/oceanic phase.	Possible, if oceanic conditions are deteriorating markedly at the same time that reproductive success per female is improving.
	Level	Possible, if oceanic conditions are improving for adults, but juveniles undergo density-dependence.	Possible. The most parsimonious inference.	Possible, if oceanic conditions are deteriorating.
	Decreasing	Unlikely, but could happen over the short term due to scramble competition at the spawning/redd phases.	Possible, if river habitat is deteriorating, and there was strong, pre-existing density dependence in the oceanic phase.	Likely. The most parsimonious inference.

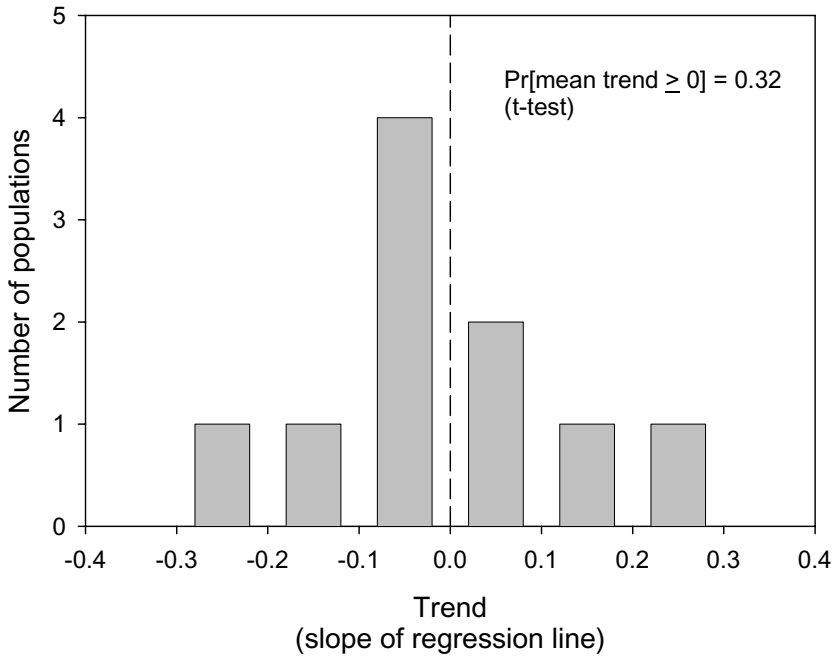


Figure B.2.6.3. Distribution of trends in juvenile density, for 10 "independent" populations within the North Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than zero indicate increase. Assuming that the populations were randomly drawn from the ESU as a whole, the hypothesis that the ESU is stable or increasing cannot be statistically rejected (p = 0.32), but is only half as likely as the hypothesis that the ESU is declining ($p = 1 - 0.32 = 0.68$).

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.), so effects on extinction risk are negligible. For freshwaters (CDFG 2002b), all streams are closed to fishing year round except for special listed streams as follows: Catch-and-release angling is allowed year round excluding April and May in the lower mainstem of many coastal streams. Most of these have a bag limit of one hatchery trout or steelhead during the winter months (Albion River, Alder Creek, Big River, Cottoneva Creek, Elk Creek, Elk River, Freshwater Creek, Garcia River, Greenwood Creek, Little River in Humboldt Co., Gualala River, Navarro River, Noyo River, Ten Mile River, and Usal Creek); in a few the one-fish bag limit extends to the entire season (Bear River and Redwood Creek, both in Humboldt Co.). The Mattole River has a slightly more restricted catch-and-release season with zero bag limit year round.

The two largest systems are the Mad River and Eel River. The mainstem Mad River is open except for April and May over a very long stretch; bag limit is two hatchery trout or

steelhead; other stretches have zero bag limit or are closed to fishing. Above Ruth Dam, an impassable barrier, the bag limit is five trout per day. The Eel River's mainstem and south fork are open to catch-and-release over large stretches, year round in some areas and closed April and May in others. The middle fork is open for catch and release except mid summer and late fall/winter. In the upper middle fork and many of its tributaries, there are summer fisheries with bag limits of two or five fish with no stipulated restriction on hatchery or wild. In the Van Duzen, a major tributary of the mainstem Eel, there is a summer fishery with bag limit five above Eaton Falls (CDFG 2002c). Elsewhere, some summer trout fishing is allowed, generally with a two- or five- bag limit. Cutthroat trout have a bag limit of two from a few coastal lagoons or estuaries.

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG monitors angling effort and catch-per-unit-effort in selected basins by way of a "report card" system in which sport anglers self-report their catch, gear used, and so forth, and in selected other basins by way of creel censuses.

Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated with existing data (due to the fact that natural abundance is not being estimated). After the Federal listing decisions, NMFS requested that CDFG prepare a Fishery Management and Evaluation Plan (FMEP) for the listed steelhead ESUs in California. This has not yet been done for the northern California ESU.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: In the watersheds inhabited by this ESU, 8% of stream kilometers lie behind two major recent barriers—Scott Dam on the Eel River and Robert Matthews dam on the Mad (Appendix B.5.2; major barriers are defined as blocking access to watersheds with areas of 100 sq. mi. or greater). Category 3 populations are documented to occur above both dams and there is ongoing stocking of hatchery fish in the Mad River above the dam. No such records of stocking were uncovered for the Eel above Scott Dam. There do not appear to be any relevant genetic studies of these Category 3 populations.

B.2.6.3 New Hatchery Information

California hatchery stocks being considered for inclusion in this ESU are those from Mad River Hatchery, Yager Creek Hatchery, and the North Fork Gualala River Steelhead Project. The stocks and their associated hatcheries were assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignments, data about broodstock origin, size, management, and genetics were gathered from fisheries biologists and are summarized below.

Mad River Hatchery (Mad River Steelhead [CDFG])

The Mad River Hatchery is located 20 km upriver near the town of Blue Lake (CDFG/NMFS 2001). The trap is located at the hatchery.

Broodstock origin and history—The hatchery was opened in 1970 and steelhead were first released in 1971. The original steelhead releases were from adults taken at Benbow Dam on the South Fork Eel River. Between 1972 and 1974, broodstock at Mad River Hatchery were composed almost exclusively of steelhead from the South Fork Eel River. After 1974, returns to the hatchery supplied about 90% of the egg take; other eggs originated from Eel River steelhead. In addition, at least 500 adult steelhead from the San Lorenzo River were spawned at Mad River Hatchery in 1972. Progeny of these fish may have been planted in the basin. All subsequent broodyears are reported to have come from trapping at the hatchery.

Broodstock size/natural population size—An average of 5,536 adults were trapped from 1991 to 2002 and an average of 178 females were spawned during the broodyears 1991-2002. There are no abundance estimates for the Mad River, but steelhead were observed to be widespread and abundant throughout the basin.

Management—Starting in 1998, steelhead are 100% marked and fish are included in the broodstock in proportion to the numbers returned. The current production goals are 250,000 yearlings raised to 4-8/lb for release in March to May.

Population genetics—Alloyzme data group Mad River samples in with the Mad River Hatchery and then with the Eel River (Busby et al.1996).

Category—The hatchery has been determined to belong in Category 3. There have been no introductions since 1974, and naturally spawned fish are being included in the broodstock. However, there is still an out-of-basin nature to the stock (SSHAG 2003; see Appendix B.5.3).

Yager Creek Hatchery (Yager Creek Steelhead [PalCo])

The Yager Creek trapping and rearing facility is located at the confluence of Yager and Cooper Mill creeks (tributaries of the Van Duzen River, which is a tributary of the Eel River).

Broodstock origin and history—The project was initiated in 1976. Adult broodstock are taken from Yeager Creek and juveniles are released in the Van Duzen River basin. As with all Co-operative hatcheries, the fish are all marked and hatchery fish are usually excluded from broodstock (unless wild fish are rare). There are no records of introductions to the broodstock.

Management—About 4,600 juvenile steelhead from Freshwater Creek (a tributary of Humboldt Bay) were released in the Yager Creek Basin in 1993 (Busby et al. 1996). The current program goal is the restoration of Van Duzen River Steelhead.

Population genetics—There are no genetic data for this hatchery.

Category—This hatchery was determined to belong to Category 1. The broodstock has had no out-of-basin introductions and hatchery fish are excluded from the broodstock (SSHAG 2003; see Appendix B.5.3).

North Fork Gualala River Hatchery (Gualala River Steelhead Project [CDFG/Gualala River Steelhead Project])

This project rears juvenile steelhead rescued from tributaries of the North Fork Gualala River. Rearing facilities are located on Doty Creek, a tributary of the Gualala River 12 miles from the mouth. Steelhead smolts resulting from this program are released in Doty Creek, the mainstem of the Gualala River, and other locations in the drainage.

Broodstock origin and history—The project was started in 1981 and has operated sporadically since then. Juvenile steelhead are rescued from the North Fork of the Gualala River and reared at Doty Creek.

Management—The current program goal is restoration of Gualala River steelhead.

Population genetics—There are no genetic data for this hatchery.

Category—Determined to be Category 1. Usually only naturally spawned juveniles are reared at the facility (SSHAG 2003; see Appendix B.5.3).

B.2.7 CENTRAL CALIFORNIA COAST STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.7.1 Summary of Previous BRT Conclusions

The Central California Coast ESU was determined to inhabit coastal basins from the Russian River (Sonoma County), to Soquel Creek (Santa Cruz County) inclusive (Busby et al. 1996). Also included in this ESU are populations inhabiting tributaries of San Francisco and San Pablo bays (though there is some uncertainty about the latter). The ESU is composed only of winter-run fish.

Summary of major risks and status indicators

Risks and limiting factors—Two significant habitat blockages reported by Busby et al. (1996) are the Coyote and Warm Springs Dams in the Russian River watershed; data indicated that other smaller fish passage problems were widespread in the geographic range of the ESU. Other impacts noted in the status report were: urbanization and poor land-use practices; catastrophic flooding in 1964 causing habitat degradation; and dewatering due to irrigation and diversion. There has been no formal analysis of the relative strengths of these various impacts. Principal hatchery production in the region comes from the Warm Springs Hatchery on the Russian River, and the Monterey Bay Salmon and Trout Project on a tributary of Scott Creek. At the time of the status review there were other small private programs producing steelhead in the range of the ESU, reported by Bryant (1994) to be using stocks indigenous to the ESU, but not necessarily to the particular basin in which the program was located. There was no information on the actual contribution of hatchery fish to naturally spawning populations.

Status indicators—One estimate of historical (pre-1960s) abundance was reported by Busby et al. (1996): Shapovalov and Taft (1954) described an average of about 500 adults in Waddell Creek (Santa Cruz County) for the 1930s and early 1940s. A bit more recently, Johnson (1964) estimated a run size of 20,000 steelhead in the San Lorenzo River before 1965, and CDFG (1965) estimated an average run size of 94,000 steelhead for the entire ESU, for the period 1959-1963 (see Table B.2.7.5 for a breakdown of numbers by basin). The analysis by CDFG (1965) was compromised by the fact that for many basins, the data did not exist for the full 5-year period of their analysis. The authors of CDFG (1965) state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource."

Recent data for the Russian and San Lorenzo Rivers (CDFG 1994, Reavis 1991, Shuman 1994[12]; see Table B.2.7.5) suggested that these basins had populations smaller than 15% of the size that they had had 30 years previously. These two basins were thought to have originally contained the two largest steelhead populations in the ESU.

[12] The basis for the estimates provided by Shuman (1994) appears to be questionable.

A status review update conducted in 1997 (NMFS 1997) concluded that slight increases in abundance occurred in the 3 years following the status review, but the analyses on which these conclusions were based had various problems, including inability to distinguish hatchery and wild fish, unjustified expansion factors, and variance in sampling efficiency on the San Lorenzo River. Presence/absence data compiled by P. Adams (SWFSC, personal communication) indicated that most (82%) sampled streams (a subset of all historical steelhead streams) had extant populations of juvenile *O. mykiss*.

Table B.2.7.5. Summary of estimated runs sizes for the Central Coast steelhead ESU, reproduced from Busby et al. (1996), Tables 19 & 20.

River Basin	Estimate of Run Size	Year	Reference
Russian River	65,000	1970	CACSS (1988)
	1750 – 7000	1994	McEwan and Jackson (1996), CDFG (1994)
Lagunitas Creek	500		CDFG (1994)
	400 – 500	1990s	McEwan and Jackson (1996)
San Gregorio	1,000	1973	Coots (1973)
Waddell Creek	481	1933–1942	Shapovolov and Taft (1954)
	250	1982	Shuman (1994)[13]
	150	1994	Shuman (1994)[13]
Scott Creek	400	1991	Nelson (1994)
	<100	1991	Reavis (1991)
	300	1994	Titus et al. (MS)
San Vicente Creek	150	1982	Shuman (1994)[13]
	50	1994	Shuman (1994)[13]
San Lorenzo River	20,000	Pre-1965	Johnson (1964), SWRCB (1982)
	1,614	1977	CDFG (1982)
	>3,000	1978	Ricker and Butler (1979)
	600	1979	CDFG (1982)
	3,000	1982	Shuman (1994)[13]
	"few"	1991	Reavis (1991)
	<150	1994	Shuman (1994)[13]
Soquel Creek	500 – 800	1982	Shuman (1994)[13]
	<100	1991	Reavis (1991)
	50 – 100	1994	Shuman (1994)[13]
Aptos Creek	200	1982	Shuman (1994)[13]
	<100	1991	Reavis (1991)
	50 – 75	1994	Shuman (1994)[13]

[13] The basis for the estimates provided by Shuman (1994) appears to be questionable.

Previous BRT conclusions

The original BRT concluded that the ESU was in danger of extinction (Busby et al. 1996). Extirpation was considered especially likely in Santa Cruz County and in the tributaries of San Pablo and San Francisco Bays. The BRT suggested that abundance in the Russian River (the largest system inhabited by the ESU) has declined seven-fold since the mid-1960s, but abundance appeared to be stable in smaller systems. Two major sources of uncertainty were: 1) few data on run sizes, which necessitated that the listing be based on indirect evidence, such as habitat degradation; and 2) genetic heritage of populations in tributaries to San Francisco and San Pablo Bays was uncertain, causing the delineation of the geographic boundaries of the ESU to be uncertain. A status review update (NMFS 1997) concluded that conditions had improved slightly, and that the ESU was not presently in danger of extinction, but was likely to become so in the foreseeable future (Minorities supported both more and less extreme views on extinction risk). Uncertainties in the update mainly revolved around sampling efforts that were inadequate for detecting status or trends of populations inhabiting various basins.

Listing status

The status of steelhead was formally assessed in 1996 (Busby et al. 1996). The original status review was updated in 1997 (NMFS 1997), and the Central California Coast ESU was listed as threatened in August 1997.

B.2.7.2 New Data and Updated Analyses

There are two significant sets of new information regarding status: 1) numerous reach-scale estimates of juvenile abundance have been made for populations of the ESU, and 2) harvest regulations have been substantially changed since the last status review. Analyses of this information are described below.

Juvenile data

Data on juvenile abundance have been collected at a number of sites using a variety of methods (Alley and Assoc. 1994, 1995, 1997, 1998, 1999, 2000, 2002a, 2002b; Smith 1992, 1994a, 1994b, 1994c, 1995, 1996a, 1996b, 1996c, 1997, 1998a, 1998b, 1998c, 1999, 2000a, 2000b 2001a, 2001b, 2002). Many of the methods involve the selection of reaches thought to be "typical" or "representative" steelhead habitat. In general, the field crew made electro-fishing counts (usually multiple-pass, depletion estimates) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

Because there are so few adult data on which to base a risk assessment of this ESU, we chose to analyze these juvenile data. However, we note that they have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems; non-random sampling of populations within the ESU; and a general lack of

estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.6.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

To estimate a trend in the juvenile data, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum number of observations per time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The general lack of data on this ESU prompted us to consider these data despite the brevity of some series.

This procedure resulted in five independent populations for which a trend was estimated (the five sites are the San Lorenzo River, Scott Cr., Waddell Cr., Gazos Cr., and Redwood Cr. [Marin Co.]). Only downward trends were observed in the five populations (Figure B.2.7.4). The mean trend across all populations was significantly less than zero (H_o: slope ≥ 0; $p < 0.022$ via one-tailed *t*-test against expected value). This suggests an overall decline in juvenile abundance, but it is important to note that such a conclusion requires the assumptions that the assessed populations 1) are indeed independent populations rather than plausibly independent populations, and 2) were randomly sampled from all populations in the ESU (they are probably better regarded as having been haphazardly sampled).

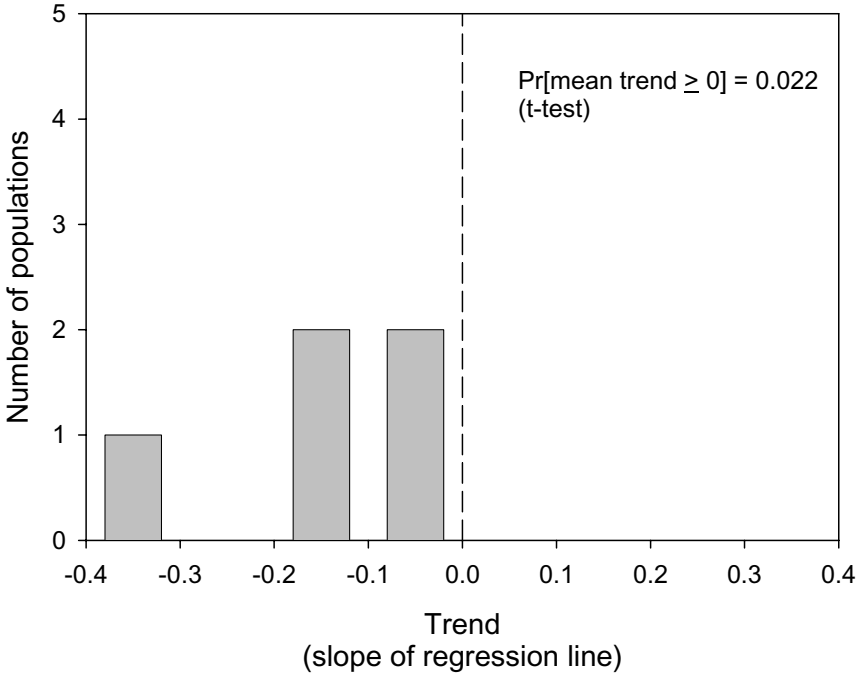


Figure B.2.7.4. Distribution of trends in juvenile densities, for five "independent" populations within the Central Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than zero indicate increase. Assuming that the populations were randomly drawn from the ESU as a whole, the hypothesis that the ESU is stable or increasing can be statistically rejected ($p = 0.022$); implying an overall decline.

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.). For freshwaters (CDFG 2002b), all coastal streams are closed to fishing year round except for special listed streams that allow catch-and-release angling or summer trout fishing. Catch-and-release angling with restricted timing (generally, winter season Sundays, Saturdays, Wednesdays, and holidays) is allowed in the lower main stems of many coastal streams south of San Francisco (Aptos Creek, Butano Creek, Pescadero Creek, San Gregorio Creek, San Lorenzo River, Scott Creek, Soquel Creek). Notably, Waddell Creek in Santa Cruz Co. for awhile had a 5-per day bag limit during the winter, for the short reach between Highway 1 and the ocean; this was a mistake as the bag limit was reduced to zero in the supplementary regulations issued in a separate document (CDFG 2002c). Catch and release is allowed year round except April and May in the lower parts of Salmon Creek in Sonoma County and Walker Creek in Marin County. Russian Gulch in Sonoma County has similar regulations except that 1 hatchery fish may be taken in the winter.

The Russian River is the largest system and probably originally supported the largest steelhead population in the ESU. The mainstem is currently open all year and has a bag limit of 2 hatchery steelhead or trout. Above the confluence with the East Branch it is closed year round. Santa Rosa Creek and Laguna Santa Rosa, Sonoma County tributaries to the Russian River, have a summer catch-and-release fishery.

Tributaries to the San Francisco Bay system have less restricted fisheries. All streams in Alameda, Contra Costa, and Santa Clara Counties (east and south Bay) have summer fisheries with bag limit five, except for special cases that are closed all year (Mitchell Creek, Redwood Creek in Alameda Co., San Francisquto Creek and tributaries, and Wildcat Creek). In the north Bay, the lower mainstem of the Napa River has catch-and-release year round except April and May; there is a bag limit of 1 hatchery steelhead or trout. Upper Sonoma Creek and tributaries have a summer fishery with bag limit 5. Summer trout fishing is allowed in some lakes and reservoirs or in tributaries to lakes, generally with 2 or 5 bag limit.

For catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG has prepared a draft Fishery Management and Evaluation Plan (CDFG 2001a) that argues the upper limit of increased mortality due to sport fishing to be about 2.5% in all populations. This estimate is based on an estimated mortality rate of 5% once a fish is hooked, which is consistent with a published meta-analysis of hooking mortality (Schill and Scarpella 1997). Experimental studies on the subject—from which the estimates are made—tend to measure mortality only for a period of a few days or a week after capture (e.g. Titus and Vanicek 1988).

The Fishery Management and Evaluation Plan contains no extensive plans for monitoring fish abundance. Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be

estimated quantitatively from the existing datasets, due to the fact that natural abundance is not being measured.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: In the watersheds inhabited by this ESU, at least 26% of stream kilometers lie behind recent barriers, and a number of resident populations are known to occur above the barriers (Appendix B.5.2). One significant set of Category 3 populations is in Alameda Creek, a tributary of San Francisco Bay. Nielson (2003) examined mitochondrial DNA and microsatellite DNA of fish from four subbasins of Alameda Creek and found that three of the subpopulations were most similar to each other and were more similar to populations from other creeks within the ESU (Lagunitas and San Francisquito creeks) than they were to populations outside the ESU. This strongly suggests that these Category 3 subpopulations should be considered part of the ESU. The fourth subpopulation, which occurred in Arroyo Mocho, was quite distinct and was more similar to Whitney hatchery stocks than it was to other subpopulations within the basin or even the wider ESU. Nielson (2003) suggests that this population may either be a population of native rainbow trout with no association to anadromous forms, or has experienced significant genetic introgression from introduced hatchery stocks.

Gall et al. (1990) examined the genetics of two populations in tributaries of the Upper San Leandro Reservoir, on San Leandro Creek. This creek drains into the San Francisco Bay and is, interestingly, the type locality for *Salmo irideus*, now known as *Oncorhynchus mykiss irideus* (Gall et al. 1990, Behnke 1992). Gall et al. (1990) analyzed genetic variability at 17 marker loci using electrophoresis, and concluded that the populations truly belonged to the coastal subspecies of *O. mykiss* (i.e. ssp. *irideus*). However, their study was not designed to assess whether the populations were more similar to hatchery stocks than to nearby wild populations. They reported anecdotal observations that the fish make steelhead-like runs to and from the reservoir.

B.2.7.3 New Hatchery Information

California hatchery stocks being considered for inclusion in this ESU are those from Don Clausen Fish Hatchery and the Monterey Bay Salmon & Trout Project. The stocks and their associated hatcheries were assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the

assignments, data about broodstock origin, size, management, and genetics were gathered from fisheries biologists and are summarized below.

Don Clausen Fish Hatchery (Warm Springs steelhead [CDFG])

The hatchery and collection site is located on Dry Creek, 14 miles above the confluence of Dry Creek and the Russian River and 47 river miles from the ocean. In 1992, the Coyote Valley Fish Facility was opened at the base of Coyote Valley Dam on the East Fork of the Russian River, 98 miles from the ocean. Both facilities trap fish on site. Coyote Valley fish are trapped and spawned there, but raised at Don Clausen Hatchery. The Coyote Valley steelhead are imprinted for 30 days at the facility before release.

Broodstock origin and history—The hatchery was founded in 1981 and the first steelhead releases were in 1982. The Coyote Valley Fish Facility was opened in 1992. Don Clausen Hatchery has had few out-of-basin transfers into its broodstock. However, significant numbers of Mad River Hatchery steelhead have been released into the basin. In the earlier part of the century, steelhead from Scott Creek were released throughout the basin. Since the Coyote Valley Fish Facility has been constructed, broodstock has been trapped at the facility.

Broodstock size/natural population size—At Don Clausen Hatchery, an average of 3,301 fish were trapped and 244 females were spawned during the broodyears 1992-2002. At the Coyote Valley Fish Facility, there have been an average of 1,947 steelhead trapped from 1993-2002 and an average of 124 females spawned. There are no steelhead abundance estimates for the Russian River, but fish are observed to be widely distributed and plentiful (NMFS, draft HGMP).

Management—As of 1998, steelhead have been 100% ad-clipped. Until broodyear 2000, both hatchery and naturally spawned fish had been included in the broodstock in the proportion that they returned to the hatchery. Since then, only adipose-marked fish are spawned and all unmarked steelhead are relocated into tributaries of Dry Creek. The production goal for Don Clausen Hatchery is 300,000 yearlings released beginning in December by size, with all fish released by April. The Coyote Valley Facility's goal is 200,000 yearlings that volitionally release between January and March.

Category—The hatchery has been determined to belong to Category 2 (SSHAG 2003; Appendix B.5.3). Although some out-of-ESU stocks were present in the basin, there have been no significant introductions since the hatchery began operations. The stock itself has only been cultivated for 20 years. The run is abundant and naturally spawned fish were included in the broodstock until 2000. Since that time only adipose-marked steelhead have been spawned.

Monterey Bay Salmon & Trout Project (Kingfisher Flat [Big Creek] Hatchery; Scott Creek steelhead)

The Kingfisher Flat Hatchery is located on Big Creek, a tributary of Scott Creek 6 km upstream from the mouth. Broodstock are taken by divers netting adults, usually in Big Creek below the hatchery, but at times throughout the Scott Creek system (NMFS, draft Biological Opinion). Steelhead are also taken at a trap on the San Lorenzo River in Felton. San Lorenzo River steelhead are kept separately and released back into the San Lorenzo Basin.

Broodstock origin and history—The Kingfisher Flat Hatchery began in 1975. However, California state hatchery activity near this site has a long history back to 1904 (Strieg 1991). The state hatchery program ended in 1942 due to flood damage. Under the California state hatchery program, Scott Creek steelhead were widely planted throughout coastal California as they were thought to be an exceptionally healthy stock. The hatchery was damaged by floods in 1941-42 and closed. There are limited records of introductions from Mt. Shasta and Prairie Creek hatcheries into this broodstock.

In 1976, the Monterey Bay Salmon & Trout Project began operations at the Big Creek location. Since then, broodstock have been taken either in Scott Creek by divers or at a trap in the San Lorenzo River near Felton. Since that time, there have been no introductions into the broodstock. As with all Co-operative hatcheries, the fish are all marked and hatchery fish are usually excluded from broodstock. Fish are released in either Scott Creek or the San Lorenzo River depending on the source of the broodstock.

Broodstock size/natural population size—An average of 98 fish were trapped and 25 females spawned during the 1990-96 broodyears. There are no abundance estimates for Scott Creek and the San Lorenzo River, but juveniles have been observed anecdotally to be widespread and abundant (NMFS, draft Biological Opinion).

Management—Starting in 2000, the practice of planting San Lorenzo fish into the North Fork of the Pajaro River Basin was discontinued. Although the distance is only a matter of miles, it is across ESU boundaries. The current program goal is the restoration of local steelhead stocks.

Population genetics—Alloyzme data groups the Scott Creek, San Lorenzo and Carmel River stocks together (Busby et al. 1996). Collectively they fall within the "south-of-the-Russian-River" grouping.

Category—The hatchery was determined to fall into Category 1 (SSHAG 2003; Appendix B.5.3). The stock has not had out-of-basin introductions in recent years, and hatchery fish are excluded from the broodstock.

B.2.8 SOUTH-CENTRAL CALIFORNIA STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.8.1 Summary of Previous BRT Conclusions

The geographic range of the ESU was determined to extend from the Pajaro River basin in Monterey Bay south to, but not including, the Santa Maria River Basin near the town of Santa Maria. The ESU was separated from steelhead populations to the north on the basis of genetic data (mitochondrial DNA and allozymes), and from steelhead populations to the south on the basis of a general faunal transition in the vicinity of Point Conception. The genetic differentiation of steelhead populations within the same ESU, and the genetic differentiation between ESUs, appears to be greater in the south than in Northern California or the Pacific Northwest; however the conclusion is based on genetic data from a small number of populations.

Summary of major risks and status indicators

Risks and limiting factors—Numerous minor habitat blockages were considered likely throughout the region; other typical problems were thought to be dewatering from irrigation and urban water diversions, and habitat degradation in the form of logging on steep erosive slopes, agricultural and urban development on floodplains and riparian areas, and artificial breaching of estuaries during periods when they are normally closed off from the ocean by a sandbar.

Status indicators—Historical data on this ESU are sparse. In the mid 1960s, the CDFG (1965) estimated that the ESU-wide run size was about 17,750 adults. No comparable recent estimate exists; however, recent estimates exist for five river systems (Pajaro, Salinas, Carmel, Little Sur, and Big Sur), indicating runs of fewer than 500 adults where previously runs had been on the order of 4,750 adults (CDFG 1965). Time-series data only existed for one basin (the Carmel River), and indicated a decline of 22% per year over the interval 1963 to 1993 (see below for a review of this conclusion).

Many of the streams were thought to have somewhat to highly impassable barriers, both natural and anthropogenic, and in their upper reaches to harbor populations of resident trout. The relationship between anadromous and resident *O. mykiss* is poorly understood in this ESU, but was thought to play an important role in its population dynamics and evolutionary potential. A status review update conducted in 1997 (NMFS 1997) listed numerous reports of juvenile *O. mykiss* in many coastal basins; but noted that the implications for adult numbers were unclear. They also discussed the fact that certain inland basins (the Salinas and Pajaro systems) are rather different ecologically from coastal basins.

Previous BRT Conclusions

The original BRT (Busby et al. 1996) concluded that the ESU was in danger of extinction, due to 1) low total abundance; and 2) downward trends in abundance in those stocks for which data existed. The negative effects of poor land-use practices and trout stocking were also noted. The major area of uncertainty was the lack of data on steelhead run sizes, past and present. The status review update (NMFS 1997) concluded that abundance had slightly increased in the years immediately preceding, but that overall abundance was still low relative to historical numbers. They also expressed a concern that high juvenile abundance and low adult abundance observed in some datasets suggested that many or most juveniles were potentially resident fish (i.e. rainbow trout). The BRT convened for the update was nearly split on whether the fish were in danger of extinction, or currently not endangered but likely to become so in the foreseeable future, with the latter view holding a slight majority.

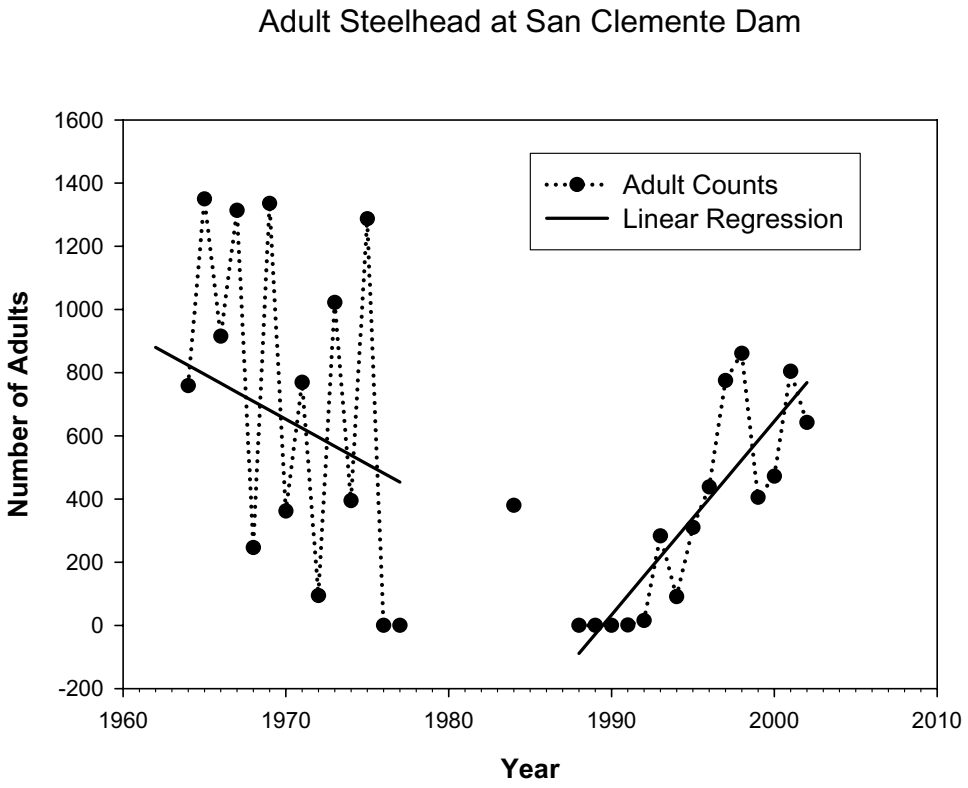


Figure B.2.8.1. Adult counts at San Clemente Dam, Carmel River. Data from the Monterey Peninsula Water Management District. See Snider (1983) for methods of counting fish before 1980; these early data are subject to substantial observation error (*N.B.* the regression line is not significantly different from flat). The increase during the 1990s followed a severe drought (and concurrent dewatering of the mainstem by a water district) in the late 1980s and early '90s.

Listing Status

The ESU was listed as threatened in 1997.

B.2.8.2 New Data and Updated Analyses

There are three new significant pieces of information: 1) updated time-series data concerning dam counts made on the Carmel River (MPWMD 2002) (See analyses section below for further discussion); 2) a comprehensive assessment of the current geographic distribution of *O. mykiss* within the ESU's historical range (Boughton & Fish MS; see next paragraph); and (3) changes in harvest regulations since the last status review (see next section).

Table B.2.8.1. Estimates of historical run sizes from the previous status review (Busby 1996).

River Basin	Run size estimate	Year	Reference
Pajaro R.	1,500	1964	McEwan and Jackson 1996
	1,000	1965	McEwan and Jackson 1996
	2,000	1966	McEwan and Jackson 1996
Carmel R.	20,000	1928	CACSS (1988)
	3,177	1964 – 1975	Snider (1983)
	2,000	1988	CACSS (1988)
	<4,000	1988	Meyer Resources (1988)

Current distribution vs. historical distribution—In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages between the northern and southern geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in any stream reach that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 36 drainages in which steelhead were known to have occurred historically, between 86% and 94% were currently occupied by *O. mykiss*. The range in the estimate of occupancy occurs because three basins could not be assessed due to restricted access. Of the vacant basins, two were considered to be vacant because they were dry in 2002, and one was found to be watered but a snorkel survey revealed no *O. mykiss*. One of the "dry" basins—Old Creek—is dry because no releases were made from Whale Rock Reservoir; however, a land-locked population of steelhead is known to occur in the reservoir above the dam.

Occupancy was also determined for 18 basins with no historical record of steelhead occurrence. Three of these basins—Los Osos, Vicente, and Villa Creeks—were found to be occupied by *O. mykiss*. It is somewhat surprising that no previous record of steelhead seems to exist for Los Osos Creek, near Morro Bay and San Luis Obispo.

The distribution of steelhead among the basins of the region is not much less than what occurred historically, so despite the widespread declines in habitat quality and population sizes, regional extirpations have not yet occurred. This conclusion rests on the assumption that juveniles inhabiting stream reaches with access to the ocean will undergo smoltification and thus are truly steelhead.

Three analyses are made below: 1) A critical review of the historical run sizes cited in the previous status review, 2) an assessment of recent trends observed in the adult counts being made on the Carmel River; and 3) a summary of new sport-fishing regulations in the region.

Review of historical run sizes—Estimates of historical sizes for a few runs were described in the previous status review (Busby et al. 1996), and are here reproduced in Table B.2.8.1.

The recent estimates for the Pajaro River (1,500, 1,000, 2,000) were reported in McEwan and Jackson (1996), but the methodology and dataset used to produce the estimates were not described. CACCS (1988) suggested an annual run size of 20,000 adults in the Carmel River of the 1920s, but gave no supporting evidence for the estimate. Their 1988 estimate of 2,000 adults also lacked supporting evidence. Meyer Resources (1988) provides an estimate of run size, but was not available for review at the time of this writing.

Snider (1983) examined the Carmel River and produced many useful data. In the abstract of his report he gave an estimate of 3,177 fish as the mean annual smolt production for 1964 through 1975; Busby et al. (1996) mistakenly cited this estimate as an estimate of run size. Snider's "3,177" figure may itself be a mistake, as it disagrees with the information in the body of the report, which estimates annual smolt production in the year 1973 as 2,708 smolts, and in the year 1974 as 2,043 smolts. Snider (1983) also gives adult counts for fish migrating upstream through the fish ladder at San Clemente Dam, for the years 1964 through 1975 (data were not reported in Busby et al. 1996; but were apparently the basis for the 22% decline reported by them. See Figure B.2.8.1 for the actual counts.). The mean run size from these data is 821 adults. To make these estimates, visual counts were made twice a day by reducing the flow through the ladder and counting the fish in each step; thus they may underestimate the run size by some unknown amount if fish moved completely through the ladder between counts (an electronic counter was used in 1974 and 1975 and presumably is more accurate). In addition, San Clemente Dam occurs 19.2 miles from the mouth of the river and a fraction of the run spawns below the dam (CDFG biologists estimate the fraction to be one third of the run, based on redd surveys).

Thus, much of the historical data used in the previous status review are highly uncertain. The most reliable data are the Carmel River dam counts, which were not reported in the previous status review. Further analysis of these data are described below.

Abundance in the Carmel River—The Carmel River data are the only time-series for the ESU. The data suggest that the abundance of adult spawners in the Carmel River has increased since the last status review (Figure B.2.8.1.). A continuous series of data exists for 1964 through 1977, although the data are probably incomplete to various degrees for each year (i.e. the counts are probably incomplete, and the year-to-year fluctuations may be mostly due to observation error rather than population variability). A regression line drawn through the data indicates a downward trend, but the trend is not statistically significant (slope = -28.45; $R^2 = 0.075$; $F = 1.137$; $p = 0.304$;). The 22% decline reported by Busby et al. (1996) is apparently based on these data in comparison with the low numbers of the early 1990s.

Continuous data have also been collected for the period 1988 through 2002. The beginning of this time series has counts of zero adults for three consecutive years, then shows a rapid increase in abundance. The trend is strongly upward (see Table B.2.6.3). The time series is too short to make a reliable estimate of mean lambda. The observed positive trend could conceivably be due either to improved conditions (i.e. mean lambda greater than one), substantial immigration or transplantation, or the transient effects of age structure. Improved conditions seem by far the most likely explanation, as the basin has been the subject of intensive fisheries management since the early 1990s. According to the Monterey Peninsula Water Management

District, the entity conducting much of the restoration of the basin's steelhead fishery, the likely reasons for the positive trend are due to improved conditions, namely

> "Improvements in streamflow patterns, due to favorable natural fluctuations…since 1995; …actively manag[ing] the rate and distribution of groundwater extractions and direct surface diversions within the basin; changes to Cal-Am's [dam] operations … providing increased streamflow below San Clemente Dam; improved conditions for fish passage at Los Padres and San Clemente Dams …; recovery of riparian habitats, tree cover along the stream, and increases in woody debris…; extensive rescues … of juvenile steelhead over the last ten years … ; transplantation of the younger juveniles to viable habitat upstream and of older smolts to the lagoon or ocean; and implementation of a captive broodstock program by Carmel River Steelhead Association and California Department of Fish & Game (CDFG), [including] planting … from 1991 to1994." (MPWMD 2001).

Even so, the rapid increase in adult abundance from 1991 (one adult) to 1997 (775 adults) seems too great to attribute simply to improved reproduction and survival of the local steelhead. There are a number of possibilities: substantial immigration or transplantation may have boosted abundance, or perhaps there was a large population of resident trout that has begun producing smolts at a higher rate under improved freshwater conditions. The transplantation hypothesis is thought unlikely: although transplantation of juveniles occurred (in the form of rescues from the lower mainstem during periods in which it was dewatered), CDFG biologists consider the scale of these efforts to be too small to effect the large increase in run size that has been observed. The scale of immigration (i.e. straying) is not known but may be a significant factor. As for the role of resident trout in producing smolts, the phenomenon is known to occur but the environmental triggers have not yet been worked out. One hypothesis, congruent with the Carmel River situation, is that environmental conditions affect growth rate of juveniles, which affects propensity to smolt into the anadromous form.

The rapid increase in adult abundance in the Carmel River system is thus very interesting. At this point two conclusions seem warranted: 1) Upon improvement of freshwater conditions such as those described above, the adult runs are capable of rapid increase in this ESU, due either to resilience of steelhead populations, high stray rates, or ability of resident trout to produce smolts. Either mechanism might allow the fish to rapidly take advantage of improved conditions, suggesting a high potential for rapid recovery in this ESU if the proper actions were taken. 2) Although some component of the increase is probably due to improved ocean conditions, it would be a mistake to assume comparable increases have occurred in other basins of the ESU, as they have not been the focus of such intensive management efforts.

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest of steelhead in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.), so effects on extinction risk are probably negligible. For freshwaters, CDFG (2002) describes the

current regulations. Summer trout fishing is allowed in some systems, often with a two- or five-bag limit. These include significant parts of the Salinas system (upper Arroyo Seco and Nacimiento above barriers; the upper Salinas; Salmon Creek; and the San Benito River in the Pajaro system (All: bag limit five trout). Also included in the summer fisheries is the Carmel River above Los Padres Dam (bag limit two trout, between 10" and 16"). A few other creeks have summer catch-and-release regulations. The original draft of the Fishery Management and Evaluation Plan (CDFG 2000) recommended complete closure of the Salinas system to protect the steelhead there, but the final regulations did not implement this recommendation, allowing both summer trout angling and winter-run catch-and-release steelhead angling in selected parts of the system (CDFG 2002).

The regulations allow catch-and-release winter-run steelhead angling in many of the river basins occupied by the ESU, specifying that all wild steelhead must be released unharmed. There are significant restrictions on timing, location, and gear used for angling. A recent draft Fisheries Evaluation and Management Plan (CDFG 2001b) has been prepared, and argues that the only mortality expected from a no-harvest fishery is from hooking and handling injury or stress. They estimate this mortality rate to be about 0.25% - 1.4%. This estimate is based on angler capture rates measured in other river systems throughout California (range: 5% - 28%), multiplied by an estimated mortality rate of 5% once a fish is hooked. The latter mortality estimate is consistent with a published meta-analysis of hooking mortality (Schill and Scarpella 1997), but experimental studies on the subject—from which the estimates are made—tend to measure mortality only for a period of a few days or a week after capture (e.g. Titus and Vanicek 1988).

The Fishery Management and Evaluation Plan contains no extensive plans for monitoring fish abundance. Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated quantitatively from the existing data, due to the fact that natural abundance is not being measured.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: There are four significant Category 3 populations within the original geographic range of the ESU (Appendix B.5.2)—two in the Salinas system, one behind Whale Rock Dam near Cayucos, and one behind the Lopez reservoir on Arroyo Grande Creek. The two in the Salinas system occur behind the dams on the Nacimiento and San Antonio Rivers, which currently block what were reported to be two of the three principal steelhead spawning areas in the basin (the other being in Arroyo Seco; Titus et al.

2003). Resident populations occur above these dams and stocking is ongoing (Appendix B.5.2). A third major barrier occurs in the headwaters of the Salinas itself; stocking currently occurs above this dam. Steelhead reportedly spawned in these streams before the dam was built, but the runs were probably relatively small and sporadic.

The Whale Rock Reservoir has a resident population that is reported to make steelhead-like runs up several tributaries for spawning. The reservoir has an associated hatchery program; see the previous section above for details on genetic studies, stocking records, *etc*.

According to David Starr Jordan, the area now blocked by the Lopez dam on Arroyo Grande Creek was originally well known as a significant steelhead area (cited in Titus et al. 2003). A resident population currently exists above this dam, and stocking is ongoing (Table B.5.1.1). We are not aware of any studies of the population's genetic affinities.

Minor barriers—defined here as blocking less than 100 sq. mi. of watershed—are numerous within the geographic range of the ESU. A nonzero number of Category 3 populations undoubtedly exist above these barriers but there are insufficient data at the present time to make a comprehensive assessment.

B.2.8.3. New Hatchery Information

The only hatchery stock being considered in this ESU is the one at Whale Rock Hatchery. This stock was assigned to one of three categories for the purpose of determining ESU membership at some future date (See "Artificial Propagation" in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignment, data about broodstock origin, size, management and genetics were gathered from fisheries biologists and are summarized below.

Whale Rock Hatchery (Whale Rock Steelhead [CDFG])

Whale Rock Reservoir was created in 1961 by placing a dam on Old Creek, 2 km upstream from the coast. Old Creek had supported a large steelhead run previous to construction of the dam and these fish were presumably trapped behind the dam (the creek is usually dewatered below the dam so no population occurs there at all). Whale Rock Hatchery was established in 1992 as an effort to improve the sport fishery in the reservoir after anglers reported a decline in fishing success. The original Whale Rock broodstock (40 fish) were collected at a temporary weir placed in the reservoir at the mouth of Old Creek Cove (Nielsen et al. 1997). Adult fish were trapped in the shallows of the reservoir using nets that are set during late winter and spring as the fish begin their migration upstream from the reservoir into Old Creek. The fish are held in an enclosure while they are monitored for ripeness. Eggs and sperm are collected from fish using non-lethal techniques, and then the adult fish are returned to the reservoir. Fish were originally hatched and raised at the Whale Rock Hatchery located below the dam at the maintenance facility, but are now raised at the Fillmore Hatchery in Ventura County. The fry are cared for until September or November at which time they are released back into the reservoir as 3-5" fingerling trout.

Broodstock origin and history—Hatchery operations began in 1992 and have been sporadic since. The project is a cooperative venture between CDFG and private parties. Fish were raised

in 1992, 1994, 2000, and 2002 (John Bell, personal communication). All broodstock are taken from the reservoir.

Broodstock size/natural population size—An average of 121 fish were spawned. Spawning success has been poor. There are no population estimates for the reservoir and the hatchery fish are not marked.

Management—The current program goal is to increase angling success in Whale Rock Reservoir.

Population genetics—Neilsen et al. (1997) found that significant genetic relatedness occurs between the Whale Rock Hatchery stock and wild steelhead in the Santa Ynez River and Malibu creeks, two basins to the south. She reported a loss of genetic diversity within the hatchery stock.

Category—The hatchery was determined to belong to Category 2 (SSHAG 2003; Appendix B.5.3). Broodstock are taken from the source population, but the small population could easily lead to significant genetic bottlenecks.

B.2.9 SOUTHERN CALIFORNIA STEELHEAD

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.9.1 Summary of Previous BRT Conclusions

The geographic range of the ESU was determined to extend from the Santa Maria River basin near the town of Santa Maria, south to the United States border with Mexico. There is a report of *O. mykiss* populations in Baja California del Norte (Ruiz-Campos and Pister 1995); these populations are thought to be resident trout, but could be found to have an anadromous component with further study (note that they do not lie within the jurisdiction of the Endangered Species Act). NMFS (1997) cites reports of several other steelhead populations south of the border. The southern California ESU is the extreme southern limit of the anadromous form of *O. mykiss*. It was separated from steelhead populations to the north on the basis of a general faunal transition (in the fauna of both freshwater and marine systems) in the vicinity of Point Conception. The genetic differentiation of steelhead populations within the ESU, and from other ESUs in northern California or the Pacific Northwest appears to be great; however the conclusion is based on genetic data from a small number of populations.

Summary of major risks and status indicators

Risks and limiting factors—The original BRT noted that there has been extensive loss of populations, especially south of Malibu Creek, due to urbanization, dewatering, channelization of creeks, human-made barriers to migration, and the introduction of exotic fish and riparian plants. Many of these southern-most populations may have originally been marginal or intermittent (i.e. exhibiting repeated local extinctions and recolonizations in bad and good years respectively). No hatchery production exists for the ESU. The relationship between anadromous and resident *O. mykiss* is poorly understood in this region, but likely plays an important role in population dynamics and evolutionary potential of the fish.

Status indicators—Historical data on the ESU were sparse. The historical run size for the ESU was roughly estimated to be at least 32,000-46,000 (estimates for the four systems comprising the Santa Ynez, Ventura, Santa Clara Rivers, and Malibu Creek; this omits the Santa Maria system and points south of Malibu Creek). Recent run sizes for the same four systems were roughly estimated to be less than 500 adults total. No time series data were found for any populations.

Previous BRT conclusions

The original BRT concluded that that ESU was in danger of extinction, noting that populations were extirpated from much of their historical range (Busby et al. 1996). There was strong concern about widespread degradation, destruction, and blockage of freshwater habitats, and concern about stocking of rainbow trout. The two major areas of uncertainty were 1) lack of data on run sizes, past and present; and 2) the relationship between resident and anadromous forms of the species in the region. A second BRT convened for an update (NMFS 1997) found

that the small amount of new data did not suggest that the situation had improved, and the majority view was that the ESU was still in danger of extinction.

Listing status

The ESU was listed as endangered in 1997. The original listing defined the ESU as having its southern geographic limits in Malibu Creek. Two small populations were subsequently discovered south of this point, and in 2002 a notice was published in the Federal Register, extending the range to include all steelhead found in drainages southward to the US border with Mexico.

B.2.9.2 New Data and Updated Analyses

There are four new significant pieces of information: 1) Four years of adult counts in the Santa Clara River; 2) observed recolonizations of vacant watersheds, notably Topanga Creek in Los Angeles county, and San Mateo Creek in Orange county; 3) a comprehensive assessment of the current distribution of *O. mykiss* within the historical range of the ESU (Boughton and Fish MS); and 4) changes in the harvest regulations of the sport fishery. Items (1), (2) and (4) are described further in the analyses section below; item (3) is described here:

Current distribution vs. historical distribution

In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages within the geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in any stream reach that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 46 drainages in which steelhead were known to have occurred historically, between 37% and 43% were still occupied by *O. mykiss*. The range in the estimate of occupancy occurs because a number of basins could not be surveyed due to logistical problems, pollution, or lack of permission to survey on private land. Three basins were considered vacant because they were dry, 17 were considered vacant due to impassable barriers below all spawning habitat; and six were considered vacant because a snorkel survey found no evidence of *O. mykiss*. These snorkel surveys consisted of spot checks in likely-looking habitat and did not involve a comprehensive assessment of each basin.

One of the “dry” basins—San Diego River—may have water in some tributaries—it was difficult to establish that the entire basin below the dam was completely dry. Numerous anecdotal accounts suggest that several of the basins that had complete barriers to anadromy may have landlocked populations of native steelhead/rainbow trout in the upper tributaries. These basins include the San Diego, Otay, San Gabriel, Santa Ana, and San Luis Rey Rivers. Occupancy was also determined for 17 basins with no historical record of steelhead occurrence; none were found to be currently occupied.

Nehlsen et al. (1991) listed the following Southern California stocks as extinct: Gaviota Creek, Rincon Creek, Los Angeles River, San Gabriel River, Santa Ana River, San Diego River, San Luis Rey River, San Mateo Creek, Santa Margarita River, Sweetwater River, and Maria Ygnacio River. The distributional study of 2002 determined that steelhead were present in two

of these systems, namely Gaviota Creek (Stoecker and CCP 2002) and San Mateo Creek (a recent colonization; see below). Nevertheless, the current distribution of steelhead among the basins of the region appears to be substantially less than what occurred historically. Except for the small population in San Mateo Creek in northern San Diego County, the anadromous form of the species appears to be completely extirpated from all systems between the Santa Monica Mountains and the Mexican border. Additional years of observations, either of presence or absence, would reduce the uncertainty of this conclusion.

Table B.2.9.1. Estimates from Busby et al. (1996), for run sizes in the major river systems of the southern steelhead ESU.

River basin	Run size estimate	Year	Reference
Santa Ynez	20,000 – 30,000	Historic	Reavis (1991)
	12,995 – 25,032	1940s	Shapovalov & Taft (1954)
	20,000	Historic	Titus et al (MS)
	20,000	1952	CDFG (1982)
Ventura	4,000-6,000	Historic	AFS (1991)
	4,000-6,000	Historic	Hunt et al. (1992)
	4,000-6,000	Historic	Henke (1994)
	4,000-6,000	Historic	Titus et al. (MS)
Matilija Cr.	2,000 – 2,500	Historic	Clanton & Jarvis (1946)
Santa Clara	7,000 – 9,000	Historic	Moore (1980)
	9,000	Historic	Comstock (1992)
	9,000	Historic	Henke (1994)

Recent colonization events

Several colonization events were reported during the interval 1996-2002. Steelhead colonized Topanga Creek in 1998 and San Mateo Creek in 1997 (R. Dagit, T. Hovey, pers. comm.). As of this writing (October 2002) both colonizations persist although the San Mateo Creek colonization appears to be declining. T. Hovey (CDFG, pers. comm.) used genetic analyses to establish that the colonization in San Mateo Creek was made by two spawning pairs in 1997. In the summer of 2002 a dead mature female was found in the channelized portion of the San Gabriel River in the Los Angeles area (M. Larsen, CDFG, pers. comm.). A single live adult was found trapped and over-summering in a small watered stretch of Arroyo Sequit in the Santa Monica Mountains (K. Pipal and D. Boughton, UCSC and NMFS, pers. comm.). The "run sizes" of these colonization attempts are of the same order as recent "run sizes" in the Santa Clara system—namely, less than five adults per year. Each of the four colonization events reported above occurred in a basin in which the presence of steelhead had been documented historically (Titus et al. MS).

Two significant analyses exist: 1) A critical review of the historical run sizes cited in the previous status review, and 2) A few new data on run size and population distribution in three of the larger basins.

Review of historical run sizes

Few quantitative data exist on historical run sizes of southern steelhead. Based on the available information at the time, the previous status review made rough estimates for three of the large river systems (Table B.2.9.1), and a few of the smaller ones (Busby et al. 1996).

The Santa Ynez.—The run size in the Santa Ynez system—probably the largest run historically—was estimated to originally lie between 20,000 and 30,000 spawners (Busby et al. 1996). This estimate was based primarily on four references cited in the status review: Reavis (1991) (20,000-30,000 spawners), Titus et al. (MS) (20,000 spawners), Shapovalov and Taft (1954) (12,995-25,032 spawners), and CDFG (1982) (20,000 spawners). Examination of these references revealed the following: Reavis (1991) asserted a run size of 20,000-30,000, but provided no supporting evidence. Titus et al. (MS) reviewed evidence described by Shapovalov (1944), to be described below. Shapovalov and Taft (1954) did not address run sizes in this geographic region; the citation is probably a mis-citation for Shapovalov (1944). CDFG (1982) makes no reference to salmonid fishes in southern California.

Entrix (1995) argued that the estimate of 20,000 – 30,000 is too large. They argued that the only direct observations of run size are from Shapovalov (1944), an assertion that appears to be correct. These data are based on a CDFG employee's visual estimate that the 1944 run was "at least as large" as runs in the Eel River (northern California), which the employee had observed in previous years. Estimated run sizes for the Eel River ranged between 12,995 and 25,032 during the years 1939 to 1944 (Shapovalov 1944), and this has thus been reported as the estimated run size of the Santa Ynez. Entrix (1995) observed, however, that the employee who made the comparison was only present at the Eel River during two seasons, 1938-39 and 1939-40. The estimates for run sizes in those years were 12,995 and 14,476 respectively, which suggests that a more realistic estimate for the Santa Ynez run of 1944 would be 13,000-14,500. Taking this chain of reasoning to its logical conclusion, the range 13,000 – 14,500 should be regarded as a minimum run size for the year in question, since the employee used the phrase "at least as large."

It is perhaps useful to place the year 1944 in context, since expert opinion about run size is based solely on observations made in that year. Entrix (1995) report that 1944 occurred toward the end of a wet period, which may have provided especially favorable spawning and rearing conditions for steelhead. Rainfall data from Santa Barbara County's historical records give a different picture from Entrix (1995): only two of the preceding eight years (1940 and 1943) were wetter than the 107-year average for the area (M. Capelli, person. comm.). 1944 was near average; otherwise rainfall was below average.

In addition, the year 1944 seems to have occurred toward the end of a period in which extensive rescues of juvenile steelhead had been made during low-flow years (Shapovalov 1944, Titus et al. MS). Over the interval 1939-1946, a total of 4.3 million juveniles were rescued from drying portions of the mainstem, and usually replanted elsewhere in the system. This averages to about 61,400 juveniles rescued per year. Assuming that rescue operations lowered the mean mortality rate as intended, during the 1939-1946 interval the Santa Ynez population may have increased somewhat (or failed to undergo a decline) due to the rescue operations. A rough estimate of magnitude can be made: Assuming deterministic population growth (as opposed to stochastic), and a survival to spawning of about 1%, the rescues would have increased the run size by about 4% per generation. High environmental stochasticity in survival of the rescued fish and in the overall population growth—which almost certainly was the case—would have reduced the effect size to be much lower than 4%.

There is a counter argument to the argument that the 1944 estimate is too high; namely that it is too low. The estimate was not made until 24 years after a significant proportion of spawning and rearing habitat had been blocked behind dams. The Santa Ynez system currently has three major dams on the mainstem that block portions of spawning and rearing habitat. The middle dam (Gibraltar) was built in 1920, and blocked access to 721 kilometers of stream, much of which was widely regarded to be high-quality spawning and rearing habitat (Table B.5.1.1; Titus et al MS). At that time, no estimates of run size had been made for the Santa Ynez. An upper dam (Juncal) was constructed in 1930 and may have had a negative effect on run size through reduction of flows to the lower mainstem. Only the lower dam (Cachuma or Bradbury) was built late enough (1953) to not cause the 1944 estimate to be a biased estimate of historical run size.

Ventura.—According to Titus et al. (MS), the Ventura River was estimated to have a run size of 4,000-5,000 adults during a normal water year. This estimate was made in 1946, although it is likely that the estimate is an expert opinion based on numerous years of observation. The system had received numerous plantings of juveniles in the preceding period (27,200 in 1943, 20,800 in 1944, and 45,440 in 1945, as well as 40,000 in 1930, 34,000 in 1931, and 15,000 in 1938). These rescues probably had small effect, for similar reason as those cited above for the Santa Ynez. As in the Santa Ynez, anecdotal accounts suggest that run sizes declined precipitously during the late 1940s and 1950s, due possibly to both drought and to anthropogenic changes to the river system such as dam construction. Similar considerations apply to the estimate made by Clanton and Jarvis (1946), of 2,000-2,500 adults in the Matilija basin, a major tributary of the Ventura River.

Santa Clara.—Moore's (1980) estimate of 9,000 spawners in the Santa Clara basin is an extrapolation of the estimate of Clanton and Jarvis' (1946) estimate for Matilija Creek. He assumed similar levels of production per stream mile in the two systems, and noted that at least five-times more spawning and rearing habitat exists in the Santa Clara. Moore (1980) regarded his estimate as biased downward, because although it included the major spawning areas (Santa Paula, Sespe, and Piru creeks), it omitted numerous small side-tributaries.

Ed Henke (cited in NMFS 1997) stated that abundance of steelhead in the Southern California ESU was probably about 250,000 adults prior to European settlement of the region. His argument is based on historical methods of research involving interviews of older residents of the area as well as written records. The original analysis producing the cited estimate is part of ongoing research and was not made available for review at the time of this writing (E. Henke, pers. comm.).

In summary, the estimates of historical run sizes for this steelhead ESU are based on very sparse data and long chains of assumptions that are plausible but have not been adequately tested. It seems reasonable to say that the existing estimates are biased upward or downward by some unknown amount. It is certainly clear from the historical record that adult run sizes of the past could be 2 or 3 orders of magnitude greater in size than those of recent years, but the long-term mean or variance in run size is not known with any reasonable precision at all. Assuming that spawning and rearing success are related to rainfall, the variance between years was likely high due to climatic variability in southern California; and variance among decades high due to the Pacific Decadal Oscillation. In addition, long-term climate change in the region likely causes

the running mean of run size (whatever it may be) to exhibit drift over time. If one were to be interested in the true potential productivity of these systems, much would be learned by some targeted field studies on the current habitat-productivity relationships for the fish, and by studies of the influence of climate, water management practices, and their interaction. It does not seem likely that further historical research will turn up information useful for making more refined estimates, despite the fact that it is useful for determining where exactly the fish occurred.

Recent run sizes of large river systems

It seems likely that the larger river systems were originally the mainstay of the ESU. Large river systems that harbored steelhead populations in the past are (from north to south) the Santa Maria, the Santa Ynez, the Ventura, the Santa Clara, the Los Angeles, the San Gabriel, the Santa Ana, and possibly the San Diego. Of these eight systems, the data suggest that steelhead currently occur in only four—the Santa Maria, Santa Ynez, Ventura, and Santa Clara.

The Santa Maria—There do not appear to be any estimates for recent run sizes in the Santa Maria system. Twitchell Dam blocks access to a significant proportion of historical spawning habitat, the Cuyama River, one of the two major branches of the Santa Maria. The other major branch, the Sisquoc River, appears to still have substantial spawning and rearing habitat that is accessible from the ocean; juvenile steelhead have recently been observed in these areas (Cardenas 1996, Kevin Cooper, Los Padres NF, pers. comm.).

The Santa Ynez—Most of the historical spawning habitat is blocked by Cachuma and Gibraltar Dams. However, extensive documentation exists for steelhead/rainbow trout populations in a number of ocean-accessible sites below Cachuma dam (Table B.2.9.2). These are Salsipuedes/El Jaro Creeks, Hilton Creek, Alisal Creek, Quiota Creek, San Miguelito Creek, and three reaches in the mainstem (Hanson 1996, Engblom 1997, 1999, 2001). Various life stages of steelhead, including upstream migrants and smolts, have been consistently observed at some of these sites (see Table B.2.9.2), suggesting the occurrence of persistent populations. Run sizes are unknown, but likely small (<100 adults total), implying the populations are not viable over the long term. A third dam, Juncal Dam, occurs above the other two dam in the watershed, and is reported to support a small population of land-locked steelhead that annually enter the reservoirs' tributaries to spawn (M. Capelli, pers. comm.)

The Ventura—There are no estimates of recent run sizes in the Ventura River. Casitas Dam on Coyote Creek and Matilija Dam on Matilija Creek block access to significant portions of the historical spawning habitat. There are recent individual reports of sightings of steelhead in the Ventura River and San Antonio Creek (M Capelli, 1997; C. Zimmerman 2000, 2001), but no quantitative estimates.

The Santa Clara—A few estimates of recent run sizes exist for the Santa Clara system, due to the presence of a fish ladder and counting trap at the Vern Freeman Diversion Dam on the mainstem. This diversion dam lies between the ocean and what is widely believed to be one of the largest extant populations of steelhead in the ESU (the Sespe Canyon population). The run size of upstream migrants was one adult in each of 1994 and 1995, two adults in 1996, and no adults in 1997. No data have been collected since that date, and the fish ladder is thought to be dysfunctional.

Harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that may potentially reduce extinction risk for the ESU.

Sport harvest of steelhead in the ocean is currently prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.). For freshwaters (CDFG 2002b), summer-fall catch-and-release angling is allowed in Piru Creek below the dam; San Juan Creek (Orange County); San Mateo Creek (one section); Santa Margarita River and tributaries; and Topanga Creek. Year-round catch and release is allowed in the San Gabriel River (below Cogswell Dam); and Sespe Creek and tributaries. All the above are historical steelhead streams and many of the stretches open to fishing are potentially used both by anadromous runs and by resident populations.

Year-round trout fisheries are allowed in Calleguas Creek and tributaries (limit 5); Piru Creek above the dam (limit 2); San Luis Rey River (limit 5); Santa Paula Creek above the falls (limit 5); the Santa Ynez River above Gibraltar Dam (limit 2); Sisquoc River (limit 5); and Sweetwater River (limit 5). With the exception of the Sisquoc River, these take-fisheries appear to be isolated from the ocean by natural or human-made barriers. Except for Calleguas Creek and possibly the Sweetwater, the above drainages are listed as historical steelhead streams by Titus et al. (MS). It is certainly possible and indeed likely that some currently harbor native trout with the potential to exhibit anadromy

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG monitors angling effort and catch-per-unit-effort in selected basins by way of a "report card" system in which sport anglers self-report their catch, gear used, and so forth, and in selected other basins by way of creel censuses.

Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated quantitatively from the existing datasets (due to the fact that natural abundance is not being estimated). After the Federal listing decisions, NMFS requested that CDFG prepare a Fishery Management and Evaluation Plan (FMEP) for the listed steelhead ESUs in California. This has not yet been done for the southern California ESU, so the rationale for the set of regulations summarized above is not transparent.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations

in the ESU (see Table B.5.1.1) revealed the following: There are numerous Category 3 populations within the original geographic range of the Southern California ESU. All of the larger watersheds originally inhabited by the ESU now have major barriers completely blocking substantial portions of habitat (Table B.5.1.1; a major barrier is defined as a complete barrier to migration that has greater than 100 sq. mi. of watershed area lying above it). In the watershed of the Santa Maria River, 71% of total stream kilometers are above Twitchell Dam. The Santa Clara watershed has 99% of stream kilometers above Vern Freeman diversion dam. This facility has a fish ladder, but the ladder is currently dysfunctional due to channel migration which has disconnected the ladder intake from the river's thalweg, combined with deficient quantities and configurations of water releases through the facility (M. Whitman, CDFG hydraulic engineer, personal communication). The Santa Ynez watershed, which probably originally harbored the strongest run of steelhead in the southern California ESU, has 58% of its stream kilometers above Cachuma dam. In each of these cases the historical record has reports of steelhead ascending to and spawning in areas that are now blocked behind the above-mentioned dams (Titus et al. 2003). In the case of the Santa Ynez, adult *O. mykiss* have been observed to make "steelhead-like" runs from the uppermost reservoir (behind Juncal dam) into the North Fork Juncal and the upper Santa Ynez for at least the past seven years (personal communication, Louis Andolora, dam tender at Juncal).

All the large watersheds further south have major barriers blocking substantial portions of stream habitat. Consequently, in the set of major watersheds originally inhabited by the ESU, at least 48% of stream kilometers are now behind barriers impassable to anadromous fish (the value is probably somewhat higher due to minor barriers not considered in Table B.5.1.1). At least 11 of these 15 major watersheds are known to have resident populations above the barriers (Table B.5.1.1).

We do not know much about the genetic relationships of these resident populations. There is one study of genetic relationships among hatchery stocks, anadromous fish, and resident populations above barriers (Nielsen et al. 1997). The study used selectively-neutral genetic markers to assess genetic distances among the various categories of fish (anadromous, residualized, hatchery, etc.) but the results were inconclusive. However, according to the provisional survey described in Table B.5.1.1, at least 7 of the 11 watersheds with resident populations above major barriers are currently being stocked with hatchery fish. It is not clear whether these stocked fish have successfully interbred with the native fish; whether such interbreeding would have led to significant gene flow between the introduced and native fish; or to what extent the local adaptations of the native fish would have been maintained by selection even if gene flow occurred.

Table B.2.9.2. Presence of steelhead in the lower Santa Ynez River system (*caught in upstream migrant trap).

Tributary	Redds	<6"	>6"	Smolts	Adults	Unspec	Year (spr.)	Source
Salsipuedes/El Jaro		Y	Y	Y	Y*		1994	Hanson 1996
				Y	Y*		1995	Hanson 1996
	Y	Y	Y	Y	Y*		1996	Hanson 1996, Engblom 1997
	Y	Y	Y	Y	Y*		1997	Engblom 1997
	Y	Y	Y		Y*		1998	Engblom 1999
	Y	Y	Y		Y*		1999	Engblom 1999
					Y*		2000	Engblom 2001
		Y	Y	Y	Y*		2001	Engblom 2001
Hilton Creek		N	N		Y*		1994	Hanson 1996
		Y	Y†	Y	Y*		1995	Hanson 1996
				N	Y*		1996	Hanson 1996, Engblom 1997
	N	Y	Y	N	Y*		1997	Engblom 1997
	Y	Y			Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
		Y	Y		Y*		2001	Engblom 2001
Alisal Creek		Y	Y		Y*		1995	Hanson 1996
Nojoqui Creek		N	N		N*		1994	Hanson 1996
				N	N*		1995	Hanson 1996
				N			1997	Engblom 1997
		N	Y		Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
Quiota Creek (& trib)	Y		Y		N*		1995	Hanson 1996
		Y	Y				1994	Hanson 1996
		Y					1998	Engblom 1999
		Y	Y				2001	Engblom 2001
San Miguelito Creek		Y	Y				1996	Hanson 1996
	Y			Y			1997	Engblom 1997
		Y		N	N*		1998	Engblom 1999
	Y			N	N*		1999	Engblom 1999
Mainstem/Hwy 154		Y	Y				1995	Hanson 1996
		Y	Y				1996	Hanson 1996
					Y		1994	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y						1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Refugio		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y	N	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Alisal reach		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
		Y	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Cargasachi		N	N				1995	Hanson 1996
		N	N				1996	Hanson 1996

B.2.10 CALIFORNIA CENTRAL VALLEY STEELHEAD

Primary contributor: Steve Lindley
(Southwest Fisheries Science Center - Santa Cruz Lab)

B.2.10.1 Summary of Previous BRT Conclusions

Summary of major risk factors and status indicators

Steelhead were once widespread throughout the Central Valley (CACSS, 1998; Reynolds et al. 1993). Steelhead require cool water in which to oversummer, and much of this habitat is now above impassable dams. Where steelhead are still extant, natural populations subject to habitat degradation, including various effects of water development and land use practices. Concerns of the BRT included extirpation from most of historical range, a monotonic decline in the single available time series of abundance (Table B.2.10.1; Figure B.2.10.1), declining proportion of wild fish in spawning runs, substantial opportunity for deleterious interactions with hatchery fish (including out-of-basin origin stocks), various habitat problems, and no ongoing population assessments. Compared to most chinook salmon populations in the Central Valley, steelhead spawning above Red Bluff Diversion Dam (RBDD) had a fairly strong negative population growth rate and small population size at the time of last census (1993) (Figure B.2.10.2).

Table B.2.10.1. Summary statistics for Central Valley steelhead trend analyses. Numbers in parentheses are 0.90 confidence intervals. Threatened and endangered chinook salmon populations are shown for comparison. Note that for steelhead, the 5-yr geometric mean refers to the period ending in 1993. There is insufficient recent data to calculate a short-term trend in abundance.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	NA
Sacramento River winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

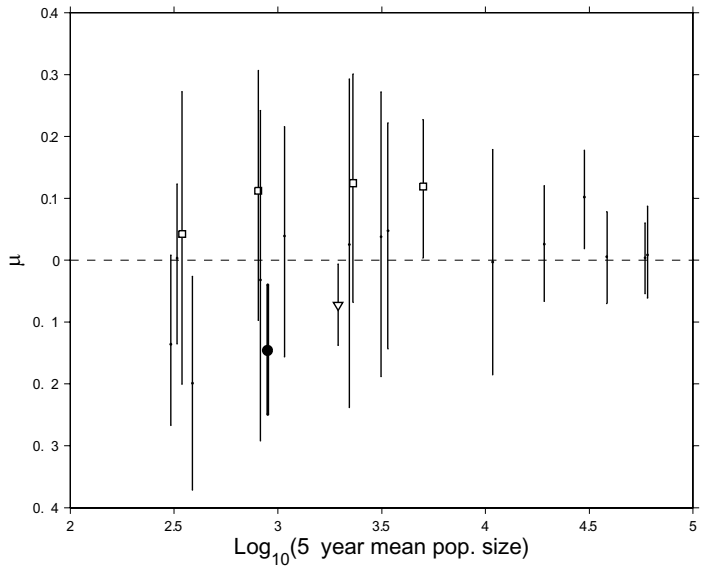


Figure B.2.10.1. Abundance and growth rate of Central Valley salmonid populations. Large filled circle- steelhead above RBDD; open squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, μ ≈log [λ].)

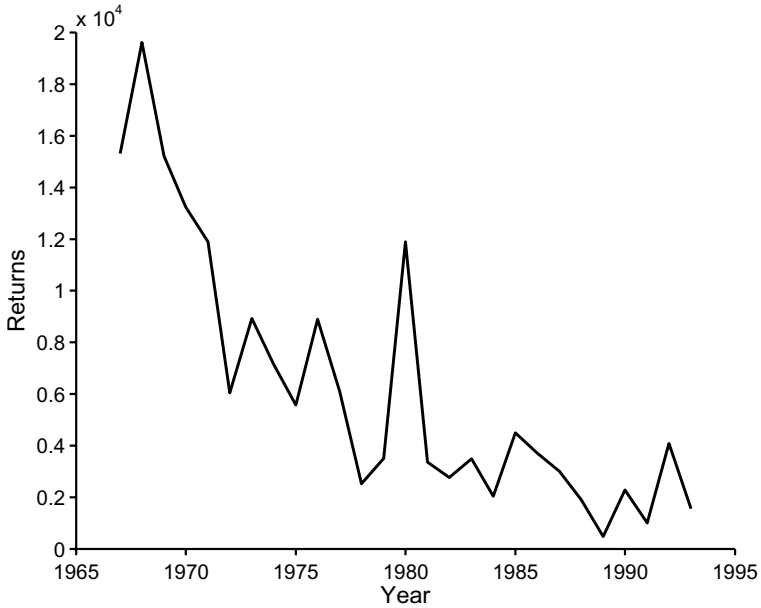


Figure B.2.10.2. Counts of steelhead passing the Red Bluff Diversion Dam fish ladders. These fish include hatchery fish from Coleman NFH.

Previous BRT Conclusions

The BRT previously concluded that the Central Valley ESU was in danger of extinction (Busby et al. 1996), and this opinion did not change in two status review updates (NMFS 1997; NMFS 1998a). The Nimbus Hatchery and Mokelumne River Hatchery steelhead stocks were excluded from the Central Valley ESU (NMFS 1998b).

Listing status

The Central Valley steelhead ESU was listed as Threatened on March 19, 1998.

B.2.10.2 New Data and Updated Analyses

Historic distribution and abundance

McEwan (2001) reviewed the status of Central Valley steelhead. Steelhead probably occurred from the McCloud River and other northern tributaries to Tulare Lake and the Kings River in the southern San Joaquin Valley. McEwan also guessed that more than 95% of historical spawning habitat is now inaccessible. He did not hazard a guess about current abundance. He guessed, on the basis of the fairly uncertain historical abundance estimates of Central Valley chinook reported by Yoshiyama et al. (1998), that between 1 million and 2 million steelhead may have once spawned in the Central Valley. McEwan's estimate is based on the observation that presently, steelhead are found in almost all systems where spring-run chinook salmon occur and can utilize elevations and gradients even more extreme than those used by spring chinook, as well as mid-elevation areas not used by spring chinook. Steelhead should therefore have had more freshwater habitat than spring chinook, and the sizes of steelhead populations should therefore have been roughly comparable those of spring chinook.

Current Abundance

One source of new abundance information since the last status review comes from midwater trawling below the confluence of the Sacramento and San Joaquin Rivers at Chipps Island. This trawling targets juvenile chinook; catches of steelhead are incidental. In a trawling season, over 2,000 20-minute tows are made. Trawling occurred from the beginning of August through the end of June in 1997/98 and 1998/99, after which trawling has occurred year-round. Usually, 10 tows are made per day, and trawling occurs several days per week.

Since the 1998 broodyear, all hatchery steelhead have been ad-clipped. Trawl catches of steelhead provide an estimate of the proportion of wild to hatchery fish, which, combined with estimates of basin-wide hatchery releases, provide an estimator for wild steelhead production:

$$N_w = \frac{C_w}{C_h} N_h \qquad (1)$$

where N_w is the number of wild steelhead, C_w and C_h are the total catches of wild and hatchery steelhead, and N_h is the number of hatchery fish released. The accuracy of the estimate depends on the assumption that hatchery and natural steelhead are equally vulnerable to the trawl gear. In particular, if hatchery fish are more vulnerable to the gear, natural production is underestimated.

Catches of steelhead are sporadic—most sets catch no steelhead, but a few sets catch up to four steelhead. To estimate the mean and variance of C_w / C_h, the trawl data sets were resampled with replacement 1,000 times. The mean C_w / C_h ranged from 0.06 to 0.30, and coefficients of variation ranged from 16% to 37% of the means.

From such calculations, it appears that about 100,000-300,000 steelhead juveniles (roughly, smolts) are produced naturally each year in the Central Valley (Table B.2.10.2). If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1% of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1million-2 million spawners before 1850, and 40,000 spawners in the 1960s. Table B.2.10.2 shows the effects of different assumptions about survival on estimates of female spawner abundance.

Table B.2.10.2. Estimated natural production of steelhead juveniles from the Central Valley. C_w/C_h = ratio of unclipped to clipped steelhead; N_r = total hatchery releases; N_w = estimated natural production; ESS = egg-to-smolt survival.

				wild female spawners		
Year	C_w/C_h	N_r (millions)	N_w (thousands)	ESS=1%	ESS=5%	ESS=10%
1998	0.300	1.12	336	6,720	1,344	672
1999	0.062	1.51	94	1,872	374	187
2000	0.083	1.38	115	2,291	458	229
average	0.148	1.34	181	3,628	726	363

Another source of information comes from screw trap operations at Knights Landing on the lower Sacramento River, just above the confluence of the Feather River (Snider and Titus 2000a, 2000b, 2000c). Over the period 1995-1999, estimates of the natural production for the areas above Knights Landing averaged 9,800 yearling steelhead outmigrants (range 7260-11,700). This level of production is about 5% of the total production as estimated above, and may be a substantial underestimate due to application of trap efficiency estimates generated from recaptures of marked chinook juveniles, which probably are less able to avoid traps.

Nobriga and Cadrett (2001) analyzed captures of steelhead in trawls at Chipps Island and in fish salvage facilities associated with water diversions in the southern Delta. They computed average daily catch of hatchery and wild steelhead per unit effort, and used these estimates to estimate the percentage of hatchery fish. They found that hatchery steelhead comprised 63-77% of the trawl catch of steelhead at Chipps Island (compared to 77-92% estimated from the resampling method described above), and generally lower percentages in the south Delta, which

is not surprising since the bulk of hatchery production comes out of Sacramento River basin. This alternative analysis of the Chipps Island trawl data suggests that wild steelhead are roughly three-fold more abundant than the resampling analysis discussed above.

Current Distribution

Recent spawner surveys of small Sacramento River tributaries (Mill, Deer, Antelope, Clear, and Beegum Creeks, Moore 2001) and incidental captures of juvenile steelhead during chinook monitoring (Calaveras, Cosumnes, Stanislaus, Tuolumne, and Merced Rivers) have confirmed that steelhead are widespread, if not abundant, throughout accessible streams and rivers. Much of this information is reviewed by McEwan (2001). Figure B.2.10.3 cartographically summarizes the information on distribution of steelhead in Central Valley streams; details are listed in Table B2.10.3.

CDFG (2003) reported trawl captures of *O. mykiss* at Mossdale on the lower San Joaquin River (below confluence of the Tuolumne, Stanislaus and Merced Rivers). Because the Mossdale area is not suitable habitat for resident *O. mykiss*, these fish are assumed to be steelhead smolts. Between 2 and 30 fish per year were captured in the 1988-2002 period. Rotary screw trap data suggests that the bulk of this production comes from the Stanislaus, although some smolts were captured in the Merced and Tuolumne as well.

Resident *O. mykiss* considerations

Coastal *O. mykiss* is widely distributed in the Central Valley basin. Roughly half of the trout habitat (by area) in the Central Valley is above dams that are impassable to fish; higher elevation habitats appear to support quite high densities of trout, ranging from a few hundred to a few thousand 4”—6” fish per km (see Appendix B.5.2).

There are several areas of substantial uncertainty that make interpreting this information difficult. First, it is not clear how anadromous and non-anadromous coastal *O. mykiss* interacted in the Central Valley before the dam-building era. In other systems, anadromous and non-anadromous *O. mykiss* forms can exist within populations, while in other systems, these groups can be reproductively isolated despite nearly sympatric distributions within rivers (Zimmerman and Reeves, 2000). Second, hatchery produced *O. mykiss* have been widely stocked throughout the Central Valley, Sierra Nevada and southern Cascades. It is possible that this stocking has had deleterious effects on native wild trout populations, although limited information indicates that native trout populations remain in some areas that have received stocked fish (Nielsen et al. 2000).

We suspect that some coastal *O. mykiss* populations that are above man-made barriers could be part of the Central Valley ESU, because these populations were probably exhibiting some degree of anadromy and interacting with each other on evolutionary time scales prior to barrier construction. Due to a lack of data, we cannot, however, identify any particular resident populations as part of the Central Valley ESU.

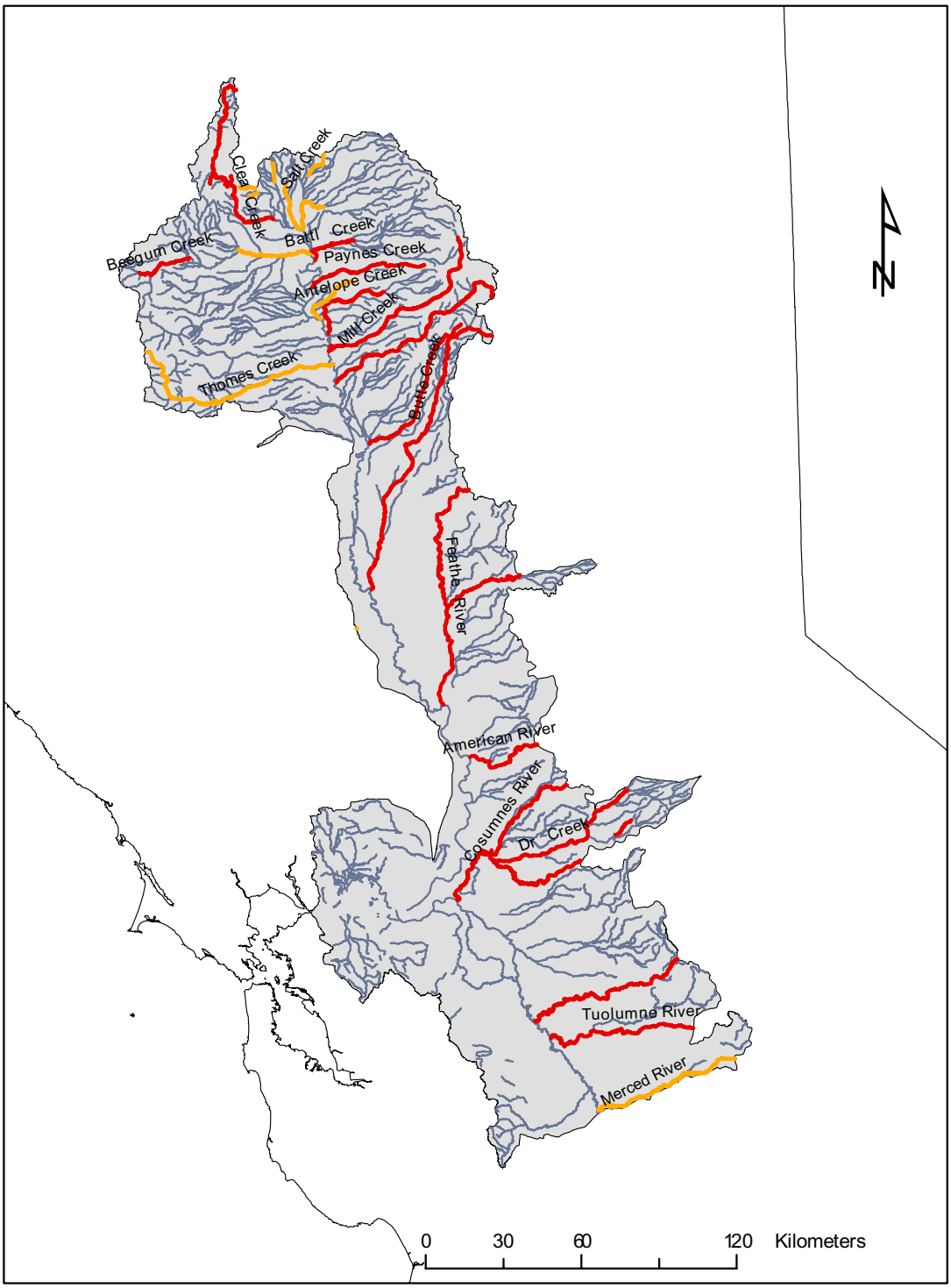


Figure B.2.10.3. Central Valley tributaries known (dark gray lines; bold font) or suspected (medium gray lines; normal font) to be used by steelhead adults. Kerrie Pipal (NMFS Santa Cruz Lab) assembled this information from agency and consultant reports and discussions with CDFG field biologists.

Table B.2.10.3. Summary of distribution information for steelhead in the Central Valley.

System	Tributary	Current presence	Most recent documented date of presence	Count / Life Stage	Comments	Source
Sacramento River	Clear Creek	Yes	2001	Adults/Juvs	Snorkel surveys and redd counts, rotary screw traps	Jess Newton (USFWS), personal communication, Aug 2002
	Rock Creek	Probable	2001	Adults/Juvs	Creek used for spawning	Mike Berry (CDFG), personal communication, Oct 2002.
	Salt Creek	Probable	2001	Adults/Juvs	Possible spawning; non-natal rearing	ibid
	Sulphur Creek	Probable	2001	Adults/Juvs	Creek used for spawning	ibid
	Olney Creek	Probable	2001	Adults/Juvs	Spawning, non-natal rearing	ibid
	Stillwater Creek	Probable	-	-	Non-natal rearing	ibid, Maslin 1998.
	Cow Creek + tribs	Probable	1992	-	Suitable habitat, access problems	CDFG 1993
	Cottonwood Creek	Probable	-	-		CDFG 1993
	Beegum Creek	Yes	2001	Adults		Moore 2001.
	South Fork Cottonwood Creek	Possible	-	-	Large populations of 'rainbow trout'	Mike Berry (CDFG), personal communication, Oct 2002.
	Bear Creek	Possible	-	-		CDFG 1993
	Battle Creek	Yes	2002	-		Kier & Associates 2001. Jess Newton (USFWS), personal communication, Aug 2002.
	Paynes Creek	Yes	2002	Adults	Self-sustaining population unlikely	Mike Berry (CDFG), personal communication, Oct 2002.
	Antelope Creek	Yes	2001	Adults + redds		Moore 2001.
	Mill Creek	Yes	2001	Adults + redds	Small numbers counted.	Moore 2001.
	Elder Creek	Possible	No recent surveys	-	Resident trout present	CDFG 1993

	Thomes Creek	Probable	1969 & 2002	-	Used by chinook, "trout" observed	Puckett 1969, Killam 2002, Mike Berry (CDFG), personal communication, Oct 2002.
	Deer Creek	Yes	2001	Adults + redds		Moore 2001
	Rice Creek	Yes	1998	Juveniles		Maslin 1998
	Big Chico Creek	Yes	-	-		CDFG 1993
	Butte Creek	Yes	2000	-	Report confirms steelhead presence, no details.	USFWS 2000
	Feather River	Yes	1998	YOY + Juvs	Screw trap captures	CDWR 1998
	Yuba River	Yes	1998	-	Report confirms steelhead presence, no details.	IEP 1998
	Deer Creek (Yuba trib)	Yes	1993	Adults	Dive survey	StreamNet database
	Dry Creek	Yes	-	-	Secret and Miners Ravines	R. Titus, CDFG
	American River	Yes	2002	Adults + redds	Counted redds, estimated number of adults based on redd counts.	Hannon and Healey 2002.
	Putah Creek	Yes	2000	-	Very small numbers of adult steelhead make their way to the base of Monticello dam	P. Moyle (UC Davis) public communication http://wdsroot.ucdavis.edu/clients/pcbr/book/04_Lake_Solano/04_04_moyle_fish_lowpc.html
San Joaquin River	Cosumnes River	Yes	1995	-	Smolts salvaged from drying pools	Nobriga 1995
	Mokelumne River	Yes	2001	Adults + juveniles		Workman 2001
	Calaveras River	Yes	2001	Adults + juveniles	Several reports list presence, but do not give any details; angler reports/photos.	Gonzalo Castillo, USFWS personal communication
	Stanislaus River	Yes	2001	YOYs & 1+		Kennedy 2002.
	Tuolumne River	Yes	2001	Juvs	Incidental rotary screw trap captures	CDFG 2003
	Merced River	Possible	2002	Juvs	Incidental rotary screw trap captures, large trout caught be anglers, enter hatchery	David Vogel (NRC), personal communication, June 2002. Michael Cozart (Merced River Hatchery), personal communication, Sept 2002.

Harvest Impacts

Steelhead are caught in freshwater recreational fisheries, and CDFG estimates the number of fish caught. Because the sizes of Central Valley steelhead populations are unknown, however, the impact of these fisheries is unknown. According to CDFG creel census, the great majority (93%) of steelhead catches occur on the American and Feather Rivers, sites of steelhead hatcheries (CDFG 2001). In 2000, 1,800 steelhead were retained and 14,300 were caught and released. The total number of steelhead contacted might be a significant fraction of basin-wide escapement, so even low catch-and-release mortality may pose a problem for wild populations. Additionally, steelhead juveniles may be affected by trout fisheries on some tributaries and the mainstem Sacramento.

The State of California's proposed Fishery Management and Evaluation Plan (part of the requirements to obtain ESA coverage for in-river sport fisheries) was recently rejected by NMFS mostly because of the inadequacy of existing and proposed monitoring of fisheries impacts.

B.2.10.3 New Hatchery Information

There is little new information pertaining to hatchery stocks of steelhead in the Central Valley. Figures B.2.10.4 and B.2.10.5 show the releases and returns of steelhead to and from Central Valley hatcheries. As discussed above in the section on new abundance information, hatchery steelhead juveniles dominate catches in the Chipps Island trawl, suggesting that hatchery production is large relative to natural production. Note that Mokelumne River Hatchery and Nimbus Hatchery stocks are not part of the CV ESU due to broodstock source and genetic, behavioral, and morphological similarity to Eel River stocks. Categorization of Central Valley steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.3.

B.2.10.4 Comparison with Previous Data

The few new pieces of information do not indicate a dramatic change in the status of the Central Valley ESU. The Chipps Island trawl data suggest that the population decline evident in the RBDD counts and the previously noted decline in the proportion of wild fish is continuing. The fundamental habitat problems are little changed, with the exception of some significant restoration actions on Butte Creek. There is still a nearly complete lack of steelhead monitoring in the Central Valley.

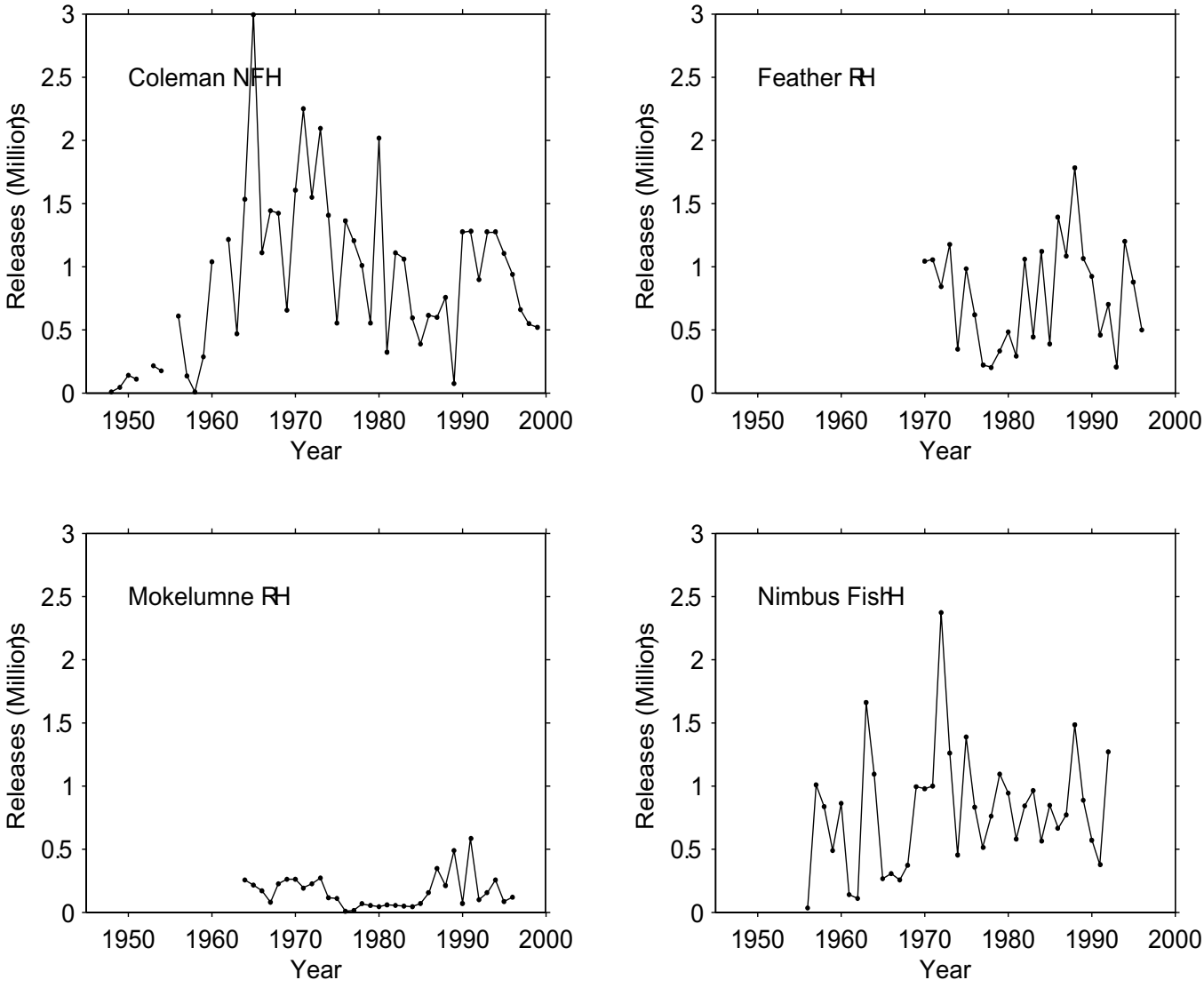


Figure B.2.10.4. Releases of steelhead from Central Valley hatcheries

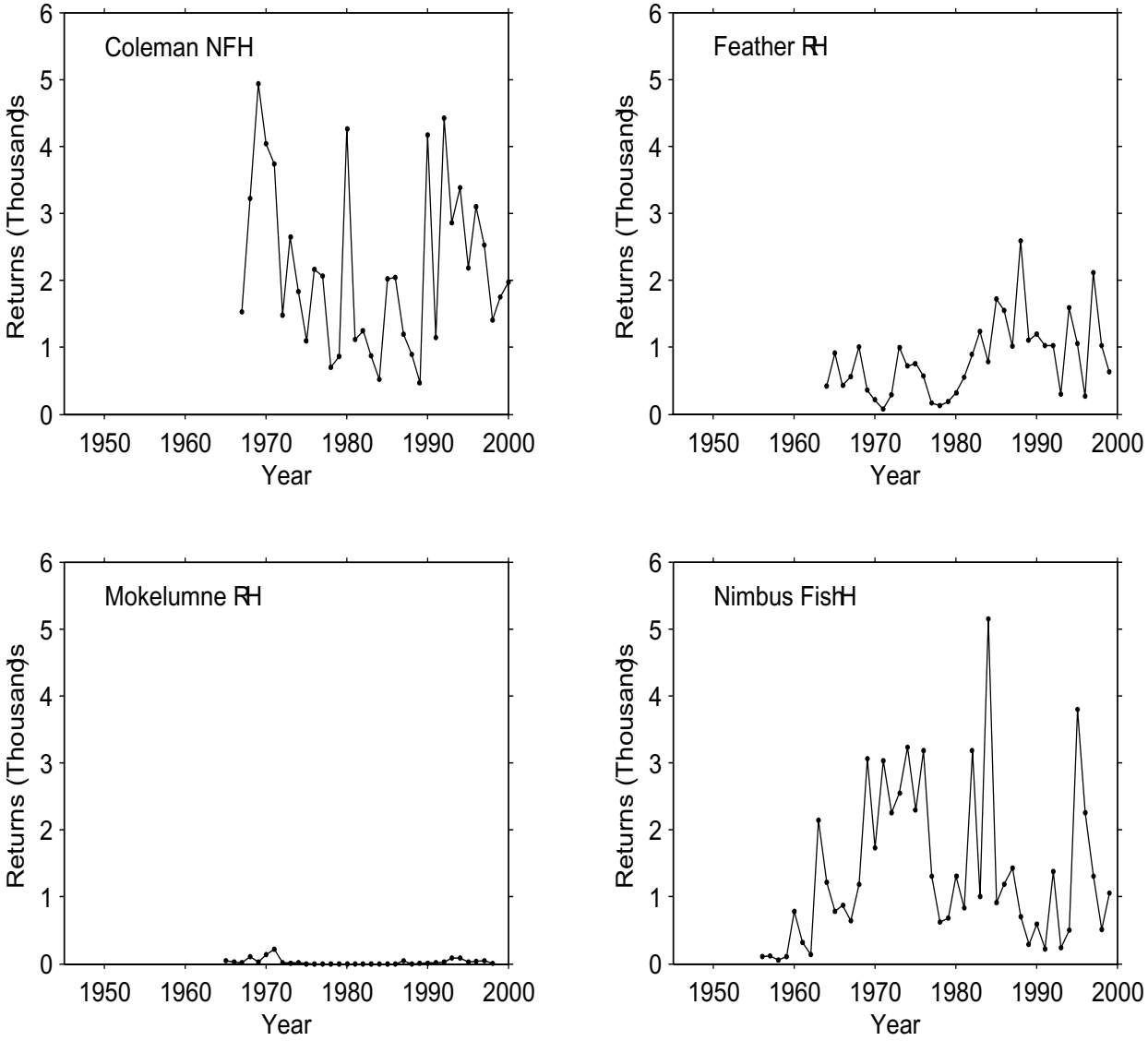


Figure B.2.10.5. Returns of steelhead to Central Valley hatcheries.

B.3 STEELHEAD BRT CONCLUSIONS

The ESA (Sec. 3) allows listing of "species, subspecies, and distinct population segments." The option to list subspecies is not available for Pacific salmon, since no formally recognized subspecies exist. However, a number of subspecies have been identified for *O. mykiss*, including two that occur in North America and have anadromous populations. According to Behnke (1992), *O. mykiss irideus* (the "coastal" subspecies) includes coastal populations from Alaska to California (including the Sacramento River), while *O. mykiss gairdneri* (the "inland" subspecies) includes populations from the interior Columbia, Snake and Fraser Rivers. Both subspecies thus include populations within the geographic range of this updated status review, but both also include northern populations outside the geographic range considered here. The BRT did not attempt to evaluate extinction risk to *O. mykiss* at the species or subspecies level; instead, we evaluated risk at the distinct population segment (ESU) level, as for the other species considered in this report.

Snake River steelhead ESU

A majority (over 70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for spatial structure to 3.2 for growth rate/productivity) (Table B.3.2). The continuing depressed status of B-run populations was a particular concern. Paucity of information on adult spawning escapements to specific tributary production areas makes a quantitative assessment of viability for this ESU difficult. As indicated in previous status reviews, the BRT remained concerned about the replacement of naturally produced fish by hatchery fish in this ESU; naturally produced fish now make up only a small fraction of the total adult run. Again, lack of key information considerably complicates the risk analysis. Although several large production hatcheries for steelhead occur throughout this ESU, relatively few data exist regarding the numbers and relative distribution of hatchery fish that spawn naturally, or the consequences of such spawnings when they do occur.

On a more positive note, sharp upturns in 2000 and 2001 in adult returns in some populations and evidence for high smolt-adult survival indicate that populations in this ESU are still capable of responding to favorable environmental conditions. In spite of the recent increases, however, abundance in most populations for which there are adequate data are well below interim recovery targets (NMFS 2002).

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Palouse and Malad Rivers) are not. Recent genetic data suggest that native resident *O. mykiss* above Dworshak Dam on the North Fork Clearwater River should be considered part of this ESU, but hatchery rainbow trout that have been introduced to that and other areas would not. The BRT did not attempt to resolve the ESU status of resident fish residing above the Hell's Canyon Dam complex, as little new information is available relevant to this issue. However, Kostow (2003) suggested that,

based on substantial ecological differences in habitat, the anadromous *O. mykiss* that historically occupied basins upstream of Hells Canyon (e.g., Powder, Burnt, Malheur, Owhyee rivers) may have been in a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Upper Columbia River steelhead ESU

A slight majority (54%) of the BRT votes for this ESU fell in the "danger of extinction" category, with most of the rest falling in the "likely to become endangered" category (Table B.3.1). The most serious risk identified for this ESU was growth rate/productivity (mean score 4.3); scores for the other VSP factors were also relatively high, ranging from 3.1 (spatial structure) to 3.6 (diversity) (Table B.3.2). The last 2-3 years have seen an encouraging increase in the number of naturally produced fish in this ESU. However, the recent mean abundance in the major basins is still only a fraction of interim recovery targets (NMFS 2002). Furthermore, overall adult returns are still dominated by hatchery fish, and detailed information is lacking regarding productivity of natural populations. The ratio of naturally produced adults to the number of parental spawners (including hatchery fish) remains low for upper Columbia steelhead. The BRT did not find data to suggest that the extremely low replacement rate of naturally spawning fish (estimated adult: adult ratio was only 0.25-0.3 at the time of the last status review update) has improved substantially.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Entiat, Methow, and perhaps Okanogan basins) are not. Resident fish potentially occur in all areas in the ESU used by steelhead. Case 3 resident fish above Conconully Dam are of uncertain ESU affinity. The BRT did not attempt to resolve the ESU status of resident fish residing above Grand Coulee Dam, as little new information is available relevant to this issue. Possible ESU scenarios for these fish include 1) they were historically part of the ESU and many of the remnant resident populations still are part of this ESU; 2) they were historically part of the ESU but no longer are, due to either introductions of hatchery rainbow trout or rapid evolution in a novel environment; or 3) they were historically part of a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Middle Columbia River steelhead ESU

A slight majority (51%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with a substantial minority (49%) falling in the "not likely to become endangered" category (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for diversity to 2.7 for abundance) (Table B.3.2).

This ESU proved difficult to evaluate for two reasons. First, the status of different populations within the ESU varies greatly. On the one hand the abundance in two major basins, the Deschutes and John Day, is relatively high and over the last five years is close to or slightly

over the interim recovery targets (NMFS 2002). On the other hand, steelhead in the Yakima basin, once a large producer of steelhead, remain severely depressed (10% of the interim recovery target), in spite of increases in the last 2 years. Furthermore, in recent years escapement to spawning grounds in the Deschutes River has been dominated by stray, out-of-basin (and largely out-of-ESU) fish—which raises substantial questions about genetic integrity and productivity of the Deschutes population. The John Day is the only basin of substantial size in which production is clearly driven by natural spawners. For the other major basin in the ESU (the Klickitat), no quantitative abundance information is available. The other difficult issue centered on how to evaluate contribution of resident fish, which according to Kostow (2003) and other sources are very common in this ESU and may greatly outnumber anadromous fish. The BRT concluded that the relatively abundant and widely distributed resident fish mitigated extinction risk in this ESU somewhat. However, due to significant threats to the anadromous component the majority of BRT members concluded the ESU was likely to become endangered.

Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in Deschutes and John Day basins) are not. Case 3 resident fish above Condit Dam in the Little White Salmon; above Pelton and Round Butte Dams (but below natural barriers) in the Deschutes; and above irrigation dams in the Umatilla Rivers are of uncertain ESU status.

Lower Columbia River steelhead ESU

A large majority (over 79%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT found moderate risks in all the VSP categories, with mean risk matrix scores ranging from 2.7 for spatial structure to 3.3 for both abundance and growth rate/productivity) (Table B.3.2). All of the major risk factors identified by previous BRTs still remain. Most populations are at relatively low abundance, and those with adequate data for modeling are estimated to have a relatively high extinction probability. Some populations, particularly summer run, have shown higher returns in the last 2-3 years. The Willamette Lower Columbia River TRT (Myers et al. 2002) has estimated that at least four historical populations are now extinct. The hatchery contribution to natural spawning remains high in many populations.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in upper Clackamas, Sandy, and some of the small tributaries of the Columbia River Gorge) are not. Case 3 resident fish above dams on the Cowlitz, Lewis, and Sandy Rivers are of uncertain ESU status.

Upper Willamette River steelhead ESU

The majority (over 76%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.6 for diversity to 2.9 for both spatial structure and growth rate/productivity) (Table B.3.2). On a positive note, after a decade in which overall abundance (Willamette Falls count) hovered around the lowest levels on record, adult returns for 2001 and 2002 were up significantly, on par with levels seen in the 1980s. Still, the total abundance is small for an entire ESU, resulting in a number of populations that are each at relatively low abundance. The recent increases are encouraging but it is uncertain whether they can be sustained. The BRT considered it a positive sign that releases of the "early" winter-run hatchery population have been discontinued, but remained concerned that releases of non-native summer-run steelhead continue.

Because coastal cutthroat trout is a dominant species in the basin, resident *O. mykiss* are not as widespread here as in areas east of the Cascades. Resident fish below barriers are found in the Pudding/Molalla, Lower Santiam, Calapooia, and Tualatin drainages, and these would be considered part of the steelhead ESU based on the provisional framework discussed in the general Introduction. Resident fish above Big Cliff and Detroit Dams on the North Fork Santiam and above Green Peter Dam on the South Fork Santiam are of uncertain ESU affinity. Although no obvious physical barrier separates populations upstream of the Calapooia from those lower in the basin, resident *O. mykiss* in these upper reaches of the Willamette basin are quite distinctive both phenotypically and genetically and are not considered part of the steelhead ESU.

Northern California steelhead ESU

The majority (74%) of BRT votes were for "likely to become endangered," with the remaining votes split about equally between "in danger of extinction" and "not warranted" (Table B.3.1). Abundance and productivity were of some concern (scores of 3.7; 3.3 in the risk matrix); spatial structure and diversity were of lower concern (scores of 2.2; 2.5); although at least one BRT member gave scores as high as 4 for each of these risk metrics (Table B.3.2).

The BRT considered the lack of data for this ESU to be a source of risk due to uncertainty. The lack of recent data is particularly acute for winter runs. While there are older data for several of the larger river systems that imply run sizes became much reduced since the early twentieth century, there are no recent data suggesting much of an improvement.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Northern California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Robert W. Matthews Dam on the Mad River and Scott Dam on the Eel River--but below natural barriers are of uncertain ESU affinity. In this ESU, the inclusion of resident fish would not greatly increase the total numbers of fish, and the resident fish have not been exposed to large amounts of hatchery stocking.

Central California Coast steelhead ESU

The majority (69%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). Abundance and productivity were of relatively high concern (mean score of 3.9 for each, with a range of 3 to 5 for each), and spatial structure was also of concern (score 3.6) (Table B.3.2). Predation by pinnipeds at river mouths and during the ocean phase was noted as a recent development posing significant risk.

There were no time-series data for this ESU. A variety of evidence suggested the largest run in the ESU (the Russian River winter steelhead run) has been reduced in size and continues to be reduced in size. Concern was also expressed about the populations in the southern part of the range of the ESU--notably populations in Santa Cruz County and the South Bay area.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Warm Springs Dam on Dry Creek, Russian River; Coyote Dam on the East Fork Russian River; Seeger Dam on Lagunitas Creek; Peters Dam on Nicasio Creek, Lagunitas Creek; and Standish Dam on Coyote Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, an estimated 22% of historical habitat is behind recent barriers. The only relevant biological information about the populations above these barriers pertains to Alameda Creek, and suggests that some but not all populations above Dam 1 are genetically similar to populations within the ESU. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

South-Central California Coast steelhead ESU

The majority (68%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). The strongest concern was for spatial structure (score 3.9; range 3-5), but abundance and productivity were also a concern (Table B.3.2). The cessation of plants to the ESU from the Big Creek Hatchery (Central Coast ESU) was noted as a positive development, whereas continued predation from sport fishers was considered a negative development.

New data suggests that populations of steelhead exist in most of the streams within the geographic boundaries of the ESU; however, the BRT was concerned that the two largest river systems—the Pajaro and Salinas basins—are much degraded and have steelhead runs much reduced in size. Concern was also expressed about the fact that these two large systems are ecologically distinct from the populations in the Big Sur area and San Luis Obispo County, and thus their degradation affects spatial structure and diversity of the ESU. Much discussion centered on the dataset from the Carmel River, including the effects of the drought in the 1980s, the current dependence of the population on intensive management of the river system, and the vulnerability of the population to future droughts.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South-Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including San Antonia, Nacimiento, and Salinas dams on the Salinas River; Los Padres Dam on the Carmel River; Whale Rock Dam on Old Creek; and Lopez Dam on Arroyo Grande Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, little of the historical habitat is behind recent barriers and most of that on the Salinas River. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Southern California steelhead ESU

The majority (81%) of BRT votes were for "in danger of extinction," with the remaining 19% of votes being for "likely to become endangered" (Table B.3.1). Extremely strong concern was expressed for abundance, productivity, and spatial structure (mean scores of 4.8, 4.3, and 4.8, respectively, in the risk matrix), and diversity was also of concern (mean score of 3.6) (Table B.3.2).

The BRT expressed concern about the lack of data on this ESU, about uncertainty as to the metapopulation dynamics in the southern part of the range of the ESU, and about the fish's nearly complete extirpation from the southern part of the range. Several members were concerned and uncertain about the relationship between the population in Sespe Canyon, which is supposedly a sizeable population, and the small run size passing through the Santa Clara River, which connects the Sespe to the ocean. There was some skepticism that flows in the Santa Maria River were sufficient to allow fish passage from the ocean to the Sisquoc River, another "stronghold" of *O. mykiss* in the ESU.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South California Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Twitchell Dam on the Cuyama River; Bradbury Dam on the Santa Ynez River; Casitas Dam on Coyote Creek, Ventura River; Matilija Dam on Matilija Creek, Ventura River; Santa Felicia Dam on Piru Creek, Santa Clara River; and Casitac Dam on Casitac Creek, Santa Clara River--but below natural barriers are of uncertain ESU affinity. In this ESU, a large portion of the original area is behind barriers, and the few density estimates that are available from this ESU indicate that the inclusion of area above recent barriers would substantially increase the number of fish in the ESU. Due to the extremely low numbers of anadromous fish in this ESU, it is possible that above-barrier populations contribute a significant number of fish to the below-barrier population by spill over. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

California Central Valley steelhead ESU

The majority (66%) of BRT votes were for "in danger of extinction", and the remainder was for "likely to become endangered" (Table B.3.1). Abundance, productivity and spatial structure were of highest concern (4.2-4.4), although diversity considerations were of significant concern (3.6) (Table B.3.2). All categories received a 5 from at least one BRT member.

The BRT was highly concerned by the fact that what little new information was available indicated that the monotonic decline in total abundance and in the proportion of wild fish in the ESU was continuing. Other major concerns included the loss of the vast majority of historical spawning areas above impassable dams, the lack of any steelhead-specific status monitoring, and the significant production of out-of-ESU steelhead by the Nimbus and Mokelumne River fish hatcheries. The BRT viewed the anadromous life-history form as a critical component of diversity within the ESU and did not place much importance on sparse information suggesting widespread and abundant *O. mykiss* populations in areas above impassable dams. Dams both reduce the scope for expression of the anadromous life-history form, thereby greatly reducing the abundance of anadromous *O. mykiss*, and prevent exchange of migrants among resident populations, a process presumably mediated by anadromous fish.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the California Central Valley Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Shasta Dam on the Upper Sacramento River; Whiskeytown Dam on Clear Creek; Black Butte Dam on Stony Creek; Oroville Dam on the Feather River; Englebright Dam on the Yuba River; Camp Far West Dam on the Bear River; Nimbus Dam on the American River; Commanche Dam on the Mokelumne River; New Hogan Dam on the Calaveras River; Goodwin Dam on the Stanislaus River; La Grange Dam on the Tuolumne River; and Crocker Diversion Dam on the Merced River--but below natural barriers are of uncertain ESU affinity. As noted above, collectively these dams have isolated a large fraction of historical steelhead habitat, and resident fish above the dams may outnumber ESU fish from below the dams.

Table B.3.1. Tally of FEMAT vote distribution regarding the status of 10 steelhead ESUs reviewed. Each of 16 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River[1]	14	103	23
Upper Columbia[1]	75	62	3
Middle Columbia[1]	1	71	68
Lower Columbia[2]	10	110	30
Upper Willamette[2]	7	106	37
Northern California	18	119	23
Central California Coast	40	111	9
South Central California	40	109	11
Southern California	129	31	0
Central Valley	106	54	0

[1] Votes tallied for 14 BRT members
[2] Votes tallied for 15 BRT members

Table B.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 10 steelhead ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River	3.1 (2-4)	3.2 (2-4)	2.5 (1-4)	3.1 (2-4)
Upper Columbia	3.5 (2-4)	4.3 (3-5)	3.1 (2-4)	3.6 (2-5)
Middle Columbia	2.7 (2-4)	2.6 (2-3)	2.6 (2-4)	2.5 (2-4)
Lower Columbia	3.3 (2-5)	3.3 (3-4)	2.7 (2-4)	3.0 (2-4)
Upper Willamette	2.8 (2-4)	2.9 (2-4)	2.9 (2-4)	2.6 (2-3)
Northern California	3.7 (3-5)	3.3 (2-4)	2.2 (1-4)	2.5 (1-4)
Central California Coast	3.9 (3-5)	3.9 (3-5)	3.6 (2-5)	2.8 (2-4)
South Central California	3.7 (2-5)	3.3 (2-4)	3.9 (3-5)	2.9 (2-4)
Southern California	4.8 (4-5)	4.3 (3-5)	4.8 (4-5)	3.6 (2-5)
Central Valley	4.4 (4-5)	4.3 (4-3)	4.2 (2-5)	3.6 (2-5)

B.4 REFERENCES

Adams, P. 2000. Memorandum to Rodney McInnis: Status review update for the steelhead northern California Evolutionarily Significant Unit. U.S. Dep. Commer., National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz/Tiburon Laboratory, Tiburon, California.

AFS (American Fisheries Society). 1991. Minutes of southern California steelhead meeting, US Fish and Wildlife Service Office, Ventura, California, January 22, 1991. Am. Fish. Soc., California-Nevada Chapter, Environmental Concerns Committee, 9 p. (Available from Trout Unlimited of California, 2530 San Pablo Ave., Suite D, Berkeley, CA 94702).

Alley, D. W., and Associates. 1994. Comparison of juvenile steelhead densities in 1981 and 1994 with estimates of total numbers of mainstem juveniles and expected numbers of adults returning to the San Lorenzo River, Soquel Creek and Corralitos Creek, Santa Cruz County, California. City of Santa Cruz Water Department, City of Watsonville Water Department Lompico County Water District San Lorenzo Valley Water District and Soquel Creek Water District. Project # 122-01, 123-01, 124-01, 125-01, Brookdale, California .

Alley, D. W., and Associates. 1995. Comparison of juvenile steelhead densities in 1981, 1994 and 1995 with an estimate of juvenile population size in the mainstem San Lorenzo River, with expected numbers of adults returning form juveniles reared in the mainstem river, Santa Cruz County, California. City of Santa Cruz Water Department, San Lorenzo Valley Water District and Lompico County Water District. Project # 135-01, 136-01. Brookdale, California.

Alley, D. W., and Associates. 1997. Comparison of juvenile steelhead densities in 1981 and 1994-96 in the San Lorenzo River and tributaries, with an estimate of juvenile population size in the mainstem river and expected adult returns from that production, Santa Cruz County, California. City of Santa Cruz Water Department and the San Lorenzo Valley Water District. Project # 143-01, 144-01. Brookdale, California.

Alley, D. W., and Associates. 1998. Comparison of juvenile steelhead densities in 1981 and 1994-97 in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size in the mainstem river and expected adult returns. City of Santa Cruz Water Department, and San Lorenzo Valley Water District. Project # 150-01. Brookdale, California .

Alley, D. W., and Associates. 1999. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1994-98; with predicted adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-02. Brookdale, California.

Alley, D. W., and Associates. 2000. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1995-99; with an index of adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-03. Brookdale, California.

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Project # 150-06. Brookdale, California .

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Draft report Project # 150-06. Brookdale, California .Anonymous. 1994. Oregon salmon and steelhead catch data, 1981-93. Unpublished.

Anonymous. 1995. 1995 Stock status review for winter steelhead, Mid-Willamette district, NW region.

Anonymous. 1997. ODFW Mid-Willamette Fish District unpublished files: winter steelhead Foster dam counts, Minto trap counts and run size estimates; Molalla R. spring chinook run size estimates through 1997.

Anonymous. 1998. Portland General Electric fish facility reports. Unpublished StreamNet Reference.

Anonymous. 1998. ODFW Columbia River Management unpublished files: Willamette Falls fish passage 1946-97.

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60), 21 p.

Behnke, R. J. 1992. Native trout of western North America. Am. Fish. Soc. Monog. 6, 275 p. American Fisheries Society, Bethesda, MD.

Berg, L (ed.). 2001. Yakima Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Berry, R. L. 1978. Salmon and steelhead sport catch statistics, 1978. Unpublished.

Bjornn, T. C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. Univ. Idaho, Coll. For., Wildl. Range Sci. Bull. 27, 57 p.

Boughton, D. A. and H. Fish. MS. The current regional distribution of steelhead (*Oncorhynchus mykiss*) in Southern California. Available from NOAA Fisheries, Southwest Science Center, 110 Shaffer Road, Santa Cruz, CA.

Brown, L. R. and P. B. Moyle. 1981. The impact of squawfish on salmonid populations: a review. N. Amer. J. Fish. Man. 1: 104 – 111.

Brown, L. R. and P. B. Moyle. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species. Environmental Biology of Fishes 49: 271 – 291.

Bryson, D. 2001. Draft Imnaha Subbasin Summary. Prepared for the Northwest Power Planning Council. 241 p.

Burgner, R. L., J. T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and origins of steelhead trout (*Oncorhynchus mykiss*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 51, 92 p.

Busby, P. J., O. W. Johnson, T. C. Wainwright, F. W. Waknitz, and R. S. Waples. 1993. Status review for Oregon s Illinois River winter steelhead. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-10, 85 p.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261p.

CACSS (California Advisory Committee on Salmon and Steelhead). 1988. Restoring the balance. Calif. Dep. Fish Game, Sacramento, CA. 84 p.

Cardenas, M. 1996. Upper Sisquoc River survey. CDFG Report.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan. Volume III supporting data: part B, inventory salmon-steelhead and marine resources. California Department of Fish and Game, Sacramento, California.679 p.

CDFG (California Department of Fish and Game). 1979. Nelson Creek wild trout management plan. California Department of Fish and Game, Sacramento, CA, 27 p.

CDFG (California Department of Fish and Game). 1982. 1982 status report of California wild and scenic rivers salmon and steelhead fisheries. Calif. Dept. Fish Game, Sacramento, CA, 159 p.

CDFG (California Department of Fish and Game). 1995. Letter to M. Schiewe for the ESA Administrative Record for west coast steelhead, dated 30 March 1995, 10 p. plus

attachments. (Avail. from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

CDFG (California Department of Fish and Game). 2000. Fishery management and evaluation plan, south-central California coast evolutionarily significant unit, steelhead, draft document. CDFG, Fisheries Programs Branch, 1416 Ninth Street, Sacramento, CA.

CDFG (California Department of Fish and Game). 2000. Fishery management plan for the Upper Sacramento River (Box Canyon Dam to Lake Shasta) 2000 to 2005. California Department of Fish and Game, Sacramento, CA, 52 p.

CDFG (California Department of Fish and Game). 2001. Fishery management plan, Central Valley, California Evolutionary Significant Unit, Steelhead. California Department of Fish and Game, Sacramento, CA, 59 p.

CDFG (California Department of Fish and Game). 2001a. Fishery management and evaluation plan, Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2001b. Fishery management and evaluation plan, South-Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2002. 2002 Freshwater sportfishing regulations booklet. Available from CDFG, 1416 Ninth Street, Room 1320, Sacramento, CA 95814. 70 pp.

CDFG (California Department of Fish and Game). 2003. Letter from D. Marston (CDFG) to M. Martinez (NMFS), dated January 9, 2003.

Chilcote, M. W. 1998. Conservation Status of Steelhead in Oregon. Information Report 98-3. Oregon Department of Fish and Wildlife.

Chilcote, M. W. 2001. Conservation Assessment of Steelhead Populations in Oregon. Oregon Department of Fish and Wildlife. Portland, OR.

Chilcote, M. W. 2002. Spreadsheet with 2002 Oregon steelhead escapement updates.

Cichosz, T., D. Saul, A. Davidson, W. Warren, D. Rollins, J. Willey, T. Tate, T. Papanicolaou and S. Juul. 2001. Clearwater Subbasin Summary. Draft submitted to the Northwest Power Planning Council. Nov. 2001. 477 p.

Clanton, D. A. and J. F. Jarvis. 1946. Memorandum to Bureau of Fish Conservation re: field inspection trip to the Matilija-Ventura watershed in relation to the construction of the proposed Matilija Dam, dated 8 May 1946. Calif. Dep. Nat. Resources., Div. Fish Game, 3 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Comstock, R. 1992. Santa Clara River steelhead restoration assessment. US Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington, 10 pp. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Cooney, T. 2001. Upper Columbia River steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary analysis of extinction risks. National Marine Fisheries Service. Hydro Program. Technical Review Draft

Cramer, D. 2002a. Portland General Electric - Clackamas winter steelhead adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Cramer, D. 2002b. Portland General Electric - sandy winter steelhead adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Cramer, S. P., and 12 co-authors. 1995. The status of steelhead populations in California in regards to the Endangered Species Act. Document prepared for Association of California Water Agencies, 167 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Cramer, S., R. Beamesderfer, P. Monk, K. Witty, A. Kalin, B. Lister & C. Akerman. 2002. Mid-Columbia steelhead trout population viability assessment. S.P. Cramer & Assoc. Progress Rept. Submitted to NMFS. April 2002.

CRFMP TAC (Columbia River Fisheries Management Plan Technical Advisory Committee). 1991. Summer steelhead. In Columbia River fish management plan: 1991 All species review. Technical Advisory Committee, U.S. v. Oregon. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Currens, K. P., S. L. Stone, and C. B. Schreck. 1987. A genetic comparison of rainbow trout (*Salmo gairdneri*) above and below Izee Falls in the John Day River, Oregon. Oregon Coop. Fish. Res. Unit Genet. Lab. Rep. 87(2), 34 p.

Currens, K. P., C. B. Schreck, and H. W. Li. 1990. Allozyme and morphological divergence of rainbow trout (*Oncorhynchus mykiss*) above and below waterfalls in the Deschutes River, Oregon. Copeia 1990:730-746.

Deinstadt, J. M., and Berry, M. A. 1999. California wild trout program, Hat Creek wild trout management plan, 1998 - 2003. California Department of Fish and Game, Sacramento, CA, 51 p.

Engblom, S. 1997. Compilation report for the 1996-97 Santa Ynez River Memorandum of understanding. SYRTAC.

Engblom, S. 1999. Compilation report for the 1998-99 Santa Ynez River Memorandum of understanding.

Engblom, S. 2001. 2001 Lower Santa Ynez River steelhead studies – annual report, Santa Barbara County, California.

Entrix. 1995. Historical steelhead run in the Santa Ynez River. Project No. 374100, prepared for Price Postel and Parma, 200 E. Carillo St., Santa Barbara, CA 93102.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, 48 p.

Foerster, R. E. 1947. Experiment to develop sea-run from land-locked sockeye salmon *(Oncorhynchus nerka kennerlyi*). J. Fish. Res. Board Can. 7(2):88-93.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and homing experiments on salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, in the Columbia River system: fish of the 1939-1944 broods. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC 12, 97 p.

Gephart, L. & D. Nordheim (eds) 2001. Tucannon Subbasin Summary. Prepared for the Northwest Power Planning Council. 222 pages.

Gorman, L. 2001. Hood steelhead at Powerdale dam. StreamNet Excel workbook provided to Paul McElhany from Leah Gorman 10/16/2001. This workbook is based on data provided by Rod French to ODFW/NMFS in the Microsoft Word file Data2000.doc on 7/31/2001.

Grass, A. 1995. Annual Report: Van Arsdale Fisheries Station, 1993-94. California Department of Fish and Game, Inland Fisheries. Administrative Report Number 95-5, 10p.

Griswold, K. E. 1996. Genetic and meristic relationships of coastal cutthroat trout (*Oncorhynchus clarki clarki*) residing above and below barriers in two coastal basins. M.S. Thesis, Oregon State Univ., Corvallis, OR, 83 p.

Hannon, J. and M. Healey. 2002. American River Steelhead Redd Surveys, 2001-2002. U. S. Bureau of Reclamation and California Department of Fish and Game. 19 p.

Hanson, C. H., J. Hagar, S. Englom, and B. Bemis. 1996. Synthesis and analysis of information collected on the fishery resources and habitat conditions of the lower Santa Ynez River: 1993 – 1996.

Harvey, B. C., J. L. White and R. J. Nakamoto. 2002. Habitat relationships and larval drift of native and nonindigenous fishes in neighboring tributaries of a coastal California river. Trans. Amer. Fish. Soc. 131: 159 – 170.

Henke, E. 1994. Letters to G. Bryant re: information on steelhead for the Administrative Record for west coast steelhead. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Hulett et al. 1995. Studies of hatchery and wild steelhead in the lower Columbia basin. Washington Department of Fish and Wildlife. Report #RAD 95-3.

Hunt, W. 1999. Calapooia River St W Spawning Surveys, Winter Steelhead Counts Upper Willamette River, Late-Run Winter Steelhead Run Size Estimates and St W Returns to Minto Trap. ODFW.

Hunt, L. E., P. E. Lehman, and M. H. Capelli. 1992. Vertebrate resources at Emma Wood State Park and the Ventura River estuary, Ventura County, California: Inventory and management. Calif. Dep. Parks Rec., document dated 6 November 1992, 107 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

IEP (Interagency Ecological Program Steelhead Project Workteam). 1998. Monitoring, assessment, and research on Central Valley steelhead: status of knowledge, review of existing programs, and assessment of needs. Available online at: http://calfed.ca.gov/programs/cmarp/a7a11.html

IDFG (Idaho Department of Fish and Game). 1994. Documents submitted to the ESA Administrative Record for west coast steelhead by E. Leitzinger, 18 October 1994. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

IDFG (Idaho Department of Fish and Game). 2002. Written comments submitted to National Marine Fisheries Service regarding status review.

James, G. and C. Scheeler. 2001. Walla Walla Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Johnson, T. H. and R. Cooper. 1995. Anadromous game fish research and planning, July 1 1993-December 31, 1994. Washington Dept of Fish and Wildlife. Streamnet.org Reference.

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A. M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-37, 292 p.

Jonsson, B. 1985. Life history patterns of freshwater resident and sea-run migrant brown trout in Norway. Trans. Am. Fish. Soc. 114:182-194.

Kaeriyama, M., S. Urawa, and T. Suzuki. 1992. Anadromous sockeye salmon (*Oncorhynchus nerka*) derived from nonanadromous kokanees: Life history in Lake Toro. Sci. Rep. Hokkaido Salmon Hatchery 46:157-174.

Kennedy, T. 2002. Stanislaus River anadromous fish surveys 2000-2001. Report from Fisheries Foundation to A. Hamilton, USFWS, Sacramento, CA.

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout *(Salmo gairdneri gairdneri*) of the Klamath River system with emphasis on the half-pounder. California Fish and Game 58(3):204-220.

Kier & Associates. 2001. Battle Creek salmon and steelhead restoration project. Draft Adaptive Management Plan. Sausalito, CA. 79 p.

Killam, D. 2002. Field notes for Thomes Creek 2002. California Department of Fish and Game, Red Bluff CA.

Kostow, K. 2002. Leaburg and McKenzie abundance. Data delivered via e-mail, September 2002.

Kostow, K. 2003. The biological implications of non-anadromous *Oncorhynchus mykiss* in Columbia basin steelhead ESUs. Report to NOAA Fisheries & ODFW. Draft report to NMFS. Jan. 13, 2003. 90 p.

Mallet, J. 1974. Inventory of salmon and steelhead resources, habitats, use and demands. Job Performance Report. Proj. F-58-R-1. Idaho Dept. of Fish and Game. Boise. Idaho.

Maslin, P. E., M. Lennox, and J. Kindopp. 1998. Intermittent streams as rearing habitat for Sacramento River chinook salmon (*Oncorhynchus tshawytscha*). CSU Chico unpublished report. 51 p.

McClure, M. M., E. E. Holmes, B. L. Sanderson & C. E. Jordan. In press. A large-scale multi-species assessment: Anadromous Salmonids in the Columbia River Basin. 45 p + figures and tables. Ecological Applications.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, and C. Steward. 2002. Willamette/Lower Columbia Pacific salmonid viability criteria. Draft report from the Willamette/Lower Columbia Technical Recovery Team. December 2002.

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D. R. 2001. Steelhead rainbow trout. Pages 418-425 *in* W. S. Leet, C. M. Dewees, C. M Klingbeil, and E. J. Larson, editors. California's living marine resources: a status report. University of California, Agriculture and Natural Resources, Publication SG01-11.

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Dep. Fish Game, 234 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Meyer Resources. 1988. Benefits from present and future salmon and steelhead production in California. Report to the California Advisory Committee on Salmon and Steelhead, 78 p. (Available from California Advisory Committee on Salmon and Steelhead Trout, 120 Schoonmaker Point, Foot of Spring Street, Sausalito, CA 94965.)

Monterey Peninsula Water Management District (MPWMD). 2001. Executive summary, 2000-20001, MPWMD Mitigation Program and Water Allocation Program Environmental Impact Report.

Moore, M. R. 1980. An assessment of the impacts of the proposed improvements to the Vern Freeman Diversion on anadromous fishes of the Santa Clara River System, Ventura County, California.

Moore, T. L. 2001. Steelhead Survey Report for Antelope, Deer, Beegum and Mill Creeks, 2001. CDFG Sacramento River Salmon and Steelhead Assessment Program. California Department of Fish and Game. 8 p.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I, U.S. Fish and Wildlife Service, Box 549, Leavenworth, WA 98826, 489 p.

Myers, J. M., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

Nehlsen, W., J.E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16: 4 – 21.

Nielsen, J. L., E. A. Heine, C. A. Gan and M. C. Fountain. 2000. Molecular analysis of population genetic structure and recolonization of rainbow trout following the Cantara spill. California Fish and Game 88:21-40.

NMFS (National Marine Fisheries Service). 1991. Notice of policy: Policy on applying the definition of species under the Endangered Species Act to Pacific salmon. Federal Register [Docket 910248-1255, 20 November 1991] 56(224):58612-58618.

NMFS (National Marine Fisheries Service). 1993. Endangered and threatened species; Illinois River winter steelhead in Oregon. Federal Register [Docket 930517-3117, 20 May 1993] 58(96): 29390-29392.

NMFS (National Marine Fisheries Service). 1997. Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon, and California. Memorandum from the Biological Review Team to the NMFS Northwest Regional Office. July 7, 1997, 72 p.

NMFS (National Marine Fisheries Service). 1998*a*. Status review update for deferred and candidate ESUs of west coast steelhead (Lower Columbia River, Upper Willamette River, Oregon Coast, Klamath Mountains Province, Northern California, Central Valley, and Middle Columbia River ESUs). Pre-decisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1998*b*. Status review update for deferred ESUs of west coast steelhead: hatchery populations (Lower Columbia River, Klamath Mountains Province, Northern California, and Central Valley). Predecisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1999. Updated Review of the Status of the Upper Willamette River and Middle Columbia River ESUs of Steelhead. Memorandum for W. Stelle and W. Hogarth from M. Schiewe. January 12, 1999, 49 p.

NMFS (National Marine Fisheries Service). 2002. Memorandum for Frank L. Cassidy, Jr. (Northwest Power Planning Council) from Bob Lohn (NMFS), April 2002. (Available at http://www.nwr.noaa.gov/occd/InterimTargets.pdf)

Nobriga, M. 1995. Cosumnes River study. California Department of Fish and Game, Rancho Cordova, CA. 10 p.

Nobriga, M. and P. Cadrett. 2001. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. IEP Newsletter 14: 30-38.

Nordeng, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40:1372-1387.

Nowak, M.C. 2001. Draft Grande Ronde Subbasin Summary. Prepared for the Northwest Power Planning Council. 385 pages.

ODFW (Oregon Department of Fish and Wildlife). 1990. Santiam and Calapooia Rivers: Willamette River subbasin : salmon and steelhead production plan. Oregon Department of Fish and Wildlife. Northwest Power Planning Council.

ODFW (Oregon Department of Fish and Wildlife). 1991. Grand Ronde River subbasin salmon and steelhead plan. Prepared for Northwest Power Planning Council. 129 pp.

ODFW (Oregon Department of Fish and Wildlife). 1999. Personal communications for reconstructed run year estimates from punch cards for steelhead, 1956-1970. Unpublished.

ONRC (Oregon Natural Resources Council), Siskiyou Regional Education Project, Federation of Fly Fishers, Kalmiopsis Audubon Society, Siskiyou Audubon Society, Klamath/Siskiyou Coalition, Headwaters, The Wilderness Society, North Coast Environmental Center, Oregon Chapter of The Sierra Club, and The National Wildlife Federation. 1992. Petition for a rule to list the Illinois River winter steelhead as threatened or endangered under the Endangered Species Act and to designate critical habitat. Unpubl. manuscr., 16 p. (Document submitted to USDOC NOAA NMFS Northwest Region, Seattle, Washington, May 1992).

Puckett, L. K. 1969. Fisheries surveys on Thomes and Stony Creeks, Glenn and Tehama Counties, with special emphasis on their potentials for King Salmon spawning. California Department of Fish and Game, Water Projects Branch Administrative Report No. 69-3. 24 p.

Rawding, D. 2002a. Lower Columbia River summer-run steelhead. Excel Workbook sent from Dan Rawding (WDFW) to Paul McElhany via e-mail to Paul McElhany and Sarah Sydor, NWFSC.

Rawding, D. 2001b. Simsam (Steelhead). Unpublished data and documentation sent from Dan Rawding (WDFW) to Paul McElhany on 5/16/2001 as Excel file and Word document, via e-mail.

Reavis, B. 1991. Status of California steelhead stocks. In Pacific States Marine Fisheries Commission and Association of Northwest Steelheaders (organizers), International Symposium on Steelhead Trout Management, January 3-5, 1991, Portland, OR, p. 57 – 63.

Reese, C. D. and B. C. Harvey. 2002. Temperature-dependent interactions between juvenile steelhead and Sacramento pikeminnow in laboratory streams. Trans. Am. Fish. Soc. 131: 599 – 606.

Reynolds, F. L., T. J. Mills, R. Benthin and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Sacramento, CA, 184 p.

Robertson, S. R. 1985. Clavey River wild trout habitat management plan. Stanislaus National Forest, Sonora, CA, 14 p. (from CV steelhead; not in master list)

Rode, M., and Weidlein, W. D. 1986. California wild trout management program, Fall River management plan. California Department of Fish and Game, Inland Fisheries Admin. Rpt. 86-2. 55 p. (from CV steelhead; not in master list)

Roelofs, T. D. 1983. Current status of California summer steelhead (*Salmo gairdneri*) stocks and habitat, and recommendations for their management. Submitted to USDA Forest Service, Region 5, 77 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Ruiz-Campos, G. and E. P. Pister. 1995. Distribution, habitat, and current status of the San Pedro Martir rainbow trout, *Oncorhynchus mykiss nelsoni* (Evermann). Bulletin of the Southern California Academy of Sciences, 94(2): 131 – 148.

Schill, D. J. and R. L. Scarpella. 1997. Barbed hook restrictions in catch-and-release trout fisheries: a social issue. N. Am. J. Fish. Man. 17: 873 – 881.

Servheen, G. Draft Salmon Subbasin Summary. Prepared for the Northwest Power Planning Council. 481 p. + app.

Shapovalov, L. 1944. Preliminary report on the fisheries of the Santa Ynez River System, Santa Barbara County, California. CDFG Report, 22 pp.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dep. Fish Game Fish Bull. 98, 375 pp.

Sharp, B. 2001. Klickitat Subbasin Summary. Northwest Power Planning Council, Portland, OR.

Shea, K., and M. Mangel. 2001. Detection of population trends in threatened coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 58: 375-385.

Smith, J. J. 1994. Abundance of coho and steelhead in Redwood Creek in 1994. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1992. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1992. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Gazos Creeks in 1993. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Waddell Creeks in 1988 and 1994: Implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1995. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of coho and steelhead in Redwood Creek in November 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1997. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1997. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1998. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1997 and the implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1998. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1999. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1999. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2000. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2000. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2002. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2002. Department of Biological Sciences, San Jose State University. San Jose, California.

Snider, B., and R. G. Titus. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; November 1995 - July 1996. California Department of Fish and Game, Stream Evaluation Program Technical report 98-5.

Snider, B., and R. G. Titus. 2000a. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1996 - September 1997. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-4.

Snider, B., and R. G. Titus. 2000b. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing October 1997-September 1998. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical Report 00-5.

Snider, B., and R. G. Titus. 2000c. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1998 - September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-6.

Snider, W. M. 1983. Reconnaissance of the steelhead resource of the Carmel River drainage, Monterey County. Calif. Dep. Fish Game, Environmental Services Branch Admin. Rep. 83-3., 41 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Snyder, J. O. 1925. The half-pounder of Eel River, a steelhead trout. Calif. Fish Game 11(2): 49-55.

Stephens, S. J., Christenson, D. P., Lechner, M., and Werner, H. 1995. Upper Kern Basin fishery management plan. California Department of Fish and Game, Sacramento, CA, 86 p.

Stoecker, M.W. and CCP (Conception Coast Project). 2002. Steelhead assessment and recovery opportunities in Southern Santa Barbara County, California. Conception Coast Project, Santa Barbara.

Titus, R. G., D. C. Erman, and W. M. Snider. MS. History and status of steelhead in California coastal drainages south of San Francisco Bay.

Titus, R. G. and C. D. Vanicek. 1988. Comparative hooking mortality of lure-caught Lahontan cutthroat trout at Heenan Lake, California. Calif. Fish Game 74: 218 – 225.

USFWS (U.S. Fish and Wildlife Service). 2000. Anadromous fish restoration actions in the Butte Creek Watershed. Programmatic Environmental Assessment. Sacramento, CA.

Waples, R. S. 1998. Willamette Steelhead. Memorandum to Mike Delarm and Garth Griffin, NMFS Regional Office, Portland, 2 July 1998. 2 p.

WDF (Washington Department of Fisheries), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1992. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildl., Olympia, 212 p. + 5 regional volumes. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091.)

WDFW ((Washington Department of Fisheries and Wildlife). 1997. "Preliminary stock status update for steelhead in the Lower Columbia River, Washington (WDFW Kalama Research)." Data via Michelle McClure; references from Eli Holmes.

Withler, R. E. 1988. Genetic consequences of fertilizing chinook salmon (*Oncorhynchus tshawytscha*) eggs with pooled milt. Aquaculture 68: 15-25.

Workman, M. L. 2001. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam, August 2000 through April 2001. East Bay Municipal Utility District, Lodi, CA. 21 p.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. N. Am. J. Fish. Man. 18:487-521.

Zimmerman, C. E. and G. H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Can. J. Fish. Aquat. Sci. 57:2152-2162.

B.5 APPENDICES

Appendix B.5.1. Distribution of *O. mykiss* trout by category in the Columbia Basin steelhead ESUs. Only major barriers are noted; numerous small barriers, both natural and artificial, also exist. Many other natural barriers are present but have *O. clarki* trout, rather than *O. mykiss* trout, above them. *O. mykiss* trout distribution in areas of sympatry with steelhead may be restricted in some areas if native *O. clarki* trout are also in the basin. The generalized listing of basins and subbasins does not imply that these constitute single trout populations or that trout distribution is continuous throughout the areas listed. Detailed trout distribution is usually unknown and actual demographically independent trout populations have not been described. All current trout distributions are decreased from historical distributions. In particular many mainstem and lower basin tributary are no longer used but probably were historically. Many current trout populations are only in upper basins and are highly fragmented (from Kostow 2003).

ESU	**Category 1 Trout Populations (Sympatric)**	**Category 2 Trout Populations (Major Natural Barriers)**	**Category 3 Trout Populations (Major Artificial Barriers)**
Willamette River	Pudding/Molalla Lower Santiam Calapooia Tualatin (Gales Cr.)	All populations upstream of Calapooia McKenzie M. Fork Willamette	N. Fork Santiam (Big Cliff/Detroit dams) S. Fork Santiam (Green Peter Dam)
Lower Columbia River	Historic use of lower basins by trout may have been greater Wind Clackamas: Callowash Other areas (?) Hood: West Fork Middle Fork Sandy (?) Upper Cowlitz Upper Kalama Upper Lewis Upper Washougal	Clackamas: Roaring R. North Fork South Fork Memaloose (?) Sandy: Little Sandy Salmon (?) Some of the Columbia Gorge small tributaries	Cowlitz (Mayfield Dam) Lewis (Merwin Dam) Sandy (Bull Run dams)

Appendix B.5.1 (continued)

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Middle Columbia River	Historically all areas where steelhead are/were present. Trout distributions currently more restricted. Fifteenmile Eightmile Deschutes Klickitat Umatilla: Upper Umatilla John Day: Upper tributaries Walla Walla Upper tributaries Yakima: Upper Yakima Naches Some other small tributaries	All natural barriers upstream of Klickitat and Deschutes Basins: Deschutes: White River Upper Deschutes (Big Falls) Upper N. Fork Crooked R. John Day: Upper S. Fork John Day	Trout distributions currently more restricted than historically Little White Salmon (Conduit Dam) Deschutes (Pelton/Round Butte dams) Metolius Squaw Cr. Crooked River Umatilla (Irrigation dams) Willow Cr. Butter Cr. McKay Cr.

Appendix B.5.1 (continued)

ESU	Category 1 Trout Populations (Sympatric)	Category 2 Trout Populations (Major Natural Barriers)	Category 3 Trout Populations (Major Artificial Barriers)
Snake River	Potentially all areas that are/were used by steelhead. Tucannon Asotin Grande Ronde Imnaha Salmon found in about 43% of streams Clearwater Selway Other areas?	Palouse River Malad River Several Hells Canyon tributaries Upper Malheur Basin "recent" disconnect from lower Malheur Lakes Basin	Trout distributions currently more restricted than historically North Fork Clearwater (Dworshak Dam) Mainstem Snake (Hells Canyon Dam) Powder Burnt Malheur Owhyee Weiser Payette Boise Burneau Salmon Falls Cr. Several small tributaries
Upper Columbia River	Potentially all areas that are/were used by steelhead Wenatchee Lower Entiat Methow Okanogan	Upper Entiat Upper Kootenay Okanogan: Enlow Falls? Methow: Chewuch? Lost	Trout distributions currently more restricted than historically Okanogan Basin: Conconully Dam/Enlow Dam? Chief Joseph Dam Lower Spokane to Post Falls Sanpoil Several small tributaries Lower Pend Oreille to Z-Canyon Columbia headwaters in Canada

Appendix B.5.2. Distribution, abundance, and stocking of *Oncorhynchus mykiss* above major recent barriers (Case 3 situations) within 5 steelhead ESUs in California, listed by ESU and watershed. A major barrier blocks or restricts access to ≥ 100 square miles of a watershed. Names of keystone (lowermost complete) barriers are shown in bold, partial or seasonal barriers shown in italics. SH=steelhead, RT=rainbow trout (usually means resident),?=unknown. Blanks indicate no data. See text for details.

ESU / Basin / Subbasin			---- Stream Length ----							*O. mykiss* above barrier				
	Dam Name	Year Built	Total (km)	Above Barrier (km)	Above Barrier (%)	present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
Northern California														
Mad River			1,188											
Mad River	**Robert W Matthews**	1962		282	24%	yes		low; gets warm in summer		yes	ongoing	various	18,000 / year	4
Eel River			8,654											
Eel River	*Van Arsdale*	1907		1,106	13%	SH, RT								
	Scott	1921		963	11%	yes								17, 5
Sfk Eel River	*Benbow*	1932		949	11%	SH								
	ESU Total		15,496	1,245	8%									
Central California Coast														
Russian River			3,129											
Russian River	*Russian Rv No 1*	1963		2,878	92%									
	Healdsburg Rec	1953		2,591	83%									
Dry Creek	**Warm Springs**	1982		271	9%	yes	all tribs			yes		private, Warm Springs	~1984-87, Russian River steelhead from Warm Springs Hatchery released above WS Dam	6
E Fk Russian River	**Coyote Valley**	1959		269	9%	yes				yes				
Lagunitas Creek			202											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
	Seeger	1961		100	50%	yes	hdwtrs of Halleck Cr, prob. in western portion of Nicasio Cr.							6
	Peters	1954		61	30%	yes				yes	ongoing	Silverado Fisheries Base		6
Alameda Creek			1,658											
Alameda Creek	**Rubber Dam 1**			1,578	95%	yes				yes				
	Rubber Dam 3	1990		1,578	95%									
Calaveras Creek	Calaveras	1925		283	17%									
Arroyo Valle	Del Valle	1968		413	25%					yes				
Coyote Creek			757											
Coyote	**Standish**	1994		747	99%									
Coyote Creek	Coyote Percol	1934		532	70%									
Coyote River	Leroy Anderson	1950		487	64%									
Coyote Creek	Coyote	1936		278	37%									
	ESU Total		11,447	3,026	26%									
South Central California Coast														
Salinas River			9,966											
San Antonio Rv	**San Antonio**	1965		1,102	11%	yes	in reservoir, unknown if in stream			yes	ongoing	Silverado Fisheries Base		1, 7
Nacimiento Rv	**Nacimiento**	1957		761	8%	yes			330-390	yes	ongoing	Silverado Fisheries Base		7, 8
Salinas River	**Salinas**	1942		293	3%	yes				yes	ongoing	Silverado Fisheries Base	released at Lake Margarita marina	1, 7
Carmel River			656											
	San Clemente	1921		337	51%	SH								1, 7

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
	Los Padres	1949		128	20%	SH, RT				no		trap and truck of steelhead around Los Padres Dam for 20 yrs		1, 7
Big Sur Coastal			711											
Estero Bay Coastal			1,521											
Old Creek	**Whale Rock**	1960	44	42	95%	yes				yes		Whale Rock	55,000 total from 1992-2002 , broodfish taken from Whale Rock Reservoir	29
Arroyo Grande Cr	**Lopez**	1969	282	143	51%	yes				yes	ongoing	Silverado Fisheries Base		1
	ESU Total		19,213	2,469	13%									
Southern California														
Santa Maria River			5,775											
Cuyama River	**Twitchell**	1958		4,088	71%	yes	all tribs			yes	10-15 yrs ago (~1987-1992)			2
Santa Ynez River			2,619											
Santa Ynez River	**Bradbury**	1953		1,517	58%	yes	all tribs			yes	ongoing	Fillmore	into Lake Cachuma	2, 9, 10
Santa Ynez Rv	Gibraltar	1920		721	28%	yes	all tribs			yes	ongoing	Fillmore	not open to fishing?	2, 10
	Juncal	1930		49	2%	yes	all tribs	lots of RT, up to 26"		?	no stocking in last 30 yrs			2, 10, 28
Ventura River			644											

ESU / Basin / Subbasin	Dam Name	Year Built	---- Stream Length ---- Total (km)	Above Barrier (km)	Above Barrier (%)	*O. mykiss* above barrier present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
Coyote Creek	**Casitas**	1959		131	20%	yes	where water present, note seasonal streams			yes	ongoing	Fillmore	32,000 pounds in 2002	2
Matilija Creek	**Robles Diversion**	1958		224	35%	yes								
	Matilija	1949		157	24%	yes				yes	5-6 yrs ago (~1996-97)	Fillmore		2, 11
Santa Clara River			3,851											
Santa Clara River	*Vern Freeman Diversion*	1991		3,830	99%	yes								2, 18
Piru Creek	**Santa Felicia**	1955		1,192	31%	yes	all tribs		2371-2940; 107-143 (>8"); 0 (>12")	yes	ongoing	Fillmore	Hot Creek strain, into Lake Piru and Frenchman's Flat	2
	Pyramid	1973		825	21%	yes	all tribs			yes	ongoing	Fillmore		2
Castaic Creek	**Castaic**	1973		378	10%	yes	reservoir and where water present, note seasonal streams			yes	ongoing		into Castaic Lake and Castaic Lagoon (below dam)	2
Malibu Creek			269											
	Rindge			264	98%									
subtotal			15,490	7,463	48%									
Los Angeles River			1,220											
Los Angeles River	**Sepulveda**[A]	1941		215	18%	no								2
Tujunga Wash	**Hansen**	1940		408	33%	yes	~5 miles or where water present	few fish		yes	ongoing	Fillmore		2
San Gabriel River			1,270											

ESU / Basin / Subbasin			---- Stream Length ----				*O. mykiss* above barrier							
	Dam Name	Year Built	Total (km)	Above Barrier (km)	Above Barrier (%)	present	distribution	abundance	Density (no./km)	stocked	most recent	source hatchery	stocking notes	source
San Gabriel River	**Whittier Narrows**[A]	1957		1,192	94%	yes	reservoir, but probably not far upstream			yes	ongoing	Fillmore		2
	Santa Fe	1949		692	54%	yes	reservoir, but probably not far upstream			yes	ongoing	Fillmore		2
	Morris	1935		626	49%	yes	reservoir			no, washdown from above				2
	San Gabriel No 1	1938		577	45%	yes	all tribs where there is water, EF usu perennial		1550-2706; 129-198 (>8"); 0 (>12")	yes	ongoing	Fillmore	in WF below Cogswell, NF, and EF of San Gabriel R	2, 21
	Cogswell	1935		121	10%	yes								2
Santa Ana River			4,620											
Santa Ana River	**Prado**[A]	1941		3,158	68%	yes								
Bear Creek						yes			96-732; 14-15 (>8"); 0 (>12")					20, 21
Upper Santa Ana River						yes			29-43; 0-14 (>8"); 0 (>12")					21
San Antonio Creek	San Antonio	1956		73	2%									
Santa Ana River	Seven Oaks	undrcnst		594	13%									
Tr Cajalco Cr	Mathews	1938		95	2%									
Santa Margarita River			1,604											
Temecula Creek	**Vail**	1949		655	41%					yes			private stocking	2
San Luis Rey River	**Henshaw**	1923	1,184	447	38%					yes	ongoing	Mojave	into WF of San Luis Rey	2
San Dieguito River	**Lake Hodges**	1918	693	618	89%	no				no			bass and catfish in L. Hodges	2
San Diego River	**El Capitan**	1934	1,013	558	55%	yes	in reservoir	few fish		no				2

ESU / Basin / Subbasin			---- Stream Length ----						*O. mykiss* above barrier					
	Dam Name	**Year Built**	**Total (km)**	**Above Barrier (km)**	**Above Barrier (%)**	**present**	**distribution**	**abundance**	**Density (no./km)**	**stocked**	**most recent**	**source hatchery**	**stocking notes**	**source**
Sweetwater River	**Sweetwater Main**	1888	440	367	83%					yes	ongoing			2
Otay River	**Savage**	1919	410	333	81%									
Tijuana River[C]			734											
Cottonwood Cr	Barrett	1922		506										
	Morena	1912		210										
	ESU Total		31,964	15,414	48%									
Central Valley														
Sacramento River			52,206											
	Red Bluff Diversion	1964		14,261	27%	SH								
	Anderson Cottonwood	1917		9,224	18%	SH								
	Keswick	1950		9,189	18%	yes							SH from below dam transported above	
	Shasta	1945		9,106	17%	yes							see below	
Upper Sacramento			568											
	Shasta	1945				yes			4163-5468 (fish kill); 420-1670 (>4")	yes		Mt. Shasta ; Sacramento and McCloud River stocks	avg. 15,000 from 1994-1998; stocked at least since 1930, average of ~80,000 / yr; max. of 4M RT planted in 1936	16
	Box Canyon	1969		127	22%	yes								
Mc Cloud River			949											
	Shasta	1945				yes			2361 (>5")					4

ESU / Basin / Subbasin			---- Stream Length ----						*O. mykiss* above barrier					
	Dam Name	**Year Built**	**Total (km)**	**Above Barrier (km)**	**Above Barrier (%)**	**present**	**distribution**	**abundance**	**Density (no./km)**	**stocked**	**most recent**	**source hatchery**	**stocking notes**	**source**
	McCloud	1965		474	50%	yes	all tribs		1864 (Squaw Valley Cr)	yes	ongoing below McCloud falls, ~7 yrs ago (~1994) above falls		15,000/yr into McCloud reservoir	4
Pit River			6,979											
	Shasta	1945				yes								
Fall River	Pit No 1 Diversn	1922				yes			1021-2541 (>6")					22
	Pit No 1 Forebay	1947				yes								
Hat Creek						yes			159-2539 (>8"); 32-1335 (>12")					19
Burney	Hat Cr No 2 Div	1942												
Clear Creek	**Whiskeytown**	1963	462	377	82%	yes	Whiskey Cr and Clear Cr		1553-3107	yes	ongoing	private hatchery		
Stony Creek			2,707											
Stony Creek	Stony Cr Gravel	1906												
	Black Butte	1963		2,427	90%	yes	migrate through Stony and Grindstone Crs, too warm in summer							13
	Stony Gorge	1928				yes	all tribs			yes	ongoing			13
Little Stony Creek	East Park	1910				yes	Trout Cr and Stony Cr seasonally			yes				13
Cache Creek			3,362											

ESU / Basin / Subbasin			---- Stream Length ----			*O. mykiss* above barrier								
	Dam Name	**Year Built**	**Total (km)**	**Above Barrier (km)**	**Above Barrier (%)**	**present**	**distribution**	**abundance**	**Density (no./km)**	**stocked**	**most recent**	**source hatchery**	**stocking notes**	**source**
Cache Creek	**Cache Cr Settling Bn**			3,362	100%									
Putah Creek			1,200											
Putah Creek	**Putah Div**	1957		1,087	91%									
	Monticello	1957		1,010	84%									
Feather River			9,094											
Feather River	Thermalito Div	1967												
	Feather R Hatchery	1964												
	Oroville	1968		7,702	85%									
Nfk Feather Rv	Poe	1959				yes							NF below L Almanor rotenoned at least 3x	12
	Lake Almanor	1927				yes				yes	ongoing	Eagle Lake strain	80,000/yr during last 15 yr	12
Bucks Creek	Bucks Storage	1928				yes				yes	ongoing		15-30,000/yr	12
Mfk Feather R						yes				yes			above wild trout section of MF	12
Nelson Creek						yes			155-621 (>6")					14
Yuba River			3,510											
Yuba River	**Englebright**	1941		2,923	83%									
Bear River			1,180											
	Camp Far West	1963		719	61%									
American River			4,480											
American River	**Nimbus**	1955		4,351	97%									
Rubicon River						yes								
Cosumnes River	Granlees[B]	1921	2,426	1,322	54%									24
Mokelumne River			1,877											
Mokelumne River	Woodbridge Diversion	1910		1,858	99%									

ESU / Basin / Subbasin			---- Stream Length ----			*O. mykiss* above barrier								
	Dam Name	**Year Built**	**Total (km)**	**Above Barrier (km)**	**Above Barrier (%)**	**present**	**distribution**	**abundance**	**Density (no./km)**	**stocked**	**most recent**	**source hatchery**	**stocking notes**	**source**
	Camanche	1963		1,800	96%									
Calaveras River	**New Hogan**	1963	1,740	1,277	73%									
Stanislaus River			3,269											
Stanislaus River	**Goodwin**	1912		3,074	94%									
Tuolumne River			3,362											
Tuolumne River	**La Grange**	1894		3,170	94%									
Clavey River						yes			1,317					23
Merced River			2,574											
Merced River	**Crocker Diversion**	1910		2,129	83%									
subtotal			73,558	43,587	59%									
San Joaquin River			3,238											
San Joaquin River	Mendota Diversn	1917												
	Friant	1942		2,876	89%									
Upper MF San Joaquin						yes			273-2985; 119-695 (>6")	yes			RT prob not native	26
Kings River			3,570											
Kings River	**Pine Flat**	1954		2,819	79%									
Kern River			4,467											
Kern River	**Diversion No 1**	1906		3,952	88%									
	Isabella	1953		3,547	79%	yes			43-620	yes		Kern River Planting Base	50,500 lbs. / yr above Isabella	27
	ESU Total		103,504	53,234	51%									

A extensive portions of river below dam are channelized or concrete apron
B Granlees Dam is not considered a keystone barrier for steelhead, impassable natural falls below dam
C portion in California
1 pers. comm., Jennifer Nelson, CDFG
2 pers. comm., Dwayne Maxwell, CDFG
3 pers. comm., Dennis Maria, CDFG
4 pers. comm., CDFG Region 1 biologists; Mike Dean, Mike Berry, Randy Benthin, Bob McAllister, Bill Jong, Phil Bairrington
5 pers. comm., Scott Downie, CDFG
6 pers. comm., Bill Cox, CDFG
7 pers. comm., Mike Hill, CDFG
8 pers. comm., Joel Casagrande, Watershed Institute, CSUMB
9 pers. comm., Mauricio Cardenas, CDFG
10 pers. comm., Scott Engblom, Cachuma Operation and Maintenance Board
11 pers. comm., Rick Rogers, NMFS
12 pers. comm., Ken Kundargi, CDFG
13 pers. comm., Emil Ekman, USFS
14 CDFG 1979.
15 CDFG 1986.
16 CDFG 2000.
17 Jones 2001
18 McEwan and Jackson 1996
19 Deinstadt and Berry 1999
20 Deinstadt et al. 1993
21 Deinstadt et al. 1990
22 Rode and Weidlein 1986
23 Robertson 1985
24 Yoshiyama et al. 2001
25 Titus et al. 2001
26 Deinstadt et al. 1995
27 Stephens et al. 1995
28 pers. comm. to M. Capelli, Jim Adams, CDFG
29 pers. comm., John Bell, Whale Rock Hatchery

Overview

The above table summarizes available information on the distribution, abundance, and stocking of *O. mykiss* above recent barriers (Case 3) within the five listed steelhead ESUs in California. Populations above longstanding natural barriers (Case 2) and below barriers (Case 1) are not listed. Historically, coastal *O. mykiss* were broadly distributed in coastal watersheds and within the Central Valley (Behnke 1992, McEwan and Jackson 1996). Hatchery produced *O. mykiss* have been stocked for over 100 years (Behnke 1992) into streams and lakes throughout California by numerous state and federal agencies, private groups, and individuals. Given their broad historical range and widespread stocking over the last century, *O. mykiss* probably occur above all major recent barriers in California. However little specific information is available on their distribution and abundance above these barriers, and stocking records are incomplete and not centralized. Because of these limitations, this table is necessarily incomplete and is intended to provide information at the level of the ESU.

Methods and scope

Data were obtained from several sources. Barrier data were derived primarily from the California Department of Water Resources (DWR, 1993) and the National Inventory of Dams (NID) compiled by the U.S. Army Corps of Engineers. Data for a few dams were missing from these databases and were obtained from other sources. These databases list over 1400 unique dams on rivers and streams in California. Of these, fewer than 200 were classified as major barriers. A major barrier was arbitrarily defined as one that blocks or restricts access to ≥ 100 mi^2 of a watershed. Keystone barriers are the lowermost complete barrier to upstream migration in a watershed. For brevity, major barriers upstream of keystone barriers are not shown for the Central Valley ESU if there is no associated data on *O. mykiss.* A few minor barriers were included if information was available.

Stream lengths were derived from the National Hydrography Dataset (NHD) produced by the U.S. Geological Survey and U.S. Environmental Protection Agency. Total stream length for a watershed (or ESU) is the sum for all streams within the watershed (or ESU), not just streams or watersheds that are listed. Above barrier totals are the sum for all streams above the barrier (watershed) or above listed keystone barriers (ESU). The above barrier totals include sections of streams that may be above longstanding natural barriers and exclude streams above smaller keystone barriers that are not listed in the table.

Data on the distribution, abundance, and stocking of *O. mykiss* were obtained from the literature and from interviews with regional fish biologists with the California Department of Fish and Game, NMFS, and other agencies and academic institutions. Data on *O. mykiss* refer to fish that occur above the associated barrier but below the next upstream barrier, if it exists. Fish densities were converted from number per mile, but were not rounded to reflect true precision of estimate.

Appendix B.5.3. SSHAG (2003) categorizations of hatchery populations of 9 of the steelhead ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

ESU	Stock	Run	Basin	SSHAG Category
Snake River	Wallowa	summer	Wallowa	3c
	Cottonwood	summer	Grande Ronde	3c
	Little Sheep Creek	summer	Imnaha	2a
	Oxbow	summer	Snake	3c
	Sawtooth	summer	Salmon	3c
	Pahsimeroi	summer	Salmon	3c
	Dworshak	summer	Clearwater	2a
	Lyons Ferry	summer	Snake	3c or 4
	Tucannon (Lyons Ferry)	summer	Tucannon	3c or 4
	Tucannon (new)	summer	Tucannon	1a
	Curl Lake	summer	Snake	3 or 4
Upper Columbia River	Wells	summer	Upper Columbia	2b
	Wenatchee	summer	Wenatchee	1b
Middle Columbia River	Deschutes (# 66)	summer	Deschutes	2a or 2c
	Umatilla (# 91)	summer	Umatilla	1a
	Dayton Pond	summer	Touchet	4
	Dayton Pond (new)	summer	Touchet	1a
Lower Columbia River	Skamania	summer	Washougal	4
	Sandy (ODFW 11)	winter	Sandy	1a
	Clackamas (#122)	winter	Clackamas	1a
	Hood (ODFW #50)	winter	Hood	1a
	Hood (ODFW #50)	summer	Hood	1a
	Big Creek/Eagle Creek	winter	Clackamas	4
	Chambers Creek	winter	various	4
	Cowlitz	late-winter	Cowlitz	2a
	Kalama	winter	Kalama	1a
	Kalama	summer	Kalama	1a
Upper Willamette River	Skamania (# 24)	summer	Santiam	4
Northern CA	Mad River	winter	Mad	3c
	Yager Creek	winter	Yager	1a
	N. Fork Gualala	winter	Gualala	1a
Central CA Coast	Don Clausen	winter	Russian	2a
	Monterey Bay	winter	Scott Creek	1a
South-Central CA Coast	Whale Rock	winter	Old Creek	1a or 2a
CA Central Valley	Coleman NFH	winter	Sacramento	2a
	Feather River	winter	Feather	2a
	Nimbus Hatchery	winter	American	4
	Mokelumne Hatchery	winter	Mokelumne	4

Appendix B.5.4. Steelhead Time Series References

Snake River Steelhead ESU

Population	Snake River Steelhead (total)
Years of Data, Length of Series	1980 - 2001, 22 years
Abundance Type	Total Live Count
Abundance References	12 ESU's data file, Eli Holmes, NWFSC
Abundance Notes	
Hatchery Reference	12 ESU's data file, Eli Holmes, NWFSC
Hatchery Notes	
Harvest Reference	US v. Oregon T.A.C. Spreadsheet from Henry Yuen
Harvest Notes	
Age Reference	12 ESU's data file, Eli Holmes, NWFSC
Age Notes	average

Population	Imnaha R (Zumwalt/Camp Creek)
Years of Data, Length of Series	1974 - 2000, 27 years
Abundance Type	Redds per Mile
Abundance References	updated spreadsheets from M. Chilcote, ODFW -2002
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Camp Creek (Imnaha)
Years of Data, Length of Series	1974 - 2002,. 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	

Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Used Grande Ronde River aggregate
Age Notes	average

Population	Grande Ronde River, Upper
Years of Data, Length of Series	1967 - 2000, 34 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Joseph Creek
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Little Sheep Creek (Imnaha River) Hatch
Years of Data, Length of Series	1985 - 2002, 18 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002

Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Population	Little Sheep Creek (Imnaha River) Wild
Years of Data, Length of Series	1985 - 2002, 18 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Snake River A-run total
Years of Data, Length of Series	1985 - 2001, 17 years
Abundance Type	Total Live Count
Abundance References	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Abundance Notes	
Hatchery Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Age Notes	yearly

Population	Snake River B-run total
Years of Data, Length of Series	1985 - 2001, 17 years
Abundance Type	Total Live Count
Abundance References	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Abundance Notes	
Hatchery Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 1996. All-Species Review; 1998-2000: spreadsheet sent from Peter Dygert & Enrique Patino, NMFS
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Age Notes	yearly

Population	Tucannon River
Years of Data, Length of Series	1987 - 2001, 13 years
Abundance Type	Total Live Count
Abundance References	Gallinat, et al. 2001, Mark Shuck, WDFW 2001 estimate
Abundance Notes	
Hatchery Reference	Gallinat, et al. 2001
Hatchery Notes	
Harvest Reference	Columbia River Basin Fish Mange Plan Tech. Adv Comm. 2002: spreadsheet sent from Henry Yuen, USFWS
Harvest Notes	
Age Reference	Gallinat, et al. 2001
Age Notes	average

Population	Wallowa River (GR)
Years of Data, Length of Series	1965 - 1996, 31 years
Abundance Type	Redds per Mile
Abundance References	Streamnet: trend 54572
Abundance Notes	
Hatchery Reference	

Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Population	Asotin Creek
Years of Data, Length of Series	1986 - 2001, 13 years
Abundance Type	Expanded Redd Count
Abundance References	Mark Schuck, WDFW (Feb. 2003)
Abundance Notes	
Hatchery Reference	
Hatchery Notes	
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Upper Columbia Steelhead

Population	Above Wells Dam
Years of Data, Length of Series	1976 - 2001, 26 years
Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001)
Abundance Notes	
Hatchery Reference	Douglas PUD - Wells Dam broodstock sampling
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Age Notes	yearly

Population	Wenatchee + Entiat Rivers
Years of Data, Length of Series	1976 - 2001, 26 years

Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001)
Abundance Notes	
Hatchery Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program
Age Notes	yearly

Population	Methow River
Years of Data, Length of Series	1976 - 2001, 26 years
Abundance Type	Total Live Count
Abundance References	QAR - Cooney (2001), 1999-2001 B.
Abundance Notes	
Hatchery Reference	Douglas PUD - Wells Dam broodstock sampling
Hatchery Notes	
Harvest Reference	QAR - Cooney (2001) TAC mainstem,WDFW trib. Rates
Harvest Notes	
Age Reference	Cooney (2001) WDFW - Priest Rapids Steelhead sampling program (Brown, 1995, WDFW annual update memos)
Age Notes	yearly

Middle Columbia Steelhead ESU

Population	John Day River, Upper North Fork
Years of Data, Length of Series	1977 - 2002, 26 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	12 ESU's data file
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	

Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Middle Fork
Years of Data, Length of Series	1974 - 2001, 28 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	12 ESU's data file
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Deschutes River
Years of Data, Length of Series	1978 - 2002, 25 years
Abundance Type	Dam Count (Sherars)
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Fifteenmile Creek (winter)
Years of Data, Length of Series	1964 - 2001, 24 years
Abundance Type	Redds per Mile
Abundance References	Streamnet
Abundance Notes	
Hatchery Reference	No annual sampling, assumed natural returns
Hatchery Notes	
Harvest Reference	Chilcote 2001

Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Lower Mainstem
Years of Data, Length of Series	1965 - 2002, 37 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	John Day River, Upper Mainstem
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2002
Abundance Notes	
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Shitike Creek (Deschutes)
Years of Data, Length of Series	1976 - 2002, 26 years
Abundance Type	Redds per Mile
Abundance References	updated spreadsheets from M. Chilcote, ODFW -2002
Abundance Notes	
Hatchery Reference	
Hatchery Notes	

Harvest Reference	
Harvest Notes	
Age Reference	Used Deschutes R ages
Age Notes	average

Population	John Day River, South Fork
Years of Data, Length of Series	1974 - 2002, 29 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Touchet River
Years of Data, Length of Series	1987 - 2001, 13 years
Abundance Type	Total Live Count
Abundance References	WDFW 1994, 1995, Bumgarner 2002 (1996-2001)
Abundance Notes	
Hatchery Reference	Streamnet: Touchet R natural (180065) divided by total (180065 + 180002)
Hatchery Notes	
Harvest Reference	Mainstem Harvest: T.A.C. spreadsheet, Tributary harvest: WDFW spreadsheet from Bob Leeland 05/24/2002
Harvest Notes	
Age Reference	
Age Notes	average

Population	Umatilla River
Years of Data, Length of Series	1966 - 2002, 35 years
Abundance Type	Total Live Count
Abundance References	Streamnet (1966-2000), Umatilla Tribal Fisheries 2002 (2001)
Abundance Notes	

Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	John Day River, Lower North Fork
Years of Data, Length of Series	1976 - 2002, 27 years
Abundance Type	Redds per Mile
Abundance References	Chilcote 2001
Abundance Notes	updated spreadsheets from M. Chilcote, ODFW -2002
Hatchery Reference	Chilcote 2002
Hatchery Notes	
Harvest Reference	Chilcote 2002
Harvest Notes	
Age Reference	Chilcote 2002
Age Notes	average

Population	Walla Walla River
Years of Data, Length of Series	1993 - 2000, 8 years
Abundance Type	Total Live Count
Abundance References	ODFW 1998, Duke 2002 (1999-2001)
Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Warm Springs National Fish Hatchery
Years of Data, Length of Series	1980 - 1999, 20 years
Abundance Type	Total Live Count
Abundance References	Chilcote 2001

Abundance Notes	
Hatchery Reference	Chilcote 2001
Hatchery Notes	
Harvest Reference	Chilcote 2001
Harvest Notes	
Age Reference	Chilcote 2001
Age Notes	average

Population	Yakima River
Years of Data, Length of Series	1980 - 2001, 23 years
Abundance Type	Total Live Count
Abundance References	From WDFW Spreadsheet 06/12/2002
Abundance Notes	
Hatchery Reference	From WDFW Spreadsheet 06/12/2002
Hatchery Notes	
Harvest Reference	Table 4-3, Biological Assessment, Yakima Operations and Maintenance, Upper Columbia Area Office, BR , Aug. 2000
Harvest Notes	
Age Reference	From WDFW Spreadsheet 06/12/2002
Age Notes	average

Population	Klickitat River
Years of Data, Length of Series	1990 - 2002, 9 years
Abundance Type	Redd Count
Abundance References	From Rolf Evenson, YIN Fisheries Biologist
Abundance Notes	
Hatchery Reference	
Hatchery Notes	No recent year data available
Harvest Reference	
Harvest Notes	
Age Reference	
Age Notes	

Lower Columbia River Steelhead ESU

Population	Hood River summer-run steelhead
Years of Data, Length of Series	1992 - 2000, 9 years
Abundance Type	Dam/weir count
Abundance References	Gorman, Leah. 2001.
Abundance Notes	Dam counts at Powerdale dam
Hatchery Reference	Gorman, Leah. 2001.
Harvest Reference	No Harvest Data Available.
Age Reference	Gorman, Leah. 2001.
Age Notes	Repeat % total ranged from 2% to 10%.
Population	Kalama River summer-run steelhead
Years of Data, Length of Series	1977 - 2003, 27 years
Abundance Type	Trap Count
Abundance References	Rawding, Dan (WDFW). 2002a.
Abundance Notes	Trap count plus correction estimate for jumpers
Hatchery Reference	Rawding, Dan (WDFW). 2002a.
Hatchery Notes	Work done at RM 10 above the two hatcheries to minimize handle of hatchery fish. Substantial rearing may occur below; trapping takes place during spring
Harvest Reference	Rawding, Dan (WDFW). 2002a.
Age Reference	Rawding, Dan (WDFW). 2002a.
Age Notes	From 1998 forward no scales have been aged and mean ages are used for these years
Population	Washougal River summer-run steelhead
Years of Data, Length of Series	1986 - 2003, 18 years
Abundance Type	Index
Abundance References	WDFW. 1997. Rawding 2002a
Hatchery Reference	No Hatchery Data.
Harvest Reference	No Harvest Data Available.
Age Reference	Busby et al.1996; Chilcote, M. W. 2001; Hulett et al. 1995.
Age Notes	Generic sum age structure

Population	Wind River summer-run steelhead
Years of Data, Length of Series	1989 - 2003, 15 years
Abundance Type	Mark recapture
Abundance References	Rawding, Dan (WDFW). 2001b; Rawding 2002a.
Abundance Notes	Estimates made from mark-recapture from trap efficiency method. Adult trap at Shiperd Falls but adult population is estimate by M-R, since fish jump the falls. Not able to differentiate winter and summer-run steelhead smolts
Hatchery Reference	Rawding, Dan (WDFW). 2001b.
Harvest Reference	Rawding, Dan (WDFW). 2001b.
Age Reference	Rawding, Dan (WDFW). 2001b.

Population	Clackamas River winter-run steelhead
Years of Data, Length of Series	1958 - 2001, 44 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002a.
Abundance Notes	Abundance data delivered via Kathryn Kostow, Or Dept of Fish and Wildlife
Hatchery Reference	Cramer, Doug. 2002a.
Hatchery Notes	Pre-1997 Wild Fraction determined by run timing; all fish counted on or after March 1 assumed to be Wild. Additional reference for 1997-2001 from Doug Cramer, PG; have #s for wild and hatchery fish as of 1996-1997 run; all winter steelhead trapped and identified as wild or hatchery
Harvest Reference	ODFW 1999. Personal Communication. Personal communications for reconstructed run year estimates from punch cards for steelhead, 1956-1970
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.
Age Notes	Generic sum age structure

Population	Upper Cowlitz, Cispus and Tilton winter-run steelhead
Years of Data, Length of Series	2002, 1 year
Abundance Type	Dam/weir count
Abundance References	Serl and Morrill 2002
Abundance Notes	Abundance data delivered via Kathryn Kostow, Or Dept of Fish and Wildlife

Population	East Fork Lewis River winter-run steelhead

Years of Data, Length of Series	1985 - 1994, 10 years
Abundance Type	Peak Count
Abundance References	Johnson, T.H. and R. Cooper. 1995.
Abundance Notes	Natural population only; East Fork Lewis River, trib to Lewis River from mile 0.0 to mile 41.8
Hatchery Reference	Busby et al. 1996. Status review of west coast steelhead from WA, ID, OR and California
Harvest Reference	No Harvest Data Available.
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.
Population	Hood River summer-run steelhead
Years of Data, Length of Series	1992 - 2000, 9 years
Abundance Type	Dam/weir count
Abundance References	Gorman, Leah. 2001.
Abundance Notes	Dam counts at Powerdale dam
Hatchery Reference	Gorman, Leah. 2001.
Harvest Reference	No Harvest Data Available.
Age Reference	Gorman, Leah. 2001.
Population	Kalama River winter-run steelhead
Years of Data, Length of Series	1977 - 2002, 26 years
Abundance Type	Trap Count
Abundance References	Rawding 2001b; Rawding 2002a.
Abundance Notes	Trap count plus correction estimate for jumpers
Hatchery Reference	Rawding 2001b.
Hatchery Notes	Work done at RM 10 above the two hatcheries to minimize handle of hatchery fish. Substantial rearing may occur below; trapping takes place during spring
Harvest Reference	Leland 2003.
Age Reference	Rawding 2001b.
Age Notes	From 1998 forward no scales have been aged and mean ages are used for these years
Population	North Fork Toutle River winter-run steelhead
Years of Data, Length of Series	1989 - 2002, 14 years
Abundance Type	Total from redd count

Abundance References	Rawding 2001b; Rawding 2002a.
Abundance Notes	100% trap count
Hatchery Reference	Rawding 2001b.
Harvest Reference	Rawding 2002a.
Age Reference	Rawding 2001b.
Population	Sandy River winter-run steelhead
Years of Data, Length of Series	1978 - 2001, 24 years
Abundance Type	Dam/weir count
Abundance References	Cramer, Doug. 2002.
Abundance Notes	Dam counts made at Marmot Dam
Hatchery Reference	Chilcote, Mark. 1998.
Hatchery Notes	Used average hatchery fraction from 1978-1997 for years 1998-2001.
Harvest Reference	Berry, R.L. 1978.
Harvest Notes	Natural population catch determined by multiplying harvest by wild fraction
Age Reference	Busby et al.1996; Chilcote, Mark. 1998; Hulett et al. 1995.
Age Notes	Generic winter age structure
Population	South Fork Toutle River winter-run steelhead
Years of Data, Length of Series	1981 - 2002, 19 years
Abundance Type	Redd Surveys
Abundance References	Leland 2003; Rawding 2001b; Rawding 2002a.
Abundance Notes	Winter steelhead in S. Fork Toutle River are by redd surveys from March 15 to May 31. Redd surveys assume that you see 100% of the redds, only wild steelhead spawn after March 15, sex ratio is 1:1, and each redd represents 0.8 females. Assumed 2% stray rate
Hatchery Reference	Rawding 2001b.
Harvest Reference	Rawding 2001b.
Age Reference	Rawding 2001b.
Age Notes	Applied Kalama estimates to S. Fork Toutle River. Pooled ages 6 and 7 into age 6 to increase r/s sample size.

Population	Washougal River winter-run steelhead
Years of Data, Length of Series	1991 - 2002, 5 years
Abundance Type	Redd index
Abundance References	Leland 2003; WDFW 1993.
Hatchery Reference	Leland 2003; WDFW 1993.
Hatchery Notes	Reports little hatchery impact
Harvest Reference	No Harvest Data Available
Age Reference	Busby et al.1996; Chilcote, M.W. 2001; Hulett et al. 1995.
Age Notes	Generic winter age structure

Population	Coweeman River winter-run steelhead
Years of Data, Length of Series	1987 - 2002, 16 years
Abundance Type	Redd Surveys
Abundance References	Leland 2003; Rawding 2001b; Rawding 2002a.
Abundance Notes	Winter steelhead estimate in the Coweeman River are by redd surveys from Mar 15 to May 31. Redd surveys assume that you see 100% of the redds, only wild steelhead spawn after March 15, sex ratio is 1:1, and each redd represents 0.8 females.
Hatchery Reference	Leland 2003; Rawding 2001b.
Hatchery Notes	Data on hatchery fraction for 1987-1989 were provided by Leland (2003), estimate for 1990-2002 based on estimate from Rawding of 50% hatchery.
Harvest Reference	Leland 2003. Rawding 2001b.
Age Reference	Rawding 2001b.
Age Notes	Only age structure data is for winter-run in N. Fork Toutle and Kalama Rivers, and summer-run in the Kalama. Age structure is very similar in Toutle and Kalama River winter-run. Toutle River has less repeats 5.3% to 8.9% possibly because kelts must pass through PVC tubes on the Sediment Dam, which negatively impacts their survival. Rawding applied the Kalama River winter-run to the Coweeman and S. F Toutle Rivers populations.

Population	East Fork Lewis River summer-run steelhead
Years of Data, Length of Series	1996 - 2003, 8 years
Abundance Type	snorkel survey
Abundance References	Rawding, Dan. 2002a.

Hatchery Reference	Rawding, Dan. 2002a.
Harvest Reference	Rawding, Dan. 2002a.
Age Reference	Rawding, Dan. 2002a.

Upper Willamette River Steelhead ESU

Population	Calapooia River winter-run steelhead
Years of Data, Length of Series	1980 - 2000, 21 years
Abundance Type	Redd Count
Abundance References	Anonymous 1995; Anonymous 1997; Hunt, Wayne. 1999.
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001
Hatchery Reference	Chilcote, Mark. 2001
Population	South Santiam River winter-run steelhead
Years of Data, Length of Series	1983 - 2000, 18 years
Abundance Type	Redd Count
Abundance References	Anonymous 1995; Anonymous 1997
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	North Santiam River winter-run steelhead
Years of Data, Length of Series	1983 - 2000, 18 years
Abundance Type	Redd Count
Abundance References	Anonymous 1998; Anonymous 1998.
Abundance Notes	Data from StreamNet
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	Molalla River winter-run steelhead
Years of Data, Length of Series	1980 - 2000, 21 years

Abundance Type	Redd Count
Abundance References	Anonymous 1997; Hunt, Wayne. 1999.
Harvest Reference	Chilcote, Mark. 2001.
Hatchery Reference	Chilcote, Mark. 2001
Population	South Santiam River (Foster Dam)
Years of Data, Length of Series	1973 - 2000, 28 years
Abundance Type	Total Live Fish
Abundance References	ODFW 1990; Anonymous 1997; Anonymous 1994; Hunt, Wayne. 1999.
Harvest Reference	Chilcote, Mark. 2001.
Population	Willamette Falls Dam winter-run steelhead
Years of Data, Length of Series	1971 - 2002, 32 years
Abundance Type	Dam/weir count
Abundance References	Kostow, Kathryn. 2002.

C. COHO SALMON

C.1 BACKGROUND AND HISTORY OF LISTINGS

Primary contributor: Laurie A. Weitkamp
(Northwest Fisheries Science Center)

Coho salmon (*Oncorhynchus kisutch*) is a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay in California north to Point Hope, AK, through the Aleutians, and from Anadyr River south to Korea and northern Hokkaido, Japan (Laufle et al. 1986). From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in freshwater and 18 months in saltwater (Gilbert 1912, Pritchard 1940, Sandercock 1991). The primary exceptions to this pattern are "jacks," sexually mature males that return to freshwater to spawn after only 5-7 months in the ocean. However, in southeast and central Alaska, the majority of coho salmon adults are 4-year-olds, having spent an additional year in freshwater before going to sea (Godfrey et al. 1975, Crone and Bond 1976). The transition zone between predominantly 3-year-old and 4-year-old adults occurs somewhere between central British Columbia and southeast Alaska.

With the exception of spawning habitat, which consists of small streams with stable gravels, summer and winter freshwater habitats most preferred by coho salmon consist of quiet areas with low flow, such as backwater pools, beaver ponds, dam pools, and side channels (Reeves et al. 1989). Habitats used during winter generally have greater water depth than those used in summer, and also have greater amounts of large woody debris. West Coast coho smolts typically leave freshwater in the spring (April to June) and re-enter freshwater when sexually mature from September to November and spawn from November to December and occasionally into January (Sandercock 1991). Stocks from British Columbia, Washington, and the Columbia River often have very early (entering rivers in July or August) or late (spawning into March) runs in addition to "normally" timed runs.

Status reviews

The status of coho salmon for purposes of ESA listings has been reviewed many times, beginning in 1990. The first two reviews occurred in response to petitions to list coho salmon in the Lower Columbia River and Scott and Waddell creeks (central California) under the ESA. The conclusions of these reviews were that NMFS could not identify any populations that warranted protection under the ESA in the LCR (Johnson et al. 1991, *FR* 56(124):29553), and that Scott and Waddell creeks' populations were part of a larger, undescribed ESU (Bryant 1994, *FR* 59(80):21744).

A review of West Coast (Washington, Oregon, and California) coho salmon populations began in 1993 in response to several petitions to list numerous coho salmon populations and NMFS' own initiative to conduct a coastwide status review of the species. This coastwide review identified six coho salmon ESUs, of which the three southern most were proposed for listing, two were candidates for listing, and one was deemed "not warranted" for listing

(Weitkamp et al. 1995, *FR* 60(142): 38011). In October 1996, the BRT updated the status review for the Central California (CC) ESU, and concluded that it was at risk of extinction (NMFS 1996a). In October 1996, NMFS listed this ESU as threatened (*FR* 61(212): 56138).

In December 1996, the BRT updated the status review update for both proposed and candidate coho salmon ESUs (NMFS 1996b). However, because of the scale of the review, comanagers' requests for additional time to comment on the preliminary conclusions, and NMFS' legal obligations, the status review was finalized for proposed coho salmon ESUs in 1997 (NMFS 1997), but not for candidate ESUs. In May 1997, NMFS listed the Southern Oregon/Northern California coasts (SONCC) ESU as threatened, while it announced that listing of the Oregon Coast (OC) ESU was not warranted due to measures in the OCSRI plan (*FR* 62(87): 24588). This finding for OC coho salmon was overturned in August 1998, and the ESU listed as threatened (*FR* 63(153): 42587).

The process of updating the coho salmon status review was begun again in October 1998 for coho salmon in Washington and the lower Columbia River. However, this effort was terminated before the BRT could meet, due to competing activities with higher priorities.

In response to a petition by (Oregon Trout et al. 2000), the status of Lower Columbia River (LCR) coho salmon was revisited in 2000, with BRT meetings held in March and May 2001 (NMFS 2001a). The BRT concluded that splitting the LCR/Southwest Washington coast ESU to form separate LCR and Southwest Washington coast coho salmon ESUs was most consistent with available information and the LCR ESU was at risk of extinction. Like the 1996 status review update, these results were never finalized.

The coho salmon BRT[1] met in January, March and April 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original BRTs. This report summarizes new information and the preliminary BRT conclusions on the following ESUs: Lower Columbia River, Oregon Coast, Southern Oregon/Northern California coasts, and Central California coast.

[1] The biological review team (BRT) for the updated status review for West Coast coho salmon included: Dr. Robert Iwamoto, Dr. Orlay Johnson, Dr. Pete Lawson, Gene Matthews, Dr. Paul McElhany, Dr. Thomas Wainwright, Dr. Robin Waples, Laurie Weitkamp, and Dr. John Williams, from NMFS Northwest Fisheries Science Center (NWFSC); Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Brian Spence from NMFS Southwest Fisheries Science Center (SWFSC); and Dr. Reginald Reisenbichler from the Northwest Biological Science Center, USGS Biological Resources Division, Seattle.

C.2.1 OREGON COASTAL COHO SALMON

Primary contributor: Peter W. Lawson
(Northwest Fisheries Science Center)

C.2.1.1 Summary of Previous BRT Conclusions

Major risk factors and status indicators

The Oregon Coastal Coho ESU has been assessed in two previous status reviews; one in 1995 (NMFS 1996a) and again in 1997 (NMFS 1997). In the 1995 status review (Weitkamp et al. 1995), the BRT considered evidence from many sources to identify ESU boundaries in coho populations from Washington to California. For the most part, evidence from physical environment, ocean conditions/upwelling patterns, marine and coded wire tag recovery patterns, coho salmon river entry and spawn timing as well as estuarine and freshwater fish and terrestrial vegetation distributions were the most informative to the ESU delineation process. Genetic information was utilized for an indication of reproductive isolation between populations and groups of populations. Based on this assessment, six ESUs were identified, including the Oregon Coast coho ESU, which includes naturally spawning populations in Oregon coastal streams north of Cape Blanco, to south of the Columbia River.

Evaluation of ESU under conditions in 1997

In 1997, there were extensive survey data available for coho salmon in this region. Overall, spawning escapements had declined substantially during the century, and may have been at less than 5% of their abundance in the early 1900s. Average spawner abundance had been relatively constant since the late 1970s, but pre-harvest abundance had declined. Average recruits-per-spawner may also have declined. Coho salmon populations in most major rivers appeared to have had heavy hatchery influence, but some tributaries may have been sustaining native stocks.

For this ESU, information on trends and abundance were better than for the more southerly ESUs. Main uncertainties in the assessment included the extent of straying of hatchery fish, the influence of such straying on natural population trends and sustainability, the condition of freshwater habitat, and the influence of ocean conditions on population sustainability. Total average (5-year geometric mean) spawner abundance for this ESU in 1996 was estimated at about 52,000. Corresponding ocean run size for the same year was estimated to be about 72,000; this corresponds to less than one-tenth of ocean run sizes estimated in the late 1800s and early 1900s, and only about one-third of those in the 1950s (ODFW 1995a). Total freshwater habitat production capacity for this ESU was estimated to correspond to ocean run sizes between 141,000 under poor ocean conditions and 924,000 under good ocean conditions (OCSRI Science Team 1996b). Abundance was unevenly distributed within the ESU at this time, with the largest total escapement in the relatively small Mid/South Coast Gene Conservation Group (GCG), and lower numbers in the North/Mid Coast and Umpqua GCGs.

Trend estimates using data through 1996 showed that for all three measures (escapement, run size, and recruits-per-spawner), long-term trend estimates were negative. More recent escapement trend estimates were positive for the Umpqua and Mid/South Coast Monitoring Areas, but negative in the North/Mid Coast. Recent trend estimates for recruitment and recruits-per-spawner were negative in all three areas, and exceed 12% annual decline in the two northern areas. Six years of stratified random survey (SRS) population estimates showed an increase in escapement and decrease in recruitment.

To put these data in a longer term perspective, ESU-wide averages in 1996 that were based on peak index and area under the curve (AUC) escapement indices, showed an increase in spawners up to levels of the mid-to-late 1980s, but much more moderate increases in recruitment. Recruitment remained only a small fraction of average levels in the 1970s. An examination of return ratios showed that spawner-to-spawner ratios had remained above replacement since the 1990 broodyear as a result of higher productivity of the 1990 broodyear and sharp reductions in harvest for the subsequent broods. As of 1996, recruit-to-spawner ratios for the 1991-1994 broods were the lowest on record, except for 1988 and, possibly, 1984. The 1997 BRT considered risk of extinction for this ESU under two scenarios: first, if present conditions and existing management continued into the foreseeable future and, second, if certain aspects of the Oregon Coastal Salmon Restoration Initiative (OCSRI) Draft Conservation Plan (Oregon Plan 1997) relating to harvest and hatchery production were implemented. The OCSRI is now (2003) called The Oregon Plan for Salmon and Watersheds.

Population abundance

Between the 1995 and 1997 status reviews, escapement increased for the ESU as a whole, but recruitment and recruits per spawner remained a small fraction of historical abundance. Spawning was distributed over a relatively large number of basins, both large and small. Natural escapement from 1990-1996 was estimated to be on the order of 50,000 fish per year in this ESU, reaching nearly 80,000 fish in 1996 coincident with drastic reductions in harvest. Pre-fishery recruitment was higher in 1996 than in either 1994 or 1995, but exhibited a fairly flat trend since 1990. The 1996 estimate of ESU-wide escapement indicated an approximately four-fold increase since 1990. When looked at on a finer geographic scale, the northern Oregon coast as of 1996, still had very poor escapement, the north/central coast showed mixed escapement with strong increases in some streams but continued very poor escapement in others, and the south/central coast continued to have increasing escapement.

Both recruitment and recruits-per-spawner had declined rapidly (12% to 20% annual declines from 1986 to 1996) in two of the three ODFW GCGs in this ESU. These declines were steeper and more widespread in this ESU than in any other coho salmon ESU for which data are available, and recruits-per-spawner continued to decline since this ESU was reviewed in 1994. The new data from 1994 to 1996 do not change the overall pattern of decline coupled with peaks in recruits-per-spawner every 4-5 years, with the height of the peaks declining through time.

Risks that this decline in recruits-per-spawner posed to sustainability of natural populations, in combination with strong sensitivity to unpredictable ocean conditions, was the most serious concern identified in 1997 by the BRT for this ESU. Some aspects of this concern

were addressed by examining results of the viability models, although none of them incorporated declining recruits per spawner except as a consequence of changing ocean conditions. Preliminary results of viability models provided a wide range of results, with one model suggesting that most Oregon coastal stocks could not sustain themselves at ocean survivals that have been observed in the last 5 years, even in the absence of harvest, and another suggesting that stocks are highly resilient and would be at significant risk of extinction only if habitat degradation continues into the future. Consequently, a major question in evaluating extinction risk for this ESU was whether recent ocean and freshwater conditions would continue into the future.

Population trends and production

For this ESU, fishery recruitment forecasts for 1997 were slightly below the actual 1996 recruitment (PFMC 1997), and actual returns were drastically lower; about 25% of 1996 recruitment and the second lowest on record after 1977. Stream production studies conducted by ODFW (Solazzi and Johnson 1996) indicated that 1996 smolt production in four central coast study streams was lower than recent averages, with overwinter survival the lowest or second lowest on record for the two streams for which estimates were made, and that age-0 fish production was also low. They concluded that the "most significant impact was on juvenile coho salmon eggs that were in the gravel at the time of the [1995-96] flood." While these results were based on a small sample of streams and may not reflect average effects of the flood, they suggested that 1997 and 1998 adult returns to some coastal basins would be reduced by the floods. Longer term effects of the floods can also be expected to vary among basins, but most reports available to us suggest that long-term effects should generally be neutral or slightly beneficial (e.g. from sediment removal and increased off-channel habitat) to coho salmon.

Hatchery production and genetic risks

Widespread spawning by hatchery fish as indicated by scale data was also a major concern to the BRT. Scale analysis to determine hatchery-wild ratios of naturally spawning fish indicate moderate to high levels of hatchery fish spawning naturally in many basins on the Oregon coast, and at least a few hatchery fish were identified in almost every basin examined. Although it is possible that these data do not provide a representative picture of the extent of this problem, they represented the best information available at the time. In addition to concerns for genetic and ecological interactions with wild fish, these data also suggest natural spawner abundance may have been overestimated by ODFW and that the declines in recruits-per-spawner in many areas may have been even more alarming than current estimates indicate. However, by 1997 Oregon had made some significant changes in its hatchery practices, such as substantially reducing coho production levels in some basins, switching to on-station smolt releases, and minimizing fry releases. Uncertainty regarding the true extent of hatchery influence on natural populations, however, was a strong concern.

Another concern discussed by the BRT in 1997 was the asymmetry in the distribution of natural spawning in this ESU, with a large fraction of the fish occurring in the southern portion and relatively few in northern drainages. Northern populations were also relatively worse off by

almost every other measure: steeper declines in abundance and recruits-per-spawner, higher proportion of naturally spawning hatchery fish, and more extensive habitat degradation.

Habitat conditions

With respect to habitat, the BRT had two primary concerns: first, that the habitat capacity for coho salmon within this ESU has significantly decreased from historical levels; and second, that the Nickelson and Lawson (1998) model predicted that, during poor ocean survival, only high quality habitat is capable of sustaining coho populations, and subpopulations dependent on medium and low quality habitats would be likely to go extinct. Both of these concerns caused the BRT to consider risks from habitat loss and degradation to be relatively high for this ESU.

Influence of OCSRI

The 1997 BRT considered only two sets of measures from the OCSRI: harvest management reforms and hatchery management reforms. The BRT did not consider the likelihood that these measures would be implemented; rather, it only considered the implications for ESU status if these measures were fully implemented as described. In order to carry out these evaluations, the BRT made the following assumptions:

1) The ocean harvest management regime would be continued as proposed into the foreseeable future, not revised in the year 2000 as stated in the plan. Without this assumption, effects of the plan beyond 2000 could not be evaluated.

2) Hatchery releases would continue at or below 1997 release levels (including approximately 1 million annual fry releases) into the foreseeable future.

3) The goals of maintaining naturally-spawning hatchery fish at less than 10% or 50% of natural escapement (depending on genetic similarity with natural fish) would be achieved and demonstrated by effective monitoring.

Some members had a strong concern that we do not know enough about the causes of declines in run size and recruits per spawner to be able to directly assess the effectiveness of specific management measures.

Harvest measures

Some members of the BRT felt that the harvest measures were the most encouraging part of the plan, representing a major change from previous management. However, there was concern that the harvest plan might be seriously weakened when it was re-evaluated in the year 2000, concern that combining the Umpqua and south/central coast GCGs into a larger aggregate (as would occur in the proposed harvest plan) might not adequately protect genetic diversity, and concern about our ability to effectively monitor non-target harvest mortality and to control overall harvest impacts.

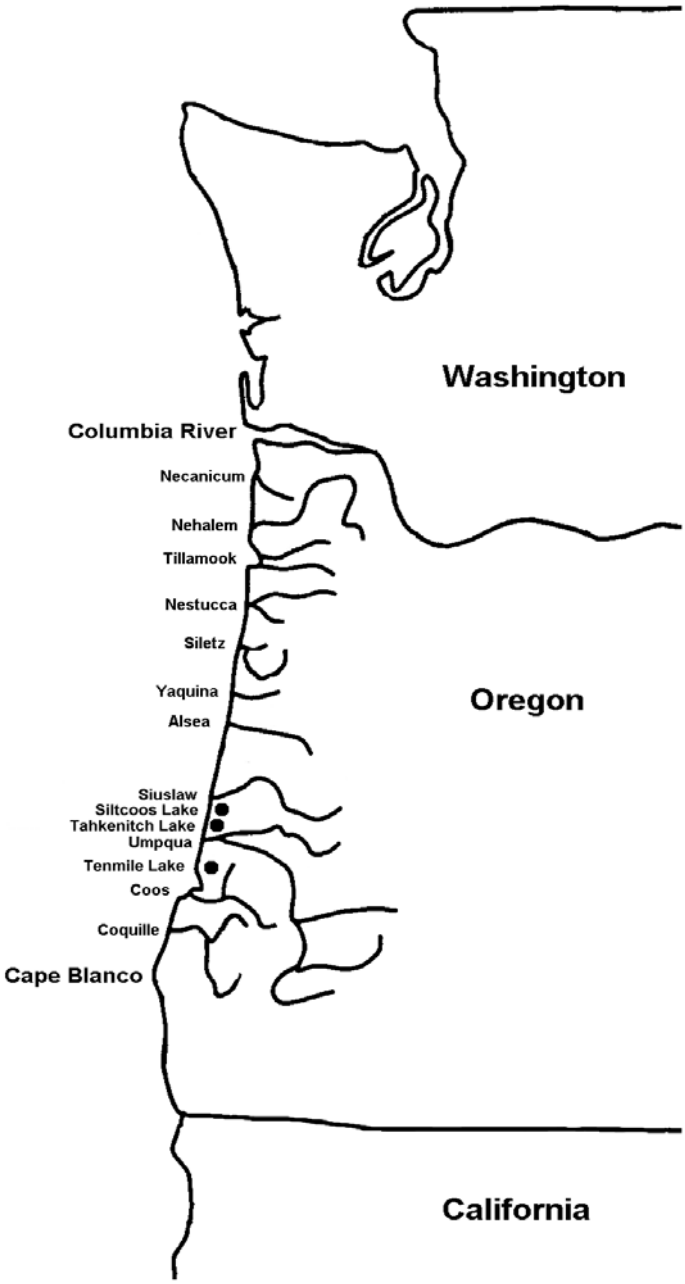
Hatchery measures

Of the proposed hatchery measures, substantial reductions in smolt releases were thought to have the most predictable benefit for natural populations; all else being equal, fewer fish released should result in fewer genetic and ecological interactions with natural fish. Marking all hatchery fish should also help to resolve present uncertainties about the magnitude of these interactions. However, the BRT expressed concerns regarding some aspects of the proposed hatchery measures. The plan was vague on several key areas, including plans for incorporation of wild broodstock and how production would be distributed among facilities after 1997. One concern was that the recent and proposed reductions appear be largely motivated by economic constraints and the present inability to harvest fish if they were produced rather than by recognition of negative effects of stray hatchery fish on wild populations. Other concerns expressed by the BRT included no reductions in fry releases in many basins, substantially higher releases of smolts in the Yaquina River Basin (which by ODFW's own assessment has more high quality habitat than any other coastal basin), and no consideration of alternative culture methods that could be used to produce higher-quality hatchery smolts which may have less impact on wild fish. Another concern was the plan's lack of recognition that hatchery-wild interactions reduce genetic diversity among populations.

Previous BRT Conclusions

In 1997, the BRT concluded that, assuming that 1997 conditions continued into the future (and that proposed harvest and hatchery reforms were not implemented), this ESU was not at significant short-term risk of extinction, but that it was likely to become endangered in the foreseeable future. A minority felt that the ESU was not likely to become endangered. Of those members who concluded that this ESU was likely to become endangered, several expressed the opinion that it was near the border between this and a "not at risk" category. The BRT generally agreed that implementation of the harvest and hatchery proposals of the OCSRI would have a positive effect on the status of the ESU, but the BRT was about evenly split as to whether the effects would be substantial enough to move the ESU out of the "likely to become endangered" category. Some members felt that, in addition to the extinction buffer provided by the estimated 80,000 naturally produced spawners in 1996, the proposed reforms would promote higher escapements and alleviate genetic concerns so that the ESU would not be at significant risk of extinction or endangerment. Other members saw little reason to expect that the hatchery and harvest reforms by themselves would be effective in reducing what they viewed as the most serious threat to this ESU—declining recruits-per-spawner. If the severe declines in recruits-per-spawner of natural populations in this ESU were partly a reflection of continuing habitat degradation, then risks to this ESU might remain high even with full implementation of the hatchery and harvest reforms. While harvest and hatchery reforms may substantially reduce short-term risk of extinction, habitat protection and restoration were viewed as key to ensuring long-term survival of the ESU, especially under variable and unpredictable future climate conditions. The BRT therefore concluded that these measures would not be sufficient to alter the previous conclusion that the ESU is likely to become endangered in the foreseeable future.

Figure C.2.1.1. Map of Oregon and Washington coasts showing the 11 major river systems plus three coastal lakes that comprise the Oregon Coast Coho Salmon ESU



Listing status

The Oregon Coast ESU of coho salmon was listed as a Threatened Species on August 10, 1998. The ESU includes all naturally spawned populations of coho salmon in Oregon Coastal Streams south of the Columbia River and north of Cape Blanco (Figure C.2.1.1).

C.2.1.2 New Comments

Alsea Valley Alliance v. Evans

On 10 September 2001 Judge Michael R. Hogan, ruling in *Alsea Valley Alliance v. Evans* for the United States District Court for the District of Oregon, found that, for the Oregon Coast ESU, "NMFS's listing decision is arbitrary and capricious, because the Oregon Coast ESU includes both "hatchery spawned" and "naturally spawned" coho salmon, but the agency's listing decision arbitrarily excludes "hatchery spawned" coho. Consequently, the listing is unlawful." (161 F. Supp. 2d 1154, D. Oreg. 2001). The lawsuit was brought by the Alsea Alliance, partly in response to an action by ODFW to terminate a domesticated coho salmon broodstock at the Fall River Hatchery on the Alsea River.

The effect of the ruling was to delist the Oregon Coast ESU. An appeal by appellant intervenors in the *Alsea* case is pending before the U.S. Court of Appeals for the Ninth Circuit. On December 14, 2001 the Court stayed the District Court ruling pending final disposition of the appeal (*Alsea Valley Alliance v. Evans*, 9th Circuit appeal, No. 01-36071, December 14, 2001). This returned the status of the Oregon Coast ESU to "threatened" under the Endangered Species Act. NMFS is currently reviewing its listing policy with regard to hatchery and wild salmon.

Petition for listing

On 25 April 2002 Regional Administrator D. Robert Lohn received a petition to define and list the wild stocks of coho along the Oregon Coast as a threatened species, pursuant to the Endangered Species Act, 16, U.S.C. Sec. 1531 et seq. (2001) (ESA). The petitioners present recent scientific reports relating to the "behavioral, physiological, ecological, reproductive and evolutionary differences between the hatchery and wild stocks" of Oregon coast coho salmon. The petition was in response to the findings of *Alsea Valley Alliance v. Evans*. The petitioners consist of Trout Unlimited, Oregon Council of Trout Unlimited, Washington Council of Trout Unlimited, Oregon Trout, Washington Trout, Native Fish Society, Oregon Council of Fly Fishers, Pacific Coast Federation of Fisherman's Associations and the Institute for Fisheries Resources, Oregon Natural Resources Council, Save our Wild Salmon, Orange Ribbon Foundation, American Rivers, Audubon Society of Portland, National Wildlife Federation, and the Siskiyou Regional Education Project. The petitioners state that:

> "NMFS has previously made findings of the detrimental impact that the artificial production of Oregon coast coho have on wild stocks, including genetic impacts, disease transmission, predation, take for broodstock purposes, and competition (62 Fed. Reg. 24588, 24600 (NMFS 1997); Flagg et al. 2000). Furthermore, recent reports indicate that these impacts are not localized, but rather widespread in every basin in the Oregon coast where wild coho are present, based on the presence of hatchery coho in every stream system (ODFW 1995b; Jacobs et al 2001). Additionally, the fluctuations in the ocean conditions, and the changes in the ocean carrying capacity, may exacerbate the impacts in certain years (NWPPC 1999). Additional reports suggest that the

> impact of these hatchery programs is resulting in at least phenotypic differences (genetic and environmental) between coho, and is not limited to hatchery management practices alone, but due to other direct biological and environmental effects (IMST 2001; Flagg et al. 2000; Chilcote 2002)."

The petitioners cite substantial updated information on current abundance, historical abundance and carrying capacity, trends in abundance, natural and human influenced factors that cause variability in survival and abundance, possible threats to genetic integrity, and recent events such as the current El Niño, significant flood events in 1995-96 and 1998, and recently improved ocean conditions (Trout Unlimited 2002).

Independent multidisciplinary science team

Since the 1997 status review, the Oregon Plan for Salmon and Watersheds (formerly Oregon Coastal Salmon Restoration Initiative Conservation Plan) has developed into an extensive effort to recover threatened or endangered salmonid populations through a combination of grass-roots actions through watershed councils, refocusing effort and resources of fisheries and other state agencies, and convening a group of scientists to "advise the state on matters of science related to the Oregon Plan for Salmon and Watersheds" (IMST 2002b). This group of scientists consists of a seven-member team with "recognized expertise in fisheries artificial propagation, stream ecology, forestry, range, watershed and agricultural management" and is known as the Independent Multidisciplinary Science Team (IMST). The IMST has been responsible for a series of review documents on the science relating to recovery of Oregon coastal coho stocks. The first of these was a workshop of agency and university fisheries professionals convened to help in the discussion of "Defining and Evaluating Recovery of OCN Coho Salmon Stocks: Implications for Rebuilding Stocks under the Oregon Plan" (IMST 1999). Alternative recovery definitions are proposed and criteria for evaluating recovery are discussed.

Additional reports issued by this team germane to the deliberations of the Oregon coastal coho BRT include: "Conservation Hatcheries and Supplementation Strategies for Recovery of Wild Stocks of Salmonids: Report of a Workshop" (IMST 2000), and "The scientific basis for artificial propagation in the recovery of wild anadromous salmonids in Oregon" (IMST 2001), which analyzes the hatchery programs of ODFW, presents three substantial conclusions and puts forth a series of ten recommendations based on these conclusions. In addition, a comprehensive look at the "Recovery of Wild Salmonids in Western Oregon Lowlands" (IMST 2002a) provides an extensive analysis of five science questions relating to the importance of lowlands to the recovery of salmonids, with twenty-one recommendations relating to recommended actions by state agencies to contribute to the recovery of salmonids in lowland areas. They do not, however, present substantially new information that can shed light on the evaluation of risk to the Oregon coastal coho ESU.

Douglas County Board of Commissioners—The board submitted a report, "Viability of coho salmon populations on the Oregon and northern California coasts," submitted to NMFS Protected Resources Division on 12 April 2002 and prepared by S.P. Cramer and Associates, Inc. (Cramer and Ackerman 2002). This report analyzes information available for both the Oregon Coastal Coho Salmon ESU and the SONCC ESU in several areas: trends in abundance and distribution, trends in survival, freshwater habitat condition, potential hatchery-wild interactions,

changes in harvest regulation, and extinction risk modeling. Few of the data presented in the report are new, but independent analyses focus on unique aspects of the data. They cite changes in fishery management, increasing spawning escapements, reduced hatchery releases, habitat restoration, and evidence of successful rearing of fry outmigrants throughout the Oregon Coast. While the report reached no conclusions regarding overall status of the ESU, the Board cites the report in concluding that coho salmon populations in this ESU are "strongly viable."

C.2.1.3 New Data and Update Analyses

Population abundance

For the Oregon Coast ESU, the BRT has received updated estimates of total natural spawner abundance based on stratified random survey (SRS) techniques, broken down by ODFW's Monitoring Areas (MAs), for 11 major river basins, and for the coastal lakes system (Steve Jacobs, Oregon Department of Fish and Wildlife, 28655 Hwy 34, Corvallis, Oregon 97333, pers. commun. Nov. 14, 2002) (ODFW's Monitoring Areas are similar, but not identical to, the GCGs that were the population units in the 1997 update). These data are for the return years 1990-2002 and are presented in Table C.2.1.1 (for consistency with the previous status review for this ESU abundance and trend analysis in this update are expressed in terms of naturally-produced fish rather than the standard of naturally spawning fish used in other status review updates). Total recent average (3-year geometric mean) spawner abundance for this ESU is estimated at about 140,600, up from 5-year geometric mean of 52,000 in the 1997 update and also higher than the estimate at the time of the status review. In 2001 the ocean run size was estimated to be about 178,000; this corresponds to one-tenth of ocean run sizes estimated in the late 1800s and early 1900s, and only about one-third of those in the 1950s (ODFW 1995a). In 2002 the ocean-run size increased to 304,500 – fourth highest since 1970 and perhaps 25% of historical abundance. Present abundance is more evenly distributed within the ESU than it was in 1997. Escapement in the relatively small Mid/South Coast MA had been the strongest in the ESU until 2001. In 2002 escapements in the Mid/South were down about 25% while the North and Mid Coast MAs showed strong gains. The Umpqua MA is up by a factor of 4 since 1996. (Table C.2.1.1).

We have updated ocean exploitation estimates based on: Oregon Productivity Index (OPI) estimated catch and escapement based on SRS methods ("OPI-SRS") for 1970-1993, post-season results of the Coho Fishery Regulation Assessment Model ("FRAM") for 1994-2001, and the pre-season FRAM estimate for 2002 (OPI-SRS and FRAM from PFMC 2002). The ODFW Standard Index spawner escapement estimates were discontinued in 1999 and data from 1970-1989 were standardized to the SRS data. All analyses were done using this updated time series. Exploitation rates are based on ocean catch and incidental mortality plus escapement. Recruits are calculated as spawners divided by 1 minus the ocean exploitation rate. A major assumption is that progeny of natural spawners are affected by fishing gear the same as hatchery fish, so that ocean mortalities are in the same proportion as escapement. Freshwater harvest and mortality is not directly assessed, but is conventionally considered to be 10% of ocean escapement for retention fisheries and 1% for catch and release fisheries. The BRT also did not attempt to adjust

trends for the contribution of stray hatchery fish; sufficient data for such an adjustment are not available for these populations.

We determined that the coded-wire-tag-based index (CWT) has become less useful since the implementation of coho non-retention fisheries in 1994. The CWT index depends on ocean recoveries of coded-wire tags and there are no tag recoveries in non-retention fisheries. Non-catch mortalities (hook-and-release, drop-off, illegal retention) are either estimated in the coho FRAM or estimated externally and input directly in the model.

We used escapement estimates provided by ODFW (Table C.2.1.1) (Steve Jacobs, Oregon Department of Fish and Wildlife, 28655 Hwy 34, Corvallis, Oregon 97333, pers. commun. Nov. 14, 2002). The SRS escapement data indicate that, on an ESU-wide basis, spawning escapement reached a 30-year high in 2001 and continued to climb in 2002 (Figures C.2.1.2 and C.2.1.3). This high escapement is due to a combination of improved marine survival and sharply curtailed ocean fisheries. When looked at on a finer geographic scale, the North Coast has responded well after a very weak period through 1999. The Mid Coast was mixed in 2001 with strong increases in some streams but continued very poor escapement in others. Substantial increases in 2002 made it the strongest area on the coast. The Mid-South coast rebounded in 2002 after a 4-year drop (Table C.2.1.1).

Three-year statistics (geometric mean, arithmetic mean, minimum and maximum spawners and recruits) in individual river basins are strongly affected by the recent two years of high marine survival (Table C.2.1.2). Abundance has grown exponentially in the past three years, so Arithmetic means are uniformly higher than geometric means. The minimum and maximum abundances show that, with a few exceptions, abundances in individual basins have increased about 10-fold in the past three years. Abundance in the Nehalem ranged only from 14285 to 22310 indicating this system may have been near capacity before survival improved. On the other hand, the Yaquina grew from 647 to 25039 – nearly a 40-fold increase. Statistics for the combined systems (Table C.2.1.3) are more stable, but indicate an overall four-fold increase in spawners over the past three years.

Table C.2.1.1. Numbers of natural-origin spawners in the Oregon Coast Coho ESU estimated from ODFW Stratified Random Surveys, 1990—2002 return years. Results are sub-totaled by ODFW Monitoring Area, rivers, lakes, and coast-wide. Monitoring Area totals from 1999-2002 are estimated by Monitoring Area and may differ from the sums of the individual rivers.

Management Area:	Return Year												
Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
North Coast:													
Necanicum and Elk Creek	191	1,135	185	941	408	211	768	253	946	728	474	5,247	2,710
Nehalem	1,552	3,975	1,268	2,265	2,007	1,463	1,057	1,173	1,190	3,713	14,285	22,310	20,654
Tillamook Bay	265	3,000	261	860	652	289	661	388	271	2,175	1,983	1,883	16,488
Nestucca	189	728	684	401	313	1,811	519	271	169	2,201	1,171	3,940	12,334
Sand Lake and Neskowin Cr	0	240	24	41	77	108	275	61	0	47	0	71	16
Miscellaneous	0	204	0	0	0	0	0	0	0	0	0	0	0
North Coast Total	2,197	9,281	2,423	4,509	3,457	3,881	3,280	2,147	2,576	8,842	17,898	33,667	52,202
Mid-North:													
Salmon	385	39	28	364	107	212	271	237	8	175	0	310	1,237
Siletz	441	984	2,447	400	1,200	607	763	336	394	706	3,553	1,437	2,369
Yaquina	381	380	633	549	2,448	5,668	5,127	384	365	2,588	647	3,039	25,039
Beaver Creek	23	0	756	500	1,259	0	1,340	425	1,041	3,366	738	5,274	7,596
Alsea	1,189	1,561	7,029	1,071	1,279	681	1,637	680	213	2,050	2,465	3,339	5,767
Yachats	280	28	337	287	67	117	176	99	102	150	79	52	1,661
Siuslaw	2,685	3,740	3,440	4,428	3,205	6,089	7,625	668	1,089	2,724	6,767	11,024	57,125
Miscellaneous	207	0	700	180	251	231	1,188	13	71	0	12	764	3,315
Mid-North Total	5,592	6,732	15,371	7,779	9,815	13,605	18,127	2,843	3,283	11,442	14,181	25,528	104,111

Table C.2.1.1 (continued).

Umpqua:													
Lower Umpqua and Smith	589	1,316	1,759	4,804	1,689	6,803	4,904	935	5,118	2,323	3,696	8,850	25,939
Umpqua	455	0	192	1,431	1,240	352	339	397	444	1,289	2,774	8,177	7,972
Elk Creek and Calapooya Creek	185	0	0	0	708	2,315	1,709	196	379	434	1,864	2,581	1,477
South Umpqua	2,508	2,284	0	2,415	579	755	1,685	512	678	1,219	479	6,482	1,419
Cow Creek	0	0	201	661	269	1,124	1,112	193	1,807	1,234	1,582	6,661	5,608
Umpqua Total	3,737	3,600	2,152	9,311	4,485	11,348	9,749	2,233	8,426	6,466	10,468	34,041	42,413
Mid-South:													
Coos Bay and Big Creek	2,273	3,813	16,545	15,284	14,685	10,351	12,128	1,127	3,167	4,945	5,386	43,301	35,005
Coquille	2,712	5,651	2,115	7,384	5,035	2,116	16,169	5,720	2,466	3,001	6,130	13,310	8,488
Miscellaneous	0	1	2	3	4	5	6	7	8	9	10	11	11
Mid-SouthTotal	4,985	9,465	18,662	22,671	19,724	12,472	28,303	6,854	5,641	7,946	11,516	56,611	43,512
Coast-wide Rivers	16,512	29,078	38,607	44,270	37,481	41,306	59,459	14,076	19,926	34,696	54,063	149,847	242,238
Lakes	4,394	7,251	1,986	10,145	5,842	11,216	13,494	8,603	11,108	12,711	12,747	19,669	22,097
Coast-wide Total	20,906	36,329	40,593	54,415	43,323	52,522	72,953	22,679	31,034	47,407	66,810	169,516	264,335

Table C.2.1.2. Three-year statistics and 13-year trends for 11 major river basins in the Oregon Coast ESU. Spawners are natural-origin spawners only. Recruits are natural-origin adults before ocean harvest.

	Spawners						Recruits					
	3 year mean		3 year range		13 year		3 year mean		3 year range		13 year	
Basin	Geometric	Arithmetic	Minimum	Maximum	Trend	SE	Geometric	Arithmetic	Minimum	Maximum	Trend	SE
Necanicum	1889	2810	474	5247	1.169	0.860	2096	3,101	522	5,667	1.076	0.941
Nehalem	18741	19083	14285	22310	1.206	0.889	20799	21,188	15,728	24,097	1.110	1.042
Tillamook	3949	6785	1883	16488	1.191	1.084	4382	7,723	2,034	18,952	1.096	1.191
Nestucca	3846	5815	1171	12334	1.230	1.015	4269	6,574	1,289	14,177	1.132	1.133
Siletz	2295	2453	1437	3553	1.070	0.760	2547	2,729	1,552	3,912	0.985	0.847
Yaquina	3665	9575	647	25039	1.204	1.205	4067	10,925	712	28,780	1.108	1.204
Alsea	3621	3857	2465	5767	1.042	0.960	4018	4,316	2,714	6,629	0.959	1.089
Siuslaw	16213	24972	6767	57125	1.120	1.037	17993	28,339	7,450	65,661	1.031	1.150
Umpqua	24351	28520	10395	42415	1.182	0.662	27025	31,857	11,445	48,753	1.088	0.764
Coos	20136	27897	5386	43301	1.088	1.066	22346	30,978	5,930	46,769	1.002	1.098
Coquille	8847	9309	6130	13310	1.070	0.649	9819	10,294	6,749	14,376	0.984	0.684

Table C.2.1.3. Three-year statistics and 33-year trends for Oregon Coast ESU rivers, lakes, and combined rivers and lakes. Spawners are natural-origin spawners only. Recruits are natural-origin adults before ocean harvest.

	Spawners						Recruits					
	3 year mean		3 year range		33 year		3 year mean		3 year range		33 year	
	Geometric	Arithmetic	Minimum	Maximum	Minimum	Maximum	Geometric	Arithmetic	Minimum	Maximum	Trend	SE
Rivers	122718	147933	50500	242200	1.017	0.600	136291	165933	55600	279000	0.950	0.575
Lakes	16189	16635	12747	22097	1.013	0.735	17966	18567	14034	25399	0.946	0.592
Combined	140568	164569	63247	264297	1.016	0.566	156105	184500	69634	304399	0.949	0.520

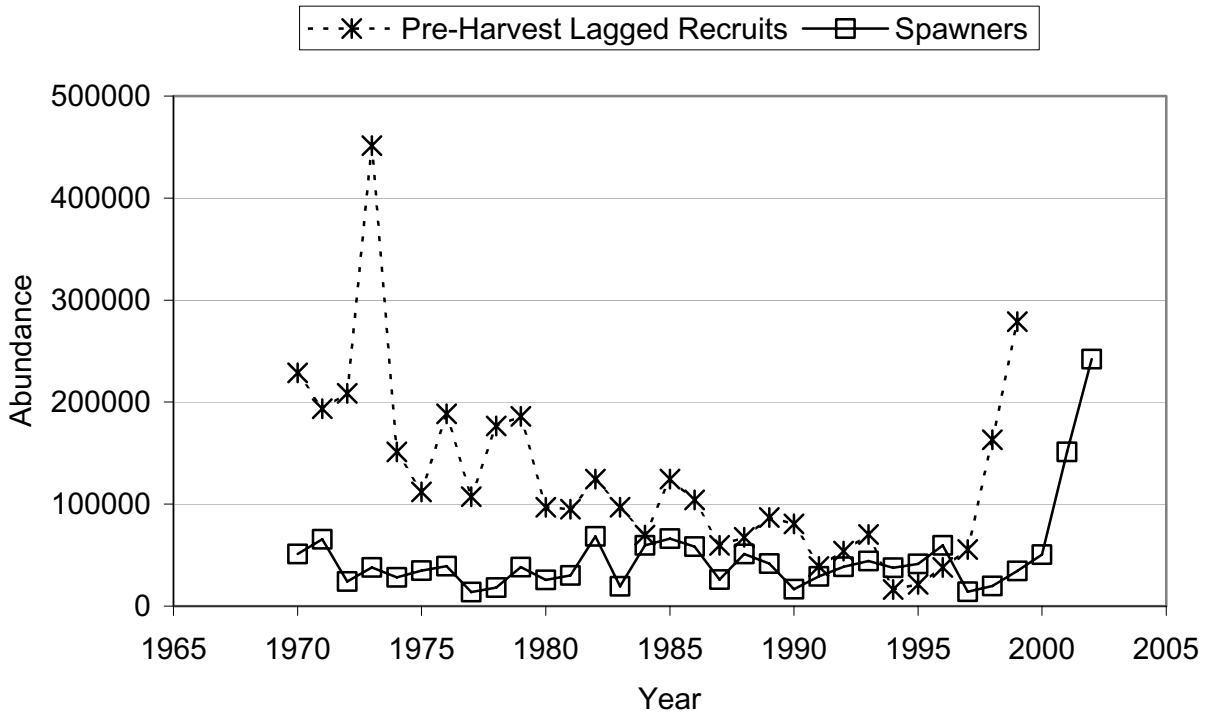


Figure C.2.1.2. Time series of spawners and pre-harvest recruits, by broodyear, for rivers in the Oregon Coast coho salmon ESU.

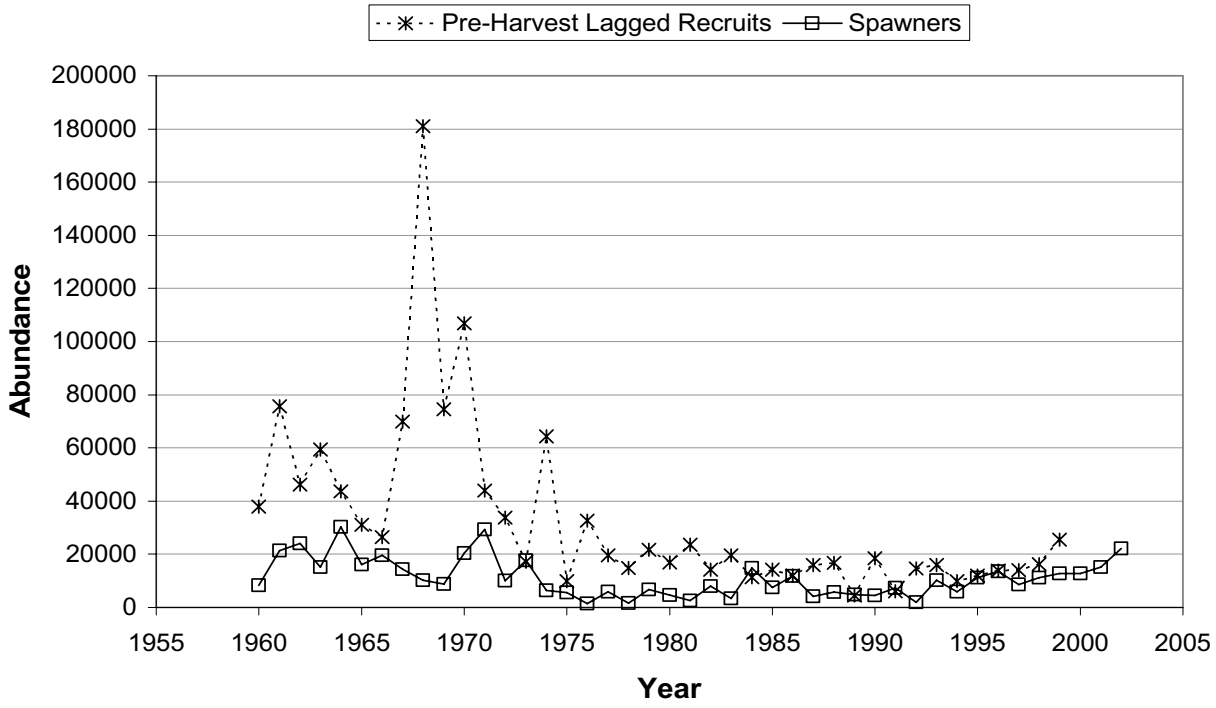


Figure C.2.1.3. Time series of spawners and pre-harvest recruits, by broodyear, for lakes in the Oregon Coast coho salmon ESU.

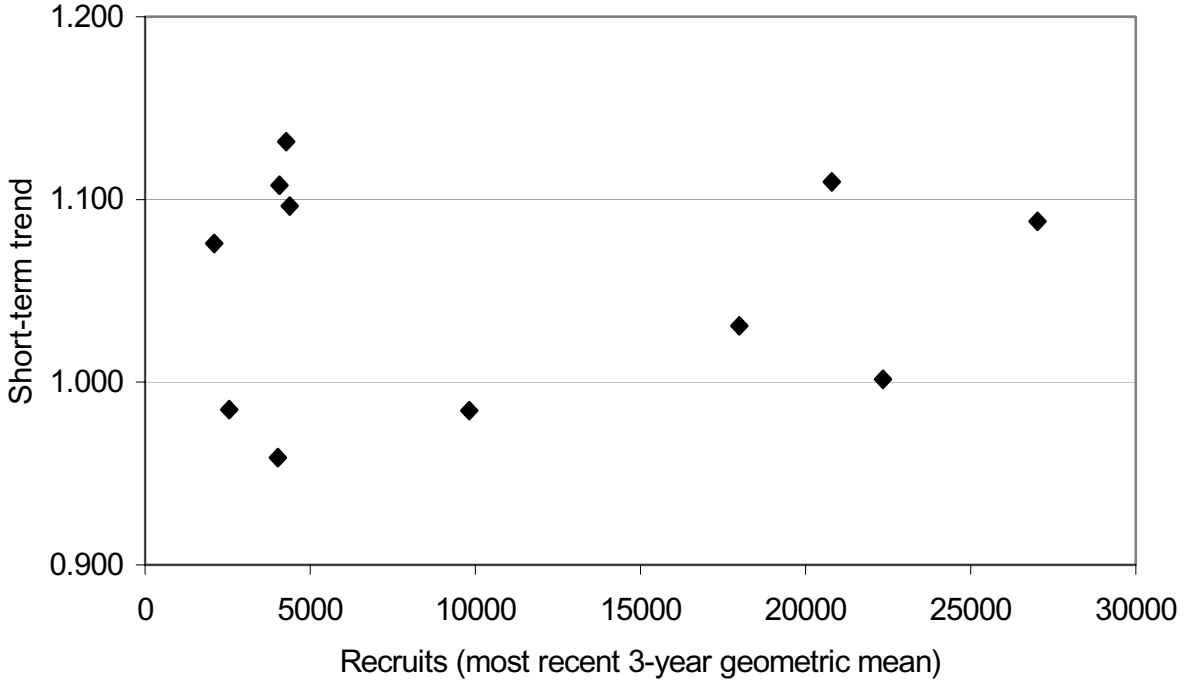


Figure C.2.1.4. Short-term (13-year, 1990-2002) trends in spawners and recruits vs. the recent 3-year geometric mean abundance plotted for 11 major river populations.

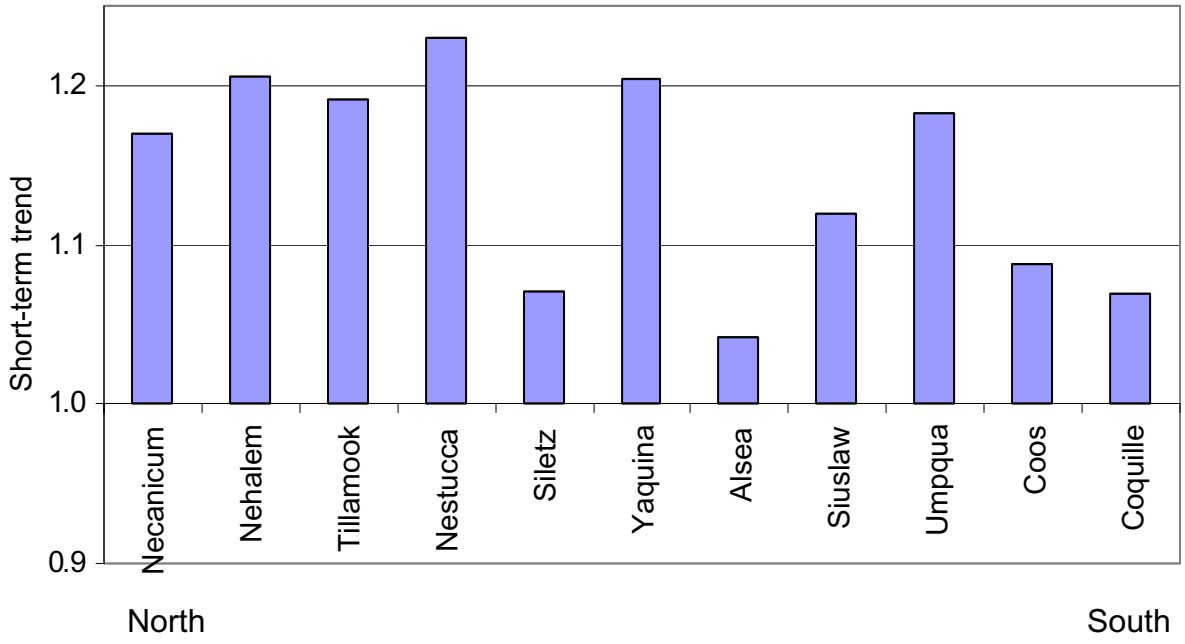


Figure C.2.1.5. Short-term (13-year, 1990-2002) trends in spawner abundance for 11 major river basins in the Oregon Coast coho salmon ESU. Basins are ordered from north to south.

In the return years 1997-1999 (broodyears 1994-1996), and for the first time on record (since 1950), recruits failed to replace the parental spawners: a recruitment failure occurred in all three brood cycles, even before accounting for harvest-related mortalities (Figure C.2.1.2). Since 1999, improving marine survival and higher rainfall are thought to be the factors contributing to an upswing in wild recruitment. Fishery recruitment for 2002 was up over four-fold from 2000 with about 304,000 recruits, but below the 30-year high of 450,000 observed in 1973. Given current habitat conditions OCN coho are thought to require an overall marine survival rate of 0.03 to achieve a spawner:recruit ratio of 1:1 in the best quality habitat (Nickelson and Lawson 1998). Less productive habitats require higher marine survivals to sustain populations. Based on OPI hatchery survival rates marine survival after exploitation exceeded 0.03 only in the year 2001. Assuming natural spawners survive at twice the hatchery rate there were seven of thirteen years since 1990 with marine survivals after exploitation high enough to sustain the strongest populations. Increases in recruits and spawners (Figures C.2.1.2 and C.2.1.3) reflect improved marine survival for the 2000 and 2001 smolt years. It is far from certain that these favorable marine conditions will continue and, with the current freshwater habitat conditions, the ability of OCN coho to survive another prolonged period of poor marine survival remains in doubt.

Growth rates/productivity

Trend analyses were performed on short-term and long-term time series of spawner abundance and pre-harvest recruit abundance calculated as described above. Short-term trends were based on stratified-random-sampling (SRS) estimates of abundance in 11 major river basins considered to be the principal populations in this ESU. Short-term trends used data from 1990-2002 return years. Long-term trends were estimated separately for the aggregated coastal rivers (including several small systems outside the 11 major river basins) and for the coastal lakes. The river trends were based on data calibrated to the SRS time series from 1970-2002. The lake trends were based on the historical time series of lakes abundance from 1970-2002.

Thirteen-year trends of spawner abundance for 11 major river systems are presented in Table 2.1.2 and illustrated in Figures C.2.1.4 and C.2.1.5. Spawner trends have been positive in all 11 basins, with the biggest increases (> 10% per year) on the north coast (Necanicum, Nehalem, Tillamook, Nestucca), mid-coast (Yaquina, Siuslaw) and the Umpqua, and with smaller increases on the central (Siletz, Siuslaw) and south (Coos, Coquille) coast. The Alsea showed the weakest trend and was > 1 as of the 2002 spawning returns (Figure C.2.1.5).

Thirteen-year trends in pre-harvest recruits (Figures C.2.1.4 and C.2.1.6) show a less favorable picture. Necanicum, Nehalem, Tillamook, Nestucca, Yaquina, and Umpqua all showed positive trends of about 8 -13% per year. Siletz, Alsea, and Coquille showed declines ranging of 1 - 4% per year. Upward trends in the Tillamook, Siuslaw, and Coos hinge on the high 2002 escapements. The most recent 3-year geometric mean abundance showed little relationship to trend (Figure C.2.1.4).

Long-term (33-year) trends in spawner abundance for both the lakes and rivers have been relatively flat (Table C.2.1.3, Figure C.2.1.7), with lakes increasing about 2% per year and rivers increasing about 1% per year. In both the lakes and rivers long-term trends in recruits have declined about 5% per year since 1970. For the ESU as a whole, spawners and recruits have declined at a 5% rate over the past 33 years.

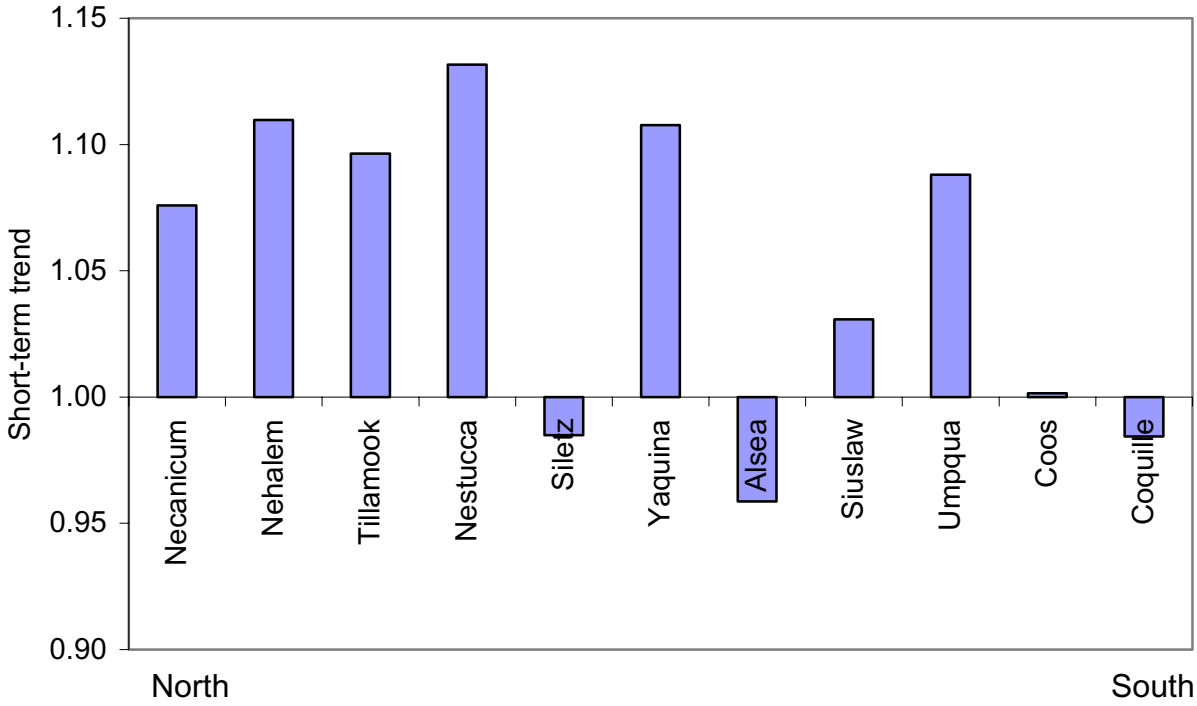


Figure C.2.1.6. Short-term (13-year, 1990-2002) trends in recruit abundance for 11 major river basins in the Oregon Coast coho salmon ESU. Basins are ordered from north to south.

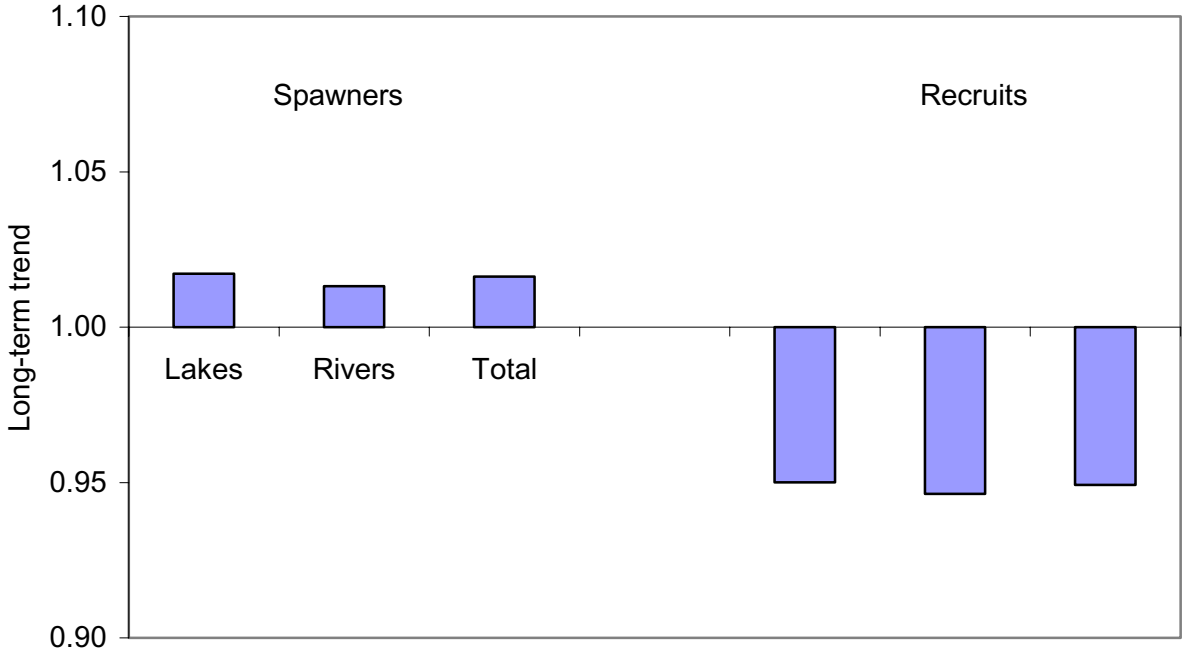


Figure C.2.1.7. Long-term trends (33 years, 1970 – 2002) for spawners and recruits in coastal lakes (Lakes), river basins (Rivers), and total OCN (Total) in the Oregon Coast coho salmon ESU.

Population spatial structure

We have very limited direct information about the spatial structure of these populations. Recent analyses (Nickelson and Lawson 1998, Nickelson 2001) have assumed that spawners from major river basins are largely isolated and that each basin comprises at least one population. The Umpqua River is large and diverse enough to hold several populations, but for the purposes of this analysis was considered as one. The three coastal lakes, Siltcoos, Tahkenitch, and Tenmile, are considered to be a single population, but may actually be separate. Genetic analyses are being conducted to resolve these questions, but results were not available at the time of this review. This is a change from the Status Review Update in 1997 (Schiewe 1997) when the coast was considered to consist of four populations, called "Gene Conservation Groups." Three of these groups (North/Mid Coast, Mid/South Coast, and Umpqua) were in the Oregon Coast ESU and the fourth (South Coast) was in the Southern Oregon/Northern California ESU.

Population diversity

New information on population diversity is anecdotal. With extremely low escapements in recent years many small systems have shown local extirpations. For example, Cummins Creek, on the central coast, had zero spawners in 1998 (Steve Johnson, Oregon Department of Fish and Wildlife, 2040 Marine Science Drive, Newport, Oregon , pers. commun. January 15, 2003), indicating the loss of a brood cycle. These systems are apt to be repopulated by stray spawners if abundances increase. Whether these events represent loss of genetic diversity or are indications of normal metapopulation function is not known.

Harvest impacts

Historical harvest rates on OPI area coho salmon were in the range of 60% to 90% from the 1960s into the 1980s. Modest harvest reductions were achieved in the late 1980s, but rates remained high until a crisis was perceived and most directed coho salmon harvest was prohibited in 1994. Subsequent fisheries have been severely restricted and most reported mortalities are estimates of indirect (non-catch) mortality in chinook fisheries and selective fisheries for marked (hatchery) coho. Estimates of these indirect mortalities are somewhat speculative and there is a risk of substantial underestimation.

Amendment 13—The Pacific Fishery Management Council adopted Amendment 13 (PFMC 1998) to their Salmon Fishery Management Plan in 1998. This amendment was developed as part of the Oregon Plan for Salmon and Watersheds (formerly OCSRI). It specified an exploitation rate harvest management regime with rates for OCN dependent on marine survival (as indexed by hatchery jack/smolt ratios) and parental and grand-parental spawning escapements. Exploitation rates ranged from 13% to a maximum of 35%. In 2000, Amendment 13 was reviewed, and the harvest rate matrix modified to include a 0-8% category under conditions of extremely poor marine survival as had been observed in the late 1990. At the same time, the maximum exploitation rate was increased to 45%. Exploitation rates were calculated to allow a doubling of spawners under conditions of moderate to good ocean survival.

Risk assessment was conducted for Amendment 13 (PFMC 1998) and the 2000 Amendment 13 Review (PFMC 2000) using the Nickelson/Lawson coho salmon habitat-based life-cycle model (Nickelson and Lawson 1998). The models were augmented to include a simulation of the fishery management process, including errors in spawner assessment, prediction, and harvest management. In general, the exploitation-rate management with a 35% cap showed a lower risk of pseudo-extinction than managing for an escapement goal of 200,000 spawners, but higher risk than a zero-harvest scenario. Starting from the very low escapements of 1994, basins on the North Coast had higher extinction risks than those on the Mid-North and Mid-South coasts.

Mark-selective fisheries—Beginning in 1998 most adult hatchery-origin coho salmon in the OPI area were marked with an adipose fin clip. This allowed the implementation of mark-selective fisheries, with legal retention only of marked fish. Unmarked fish were to be released unharmed. Recreational mark-selective fisheries have been conducted on the Oregon coast in each year since 1998, with quotas ranging from 13,000 to 24,000 marked fish. Commercial troll fisheries targeting chinook salmon were also operating.

Both fisheries catch and release coho salmon, resulting in incidental mortalities. In addition, some coho encounter the gear but escape or are eaten by predators – so called "drop-offs." Estimates of non-catch mortalities from hook and release and drop-off are difficult because they are, by their nature, unobserved. Field studies in the 1990s (NRC 1996) and a literature review and meta-analysis resulted in the adoption, by the PFMC, of hooking mortality rates of 13% for recreational fisheries and 24% for commercial fisheries. In addition, dropoff mortalities were assumed to equal 5% of the number of fish brought to the boat. Based on these mortality rates the PFMC uses a coho Fisheries Regulation Assessment Model (FRAM) to estimate noncatch mortalities in Council-managed fisheries. Post-season estimates of OCN exploitation rates based on FRAM modeling have ranged from 0.07 to 0.12 since the cessation on directed coho salmon fishing in 1994 (Table C.2.1.4). There is concern that these rates may be underestimates, and that actual mortalities may be greater. It is difficult to assess the risk to these stocks resulting from harvest at these levels.

Table C.2.1.4. OPI area hatchery marine survival, Oregon Coastal hatchery adult returns per smolt, and OPI area exploitation rate on unmarked coho salmon. All values are lagged to adult return year.

Year	OPI Hatchery Adults per Smolt	Coastal Hatchery Adults per Smolt	OPI Area Unmarked Exploitation Rate	OPI Marine Survival after Exploitation
1990	0.020	0.003	0.72	0.006
1991	0.050	0.007	0.57	0.022
1992	0.026	0.004	0.56	0.011
1993	0.011	0.003	0.45	0.006
1994	0.018	0.005	0.03	0.017
1995	0.024	0.005	0.23	0.018
1996	0.021	0.006	0.15	0.018
1997	0.006	0.005	0.13	0.005
1998	0.008	0.005	0.07	0.007
1999	0.011	0.008	0.08	0.010

2000	0.023	0.014	0.09	0.021
2001	0.050	0.044	0.07	0.046
2002	0.026	0.033	0.12*	0.023

*preseason estimate

Despite these uncertainties there is no doubt that harvest-related mortalities have been reduced substantially over the past decade. This reduction is reflected in positive short-term trends in spawner escapements (Figure C.2.1.5) despite continued downward trends in pre-harvest recruits for six of 11 major river basins (Figure C.2.1.6). Harvest management has succeeded in maintaining spawner abundance in the face of a continuing downward trend in productivity of these stocks. Further harvest reductions can have little effect on spawning escapements. Future remedies must be found outside of harvest management until the decline of productivity is reversed.

Habitat condition

Freshwater—The Oregon Plan for Salmon and Watersheds (Oregon Plan 1997) is the most ambitious and far-reaching program to improve watersheds and recover salmon runs in the Pacific Northwest. It is a voluntary program focused on building community involvement, habitat restoration, and monitoring. All State agencies with activities affecting watersheds are required to evaluate their operations with respect to salmon impacts and report on actions taken to reduce these impacts to the Governor on a regular basis. The original Coastal Salmon Restoration Initiative was written in 1997, so the Plan has been in operation for about 5 years. As a result of the plan, watershed councils across the State have produced watershed assessments of limiting factors for anadromous salmonids on both public and private land. The State of Oregon has dedicated about $20 million/year to implement restoration projects and is developing a system to link project development with whole-watershed assessments. The Oregon Department of Environmental Quality and the Oregon Department of Agriculture are implementing regulatory mechanisms to reduce non-point-source pollution. If these efforts are successful Oregon could see a widespread improvement in water quality. There is room for improvement in the reporting of watershed assessment results and limiting factors, and identification of actions to be taken or progress made in addressing these limiting factors. While this is a significant recovery effort in the Pacific Northwest, and an extensive, coordinated monitoring program is in place, measurable results of the program will take years or decades to materialize.

Marine—The regime shift in 1976 was the beginning of an extended period of poor marine survival for coho salmon in Oregon. Conditions worsened in the 1990s, and OPI hatchery survival reached a low of 0.006 adults per smolt in 1997 (1996 ocean entry, Table C.2.1.4). Coastal hatcheries appear to have fared even worse, although adult counts at these facilities are often incomplete, biasing these estimates low. Following an apparent shift to a more productive climate regime in 1998 marine survival has started to improve, reaching 0.05 for adults returning in 2001 (Table C.2.1.4). The Pacific Decadal Oscillation (PDO) had been in a cold, productive phase for about 4 years and in August reversed indicating a warm, unproductive period. This reversal may be short-lived; the PDO historically has show a 20-60 year cycle. However, "the rising influence of global warming should throw up a big caution sign to us when trying to use past decadal patterns as predictive models for the future" (Nathan J. Mantua, School of Marine

Affairs/Joint Institute for the Study of Atmospheric and Oceanic Climate Impacts Group, University of Washington, Seattle, pers. commun. January 7, 2003).

Table C.2.1.5. Millions of smolts released, adult returns, and number of operating hatcheries on the Oregon Coast from 1990 to 2002. [1]Excludes three small hatcheries: Elk River, Cedar Creek, and Eel Lake. [2]An additional 5.4 million smolts were released from private facilities in 1990.

Year	Smolts Released (millions)	Adult Returns to Hatchery	Number of Hatcheries[1]
1990[2]	5.70	15,489	6
1991	5.30	39,555	6
1992	6.20	23,307	6
1993	4.33	20,209	6
1994	5.02	23,435	6
1995	3.71	25,173	6
1996	3.28	23,422	7
1997	2.92	17,776	7
1998	1.66	15,287	7
1999	1.06	13,347	6
2000	0.86	14,984	5
2001	0.93	38,149	5
2002	0.98	30,862	5

A long-term understanding of the prospects for OCN coho can be constructed from a simple conceptual model incorporating a trend in habitat quality and cyclical ocean survival (Figure C.2.1.8, Lawson 1993). Short-term increases in abundance driven by marine survival cycles can mask longer-term downward trends resulting from freshwater habitat degradation (as in Figure C.2.1.8) or longer-term trends in marine survival that may be a consequence of global climate change. Decreases in harvest rates (C in Figure C.2.1.8) can increase escapements and delay ultimate extinction (D in Figure C.2.1.8). Harvest rates have been reduced to the point where no further meaningful reductions are possible. The current upswing in marine survival is a good thing for OCN coho, but will only provide a temporary respite unless other downward trends are reversed.

C.2.1.4. New Hatchery Information

Interactions between hatchery and wild fish are generally considered to have negative outcomes for the wild fish. A growing body of literature documents reduced spawning success, freshwater survival and production of wild fish when hatchery fish are present (IMST 2001, Einum and Fleming 2001, Flagg et al. 2000, Independent Scientific Group 1996, National Research Council 1996, Flagg and Nash 1999, Chilcote 2002). Additional negative interactions are associated with mark-selective fisheries directed at hatchery coho salmon in the ocean. In the past 12 years there have been closures of some Oregon coastal hatchery facilities, reduction in numbers of smolts released from the remaining facilities, and efforts to

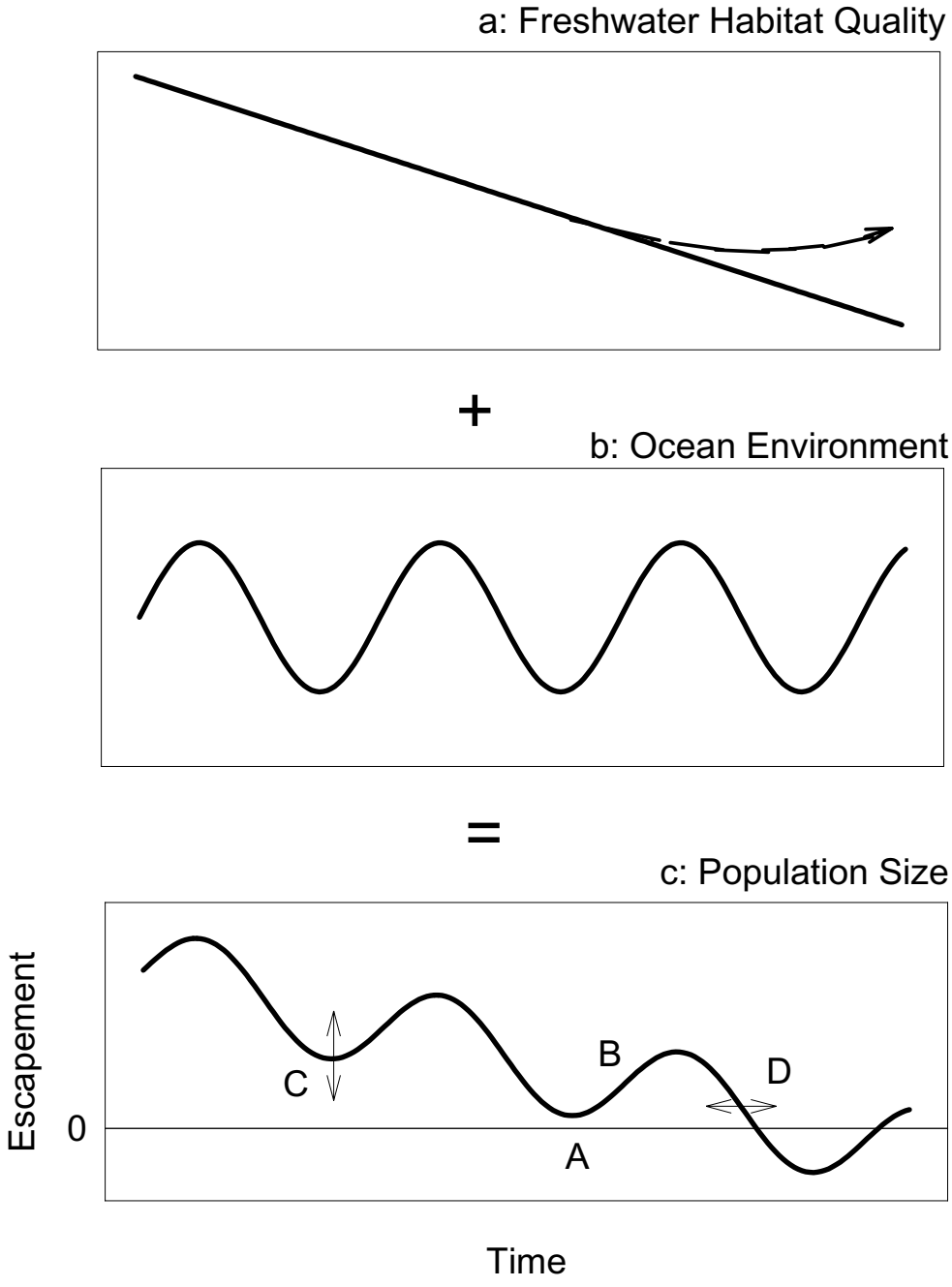


Figure C.2.1.8. Conceptual model of effects of declining habitat quality and cyclic changes in ocean productivity on the abundance of Oregon's coastal natural coho salmon. a: trajectory over time of habitat quality. Dotted line represents possible effects of habitat restoration projects. b: generalized time series of ocean productivity. c: sum of top two panels. Labeled points on c: A = situation in the mid 1990s, B = current situation, C = change in escapement from increasing or decreasing harvest, and D = change in time of extinction from increasing or decreasing harvest. Figure from Lawson 1993

include more native broodstock. In principle, these changes should somewhat reduce risks to naturally spawning coho on the Oregon coast.

Starting in 1999 most adult coho salmon of hatchery origin were marked with an adipose fin clip. This has enabled the introduction of mark-selective fisheries for hatchery (fin-clipped) coho salmon. An additional benefit is better accounting of hatchery fish spawning in the wild.

Hatchery smolts released are reported in Table C.2.1.5. Numbers have dropped from a high of 6.2 million in 1992 to 0.93 million in 2001. Over that time period several small hatcheries have closed or stopped releasing coho. For three years (1995 – 1997) coho smolts were released from the acclimation facility on Yaquina Bay. In 1999 Fall Creek Hatchery on the Alsea River stopped releasing coho salmon smolts. The percentage of hatchery-origin spawners on natural spawning grounds has also decreased (Figure C.2.1.9, Table C.2.1.6, Table C.2.1.7). Throughout most of the 1990s, the percentage of natural spawners that were of hatchery origin exceeded 10% in over half of Oregon coast basins and exceeded 70% in three. By contrast, in the most recent three years the proportion of hatchery-origin spawners has generally been much lower (Table C.2.1.6, Table C.2.1.7). The decrease is most notable in North Coast systems that had up to 70% hatchery spawners in the early 1990s and have averaged below 5% since 1999. Both the Tillamook and Umpqua basins continue to show elevated numbers of hatchery-origin spawners in most years, and the Alsea River had 7% hatchery spawners in 2001 despite the closure of the Fall Creek Hatchery in that system.

Overall, the reduction in hatchery activity is expected to benefit wild runs. However, it may take several years before these benefits become apparent, depending on the mix of demographic and genetic effects on natural production. In the meantime, the future of the hatchery program is uncertain. On one hand, public opinion and a perceived short-term benefit may create pressure to increase hatchery activity despite the likely negative effects on wild runs. On the other hand, Oregon State budget problems may force additional hatchery closures. The Trask and Salmon River hatcheries were scheduled to be closed in 2001 but were given a last-minute reprieve by the Oregon Legislature.

Jacobs et al. (2000) discuss potential errors associated with the change in methodology used to determine the origin of natural spawners. Prior to 1998, hatchery or wild origin was determined primarily by scale analysis, while mass marking permitted the use of adipose fin clips beginning in 1998. In 1998 and 1999 both methods were used. Comparison of results from the two methodologies show that scales tend to indicate greater proportion of hatchery fish than fin clips, although there are limitations associated with both methodologies. The primary limitation of scale analysis is availability of adequate reference scales for naturally produced fish, while marking programs may not actually mark 100% of the fish as intended.

Estimates of hatchery fish contribution rates from scale analysis are complicated by the low sample sizes collected during the extremely low coho abundances in the 1990s. ODFW determined that acceptable estimates of hatchery contribution rates could not be made in cases where fewer than 10 scales were collected in a basin in a year. These were reported as zero percent hatchery fish even when hatchery scales were observed in the sample. Small sample zeros are not distinguishable from true zeros in Table C.2.1.7, resulting in an under reporting of hatchery contributions that we are unable to evaluate. Figure C.2.1.9 attempts to minimize this problem by aggregating data over the years 1992-1998, and probably presents a truer overall picture for that time period of general patterns in hatchery fish distribution in the ESU.

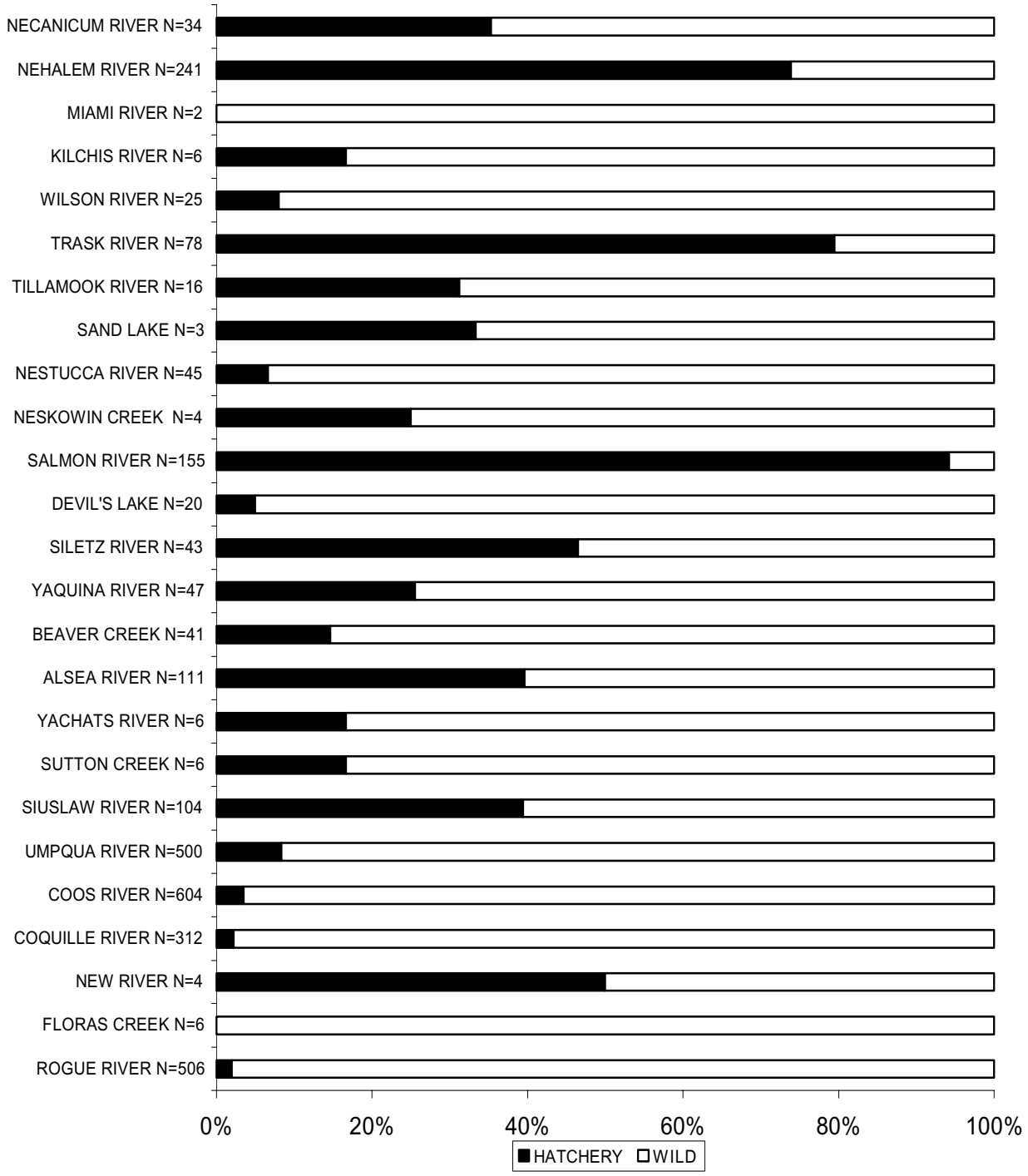


Figure C.2.1.9. Rearing origin of naturally spawning adult coho salmon in major coastal river basins over the 6-year period of 1992-98. Estimates derived from analysis of scales collected on random spawning surveys. Samples from the Rogue Basin are only from the most recent 3-year period (1996-98). Solid bars represent hatchery fish and open bars represent naturally produced fish. Reproduced from Jacobs et al. 2000.

Table C.2.1.6. Percent of natural spawning coho salmon of hatchery origin based on fin clips from carcasses (1998, 1999) or both carcasses and live fish (2000-2002). Hatchery percentages from 1998 and 1999 are adjusted by marked:unmarked ratios at nearest hatchery facility. Data from Jacobs et al. 2000, 2001, 2002, and Jacobs pers. comm. (4/9/03).

Major Basin	1998		1999		2000		2001		2002	
	n	% H	n	% H	n	% H	n	% H	n	% H
North Coast:										
Necanicum & Elk Creek	2	0.0	8	0.0			605	6.4	280	2.9
Nehalem[1]	22	26.0	14	0.0	1,995	0.5	2,735	2.0	2,535	6.2
Tillamook Bay	1	0.0	18	5.6	224	10.8	124	4.1	1,874	2.0
Nestucca	1	0.0	20	0.0	188	2.1	212	10.4	1,034	1.6
North Coast totals, Avg.	26	22.0	60	1.7	2,407	1.6	3,676	3.3	5,723	3.8
Mid-North:										
Salmon	142	98.6	6	17.5					145	34.5
Siletz[2]	2	100.0	5	41.9	185	2.7	153	12.4	171	1.8
Yaquina	16	37.5	6	0.0			239	1.7	1,579	0.3
Devil's Lk. & Beaver Cr.	19	21.1	13	0.0			193	1.6	527	0.8
Alsea	24	87.5	4	0.0	107	2.8	162	7.4	448	0.2
Siuslaw	9	11.1	15	6.7	351	0.9	782	1.2	3,240	0.3
Coastal lakes	647	0.0	80	1.3	54	0.0	183	0.0	3,293	0.1
Mid-North totals, Avg.	859	20.3	129	4.0	697	1.6	1,712	2.8	9403	0.8
Umpqua:										
Smith[3]	59	0.0	25	0.0	693	0.4	1,603	2.3	2,252	1.1
Mainstem Umpqua	7	14.3	17	5.9	209	3.3	508	40.8	617	5.8
Elk & Calapooya Cr.	10	10.0	13	15.4	231	3.9	158	1.3	204	2.9
South Umpqua	11	36.4	47	6.4			285	4.6	67	0.0
Cow Creek	21	14.0	34	3.0	124	21.8	498	5.1	192	1.6
Umpqua totals, Avg.	108	8.3	136	5.2	1,257	3.7	3,052	9.3	3,332	2.1
Mid-South										
Coos Bay	53	1.9	85	0.0	376	0.0	2,569	0.8	4,145	0.3
Coquille	29	0.0	40	0.0	431	0.2	1,733	6.0	880	0.9
Tenmile Lake	51	0.0	80	0.0	65	0.0	767	0.1	341	1.5
Floras Cr & New R	10	0.0	4	0.0			217	5.1	2	0.0
Mid-South Totals, Avg.	143	0.7	209	0.0	872	0.1	5,286	2.6	5368	0.4
Coast-wide *Totals, Avg.*	1,136	16.7	534	2.5	5,233	1.8	13,726	4.3	23,826	1.6

[1]2002 data is missing dead fish from North Nehalem, area of high hatchery straying.
[2]In 2002, does not include recoveries from Steer Cr., located near Siletz Tribal Release Point. With Steer Cr. recoveries, n = 435, % H = 49.4%.
[3]Includes Lower Umpqua River in 2000, 2001, and 2002

Table C.2.1.7 Proportion of natural spawning fish of hatchery origin. Data from 1990-1997 are based on scale analysis. In some cases with insufficient data ODFW reported 0.00 hatchery spawners when, in fact, hatchery spawners may have been present. Data from 1998-2002 are based on fin clips.

Management Area: Return Year													
Location	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
North Coast:													
Necanicum and Elk Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
Nehalem	0.65	0.22	0.43	0.81	0.43	0.49	0.74	0.45	0.23	0.00	0.00	0.02	0.08
Tillamook Bay	0.00	0.00	0.00	0.53	0.29	0.62	0.14	0.08	0.00	0.06	0.11	0.13	0.02
Nestucca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.02
Sand Lake and Neskowin Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00	0.00
North Coast Avg.	0.57	0.11	0.28	0.70	0.34	0.33	0.49	0.32	0.12	0.02	0.02	0.02	0.05
Mid-North:													
Salmon	0.11	0.00	0.80	0.00	0.93	0.84	0.90	0.43	0.99	0.17	1.00	0.76	0.20
Siletz	0.00	0.71	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.30	0.45
Yaquina	0.38	0.00	0.00	0.00	0.00	0.00	0.16	0.27	0.38	0.00	0.00	0.05	0.00
Beaver Creek	0.00		0.00	0.00	0.00		0.00	0.00	0.21	0.00	0.00	0.07	0.00
Alsea	0.01	0.00	0.17	0.00	0.00	0.00	0.00	0.27	0.87	0.00	0.00	0.15	0.00
Yachats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siuslaw	0.00	0.00	0.00	0.04	0.38	0.00	0.26	0.00	0.11	0.07	0.00	0.00	0.00
Miscellaneous	0.00	1.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00	0.00	0.00
Mid-North Avg.	0.05	0.26	0.14	0.02	0.26	0.08	0.25	0.17	0.45	0.08	0.04	0.09	0.02

Table C.2.1.7 (continued).

Umpqua:													
Lower Umpqua and Smith	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.03	0.01	0.02
Umpqua	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.06	0.08	0.32	0.04
Elk Creek and Calapooya Creek	0.00				0.00	0.00	0.00	0.00	0.10	0.15	0.03	0.02	0.00
South Umpqua	0.00	0.00		0.00	0.00	0.08	0.77	0.21	0.05	0.04	0.00	0.08	0.00
Cow Creek			0.00	0.00	0.71	0.08	0.58	0.00	0.67	0.00	0.09	0.09	0.02
Umpqua Avg.	0.06	0.00	0.00	0.00	0.13	0.01	0.43	0.08	0.09	0.03	0.05	0.14	0.02
Mid-South													
Coos Bay and Big Creek	0.00	0.00	0.03	0.05	0.03	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.00
Coquille	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.01
Mid-South Avg.*	0.00	0.00	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Coast-wide Rivers	0.17	0.11	0.09	0.21	0.15	0.07	0.22	0.11	0.16	0.03	0.03	0.07	0.02
Lakes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coast-wide Total	0.17	0.11	0.09	0.21	0.15	0.07	0.22	0.11	0.16	0.03	0.03	0.07	0.02

* Excluding Floras Creek and Sixes River.

C.2.2 SOUTHERN OREGON/NORTHERN CALIFORNIA COASTS COHO SALMON

Primary contributors: Brian C. Spence, Thomas C. Wainwright, and Eric P. Bjorkstedt (Southwest Fisheries Science Center – Santa Cruz Lab and Northwest Fisheries Science Center)

C.2.2.1 Summary of Previous BRT Conclusions

The Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU) extends from Cape Blanco in southern Oregon to Punta Gorda in northern California (Weitkamp et al. 1995). The status of coho salmon coastwide, including the SONCC ESU, was formally assessed in 1995 (Weitkamp et al. 1995). Two subsequent status review updates have been published by NMFS, one addressing all West Coast coho salmon ESUs (NMFS 1996b) and a second specifically addressing the Oregon Coast and Southern Oregon-Northern California ESUs (NMFS 1997). Information from those reviews regarding extinction risk, risk factors, and hatchery influences is summarized in the following sections.

Status indicators and major risk factors

California populations—Data on population abundance and trends were limited for the California portion of the SONCC ESU. The BRT found no regular estimates of natural spawner escapement for coho salmon in the SONCC, and most information used by the BRT came from reviews by California Department of Fish and Game (CDFG 1994) and Brown et al. (1994). Historical point estimates of coho salmon abundance for the early 1960s and mid 1980s cited in these reviews were taken from CDFG (1965), Wahle and Pearson (1987), and Sheehan (1991)[2]. These estimates suggest that statewide coho spawning escapement in the 1940s ranged between 200,000 and 500,000 fish (E. Gerstung, CDFG pers. comm. cited in Brown et al. 1994). By the early-to-mid 1960s, statewide escapement was estimated to have declined to just under 100,000 fish (CDFG 1965), with approximately 43,000 fish (44%) originating from rivers within the SONCC ESU (Table C.2.2.1). Wahle and Pearson (1987) estimated that statewide coho salmon escapement had declined to approximately 30,000 fish by the mid-1980s, with about 12,400 (41%) originating within the SONCC ESU. For the late 1980s, Brown et al. (1994) estimated wild and naturalized coho salmon populations at 13,240 for the state, and 7,080 (53%) for the California portion of the SONCC ESU. To derive their estimate, they employed a "20-fish rule" in which all streams known to historically support coho salmon, except those for which recent surveys indicated coho salmon no longer persist (19% of the total), were assumed to still support 20 spawners. For streams where a recent estimate of spawner abundance existed, they used either that estimate or 20 fish, whichever was larger. They suggested that application of the "20-fish rule" likely overestimated total abundance. As Brown et al. (1994) point out, all of these historical estimates are "guesses" of fishery managers and biologists generated using a combination of limited catch statistics, hatchery records, and personal observations.

[2]For mid-1980s estimates, Brown et al. (1994) cite Wahle and Pearson (1987) who estimate 30,480 total spawners in California whereas CDFG (1994) cites Sheehan's (1991) estimate of 33,500 spawners. It is unclear how Sheehan's estimates were derived and no basin-specific estimates are presented; thus, we have included the estimates of Wahle and Pearson (1987) in Table C.2.2.1 rather than the Sheehan (1991) estimates cited by the BRT (Weitkamp 1995).

Table C.2.2.1. Historical estimates of coho salmon spawner abundance for various rivers and regions within the Southern Oregon/Northern California Evolutionarily Significant Unit.

	Estimated Escapement		
	CDFG (1965)[a]	**Wahle & Pearson (1987)[b]**	**Brown et al. (1994)[c]**
River/Region	**1965**	**1984-1985**	**1987-1991**
CA rivers trib. to OR coast streams	1,000		
Smith River	5,000	2,000	820[d]
Other Del Norte County	400		180[d]
Klamath River	15,400	3,400	1,860
Mainstem Klamath River & tribs.	8,000	1,000	
Shasta River	800	300	
Scott River	800	300	
Salmon River	800	300	
Trinity River	5,000	1,500	
Redwood Creek	2,000	500	280
Mad River	2,000	500	460
Eel River	14,000	4,400	2,040[d]
Mainstem Eel River	500	200	
Van Duzen River	500	200	
South Fork Eel River	13,000	4,000	
North Fork Eel River	0	0	
Middle Fork Eel River	0	0	
Mattole River	2,000	500	760[d]
Other Humboldt County	1,500	1,130	680[d]
ESU Total	43,300	12,430	7,080
California Statewide Total[e]	99,400	30,480	13,240

a. Excludes ocean catch.
b. Estimates are for wild or naturalized fish; hatchery returns excluded.
c. Estimates are for wild or naturalized fish; hatchery returns excluded. For streams without recent spawner estimates (or estimates lower than 20 fish), assumes 20 spawners.
d. Indicates high probability that natural production is by wild fish rather than naturalized hatchery stocks.
e. Estimated number of coho salmon for CCC ESU and California portion of the SONCC ESU combined.

Additional information regarding the status of coho salmon in the SONCC ESU was obtained from an analysis of recent (1987-1991) occurrence of coho salmon in streams historically known to support coho populations (Brown et al. 1994). Of 115 historical streams in the SONCC ESU for which recent data were available, 73 (63%) were determined to still support coho salmon, whereas it was believed they had been lost from 42 (37%). The estimated percentage of streams with coho salmon still present was lower for Del Norte County (55%) than for Humboldt County (69%). NMFS (1996b) presented more recent data (1995-1996) on presence of coho salmon within the SONCC ESU, which suggested that the percentage of streams still supporting coho salmon was lower than estimated by Brown et al. (1994). Of 176 streams recently surveyed in the SONCC ESU, 92 (52%) were found to still support coho salmon (P. Adams, NMFS Southwest Fisheries Science Center, pers. comm. cited in NMFS 1996b). The estimated percentage of streams still supporting coho salmon was lower (46%) in Del Norte County than in Humboldt County (55%).

Two recent reviews assessing the status of coho salmon stocks in California were also reviewed by the BRT. Nehlsen et al. (1991) identified coastal populations of coho salmon north of San Francisco Bay (includes portions of the SONCC and CCC ESUs) as being at moderate risk of extinction and Klamath River coho salmon as a stock of special concern. The Humboldt Chapter of the American Fisheries Society (Higgins et al. 1992), utilizing more detailed information on individual river basins, considered three stocks of coho salmon in the SONCC ESU as at high risk of extinction (Scott River [Klamath], Mad River, and Mattole River), and eight more stocks as of special concern (Wilson Creek, Lower Klamath River, Trinity River, Redwood Creek, Little River, Humboldt Bay tributaries, Eel River, and Bear River)[3].

Oregon populations—For the 1997 status update (NMFS 1997), the BRT was asked to evaluate the status of the ESU under two conditions: first, under existing conditions; second, assuming that hatchery and harvest reforms of the Oregon Coastal Salmon Restoration Initiative (OCSRI) were implemented.

Evaluation under existing conditions—In the Rogue River Basin, natural spawner abundance in 1996 was slightly above levels in 1994 and 1995. Abundances in the most recent 3 years were all substantially higher than abundances in 1989-1993, and were comparable to counts at Gold Ray Dam (upper Rogue) in the 1940s. Estimated return ratios for 1996 were the highest on record, but this may have been influenced by an underestimate of parental spawners. The Rogue River run included an estimated 60% hatchery fish in 1996, comparable to previous years. The majority of these hatchery fish returned to Cole Rivers Hatchery, but there was no estimate of the number that strayed into natural habitat.

Evaluation with hatchery and harvest reforms—The BRT considered only two sets of measures from the OCSRI—harvest management reforms and hatchery management reforms. The BRT did not consider the likelihood that these measures will be implemented; rather, it only considered the implications for ESU status if these measures were fully implemented as described. The BRT had several concerns regarding both the harvest and hatchery components of the OCSRI plan. Some members had a strong concern that we do not know enough about the

[3] Weitkamp et al. (1995), citing Higgins et al. (1992), indicate that the numbers of stocks at "moderate risk of extinction" and "of special concern" in the SONCC are 6 and 10, respectively. These numbers appear to be in error.

causes of declines in run size and recruits per spawner to be able to directly assess the effectiveness of specific management measures. Some felt that the harvest measures were the most encouraging part of the plan, representing a major change from previous management. However, there was concern that the harvest plan might be seriously weakened when it is re-evaluated in the year 2000 and concern about our ability to effectively monitor non-target harvest mortality and to control overall harvest impacts.

Of the proposed hatchery measures, substantial reductions in smolt releases were thought to have the most predictable benefit for natural populations; all else being equal, fewer fish released should result in fewer genetic and ecological interactions with natural fish. Marking all hatchery fish should also help to resolve present uncertainties about the magnitude of these interactions. However, the BRT expressed concerns regarding some aspects of the proposed hatchery measures. The plan was vague on several key areas, including plans for incorporation of wild broodstock and how production would be distributed among facilities after 1997. One concern was that the recent and proposed reductions appear be largely motivated by economic constraints and the present inability to harvest fish if they were produced rather than by recognition of negative effects of stray hatchery fish on wild populations. Other concerns expressed by the BRT included no reductions in fry releases in many basins and no consideration of alternative culture methods that could be used to produce higher-quality hatchery smolts, which may have less impact on wild fish. Another concern was the plan's lack of recognition that hatchery-wild interactions reduce genetic diversity among populations.

Specific risk factors identified by the BRT included low current abundance, severe decline from historical run size, the apparent frequency of local extinctions, long-term trends that are clearly downward, degraded freshwater habitat and associated reduction in carrying capacity, and widespread hatchery production using exotic stocks. Of particular concern to the BRT was evidence that several of the largest river basins in the SONCC—including the Rogue, Klamath, and Trinity rivers—were heavily influenced by hatchery releases of coho salmon. Historical transfer of stocks back and forth between SONCC and CCC streams was common, and SONCC streams have also received plants from stocks from hatcheries in the lower Columbia River/Southwest Washington, Puget Sound/Strait of Georgia, and Oregon Coast ESUs. However, the BRT considered the frequency of out-of-basin plants to be relatively low compared with other coho salmon ESUs. Recent (late 1980s and early 1990s) droughts and unfavorable ocean conditions were identified as further likely causes of decreased abundance.

Previous BRT conclusions

In the 1995 status review, the BRT was unanimous in concluding that coho salmon in the SONCC ESU were not in danger of extinction but were likely to become so in the foreseeable future if present trends continued (Weitkamp et al. 1995). In the 1997 status update, estimates of natural population abundance in this ESU were based on very limited information. Favorable indicators included recent increases in abundance in the Rogue River and the presence of natural populations in both large and small basins, factors that may provide some buffer against extinction of the ESU. However, large hatchery programs in the two major basins (Rogue and Klamath/Trinity) raised serious concerns about effects on, and sustainability of, natural populations. New data on presence/absence in northern California streams that historically

supported coho salmon were even more disturbing than earlier results, indicating that a smaller percentage of streams in this ESU contained coho salmon compared to the percentage presence in an earlier study. However, it was unclear whether these new data represented actual trends in local extinctions, or were biased by sampling effort. This new information did not change the BRT's conclusion regarding the status of the SONCC ESU. Although the OCSRI proposals were directed specifically at the Oregon portion of this ESU, the harvest proposal would affect ocean harvest of fish in the California portion as well. The proposed hatchery reforms can be expected to have a positive effect on the status of populations in the Rogue River Basin. However, the BRT concluded that these measures would not be sufficient to alter the previous conclusion that the ESU is likely to become endangered in the foreseeable future.

Listing status

Coho salmon in the SONCC ESU were listed as threatened in May of 1997 (62FR24588). On July 18, 1997, NMFS published an interim rule (62FR38479) that identified several exceptions to the Endangered Species Act's Section 9 take prohibitions.

C.2.2.2 New Data and Updated Analyses

Because data types and sources differ substantially between the California and Oregon portions of the ESU, we present information separately for each area.

California populations

Since the status review for West Coast coho salmon (Weitkamp et al. 1995) and subsequent updates (NMFS 1996b, and NMFS 1997) were completed, new data and analyses related to the status of coho salmon in the California portion of the SONCC ESU have become available. Most data are of two types: 1) compilations of presence-absence information for coho streams from the period 1987 to the present, and 2) new data on densities of juvenile coho salmon in index reaches surveyed by private timber companies. We found no time series of adult counts (excepting those substantially influenced by hatchery production), and only five time series of adult spawner indices (maximum live/dead counts) for tributaries of the Eel River (Sprowl Creek), the Mad River (Canon Creek), and the Smith River (West Branch of Mill Creek [two datasets] and East Branch of Mill Creek) that span a period of 8 years or more, none of which are considered reliable indicators of population trends. Limitations of these datasets are discussed in detail below.

Two independent analyses of presence-absence and limited time series data for the SONCC have been published recently. CDFG (2002) analyzed coho salmon presence-absence for SONCC streams spanning broodyears 1986-2000. NMFS (2001b) published an updated status review for coho salmon in the California portion of the SONCC, which also included analysis of presence-absence information. Since then, scientists at the Southwest Fisheries Science Center have continued compiling data on coho salmon distribution and abundance and re-analyzed the updated data, inclusive of data used in the CDFG (2002) analysis. Thus, results presented in this report supercede those presented in NMFS (2001b).

CDFG presence-absence analysis

Methods—Staff at the North Coast Region of the California Department of Fish and Game attempted to gather all published and unpublished data collected for 392 streams identified by Brown and Moyle (1991) as historical coho salmon streams[4]. Sources of data included field notes, planting records, and fish surveys from federal, state and tribal agencies, private landowners, and academic institutions, as well as summaries contained in several recently published status reviews (Ellis 1997, Brownell et al. 1999, and NMFS 2001b). For each stream and year in which surveys were conducted, observations of coho salmon presence or absence were assigned to the appropriate broodyear. If more than one life stage was observed during a survey, then presence was assigned to more than one broodyear. Streams that were not surveyed during a particular year were assigned a "presence" value if fish were documented in an upstream tributary during that year. Overall, the CDFG dataset encompasses records from broodyear 1986 to 2000, or five complete brood cycles. Additionally, CDFG (2002) presented results of an extensive field study conducted in the summer of 2001 in which 287 of the 392 Brown and Moyle (1991) streams were surveyed for juvenile coho salmon presence-absence[5].

For their brood-year analysis, CDFG (2002) compared the percentage of streams for which coho salmon were detected at any time during two time periods: broodyears 1986-1991 and 1996-2000. The first period was designed to coincide with the period encompassed by the Brown and Moyle (1991) study. Statistics were generated based on data from all streams within the SONCC on the original Brown and Moyle list as well as the subset of these streams that were sampled at least once during each of the two time periods. CDFG (2002) also calculated the percentage of streams for which coho salmon were detected in the 2001 field survey.

Results—Including only streams on the Brown and Moyle list, CDFG (2002) found that coho salmon were observed in 143 of 235 (61%) streams surveyed during the period covering broodyears 1986-1991 (Table C.2.2.2). This number is similar to the value of 63% found by Brown and Moyle (1991) based on information on about half as many streams (115). For broodyears 1995-2000, surveys were conducted on 355 of the 392 historical coho salmon streams. Of these, coho salmon were detected in 179 (50%), suggesting a decline in occupancy. However, when the analysis was restricted to only the 223 streams for which data were available from both time periods, the percent of streams in which coho were detected went from 62% in 1986-1991 to 57% in 1995-2000, a change that was not statistically significant (Pearson Chi square test, $p = 0.228$; Yates corrected chi square test, $p = 0 .334$).

For the 2001 field survey, presence was confirmed in only 121 (42%) of the 287 streams surveyed within the SONCC ESU. CDFG (2002) makes two cautions in interpreting their year 2001 results. First, CDFG considered sampling intensity to be sufficient to have a high likelihood of detecting fish for only 110 of the 166 streams where coho salmon were not found. Second, they note that absence of fish in a single year class does not mean that fish have been extirpated from the system.

---

[4]Brown and Moyle (1991) identified 396 streams in California as historical coho streams; however, four of those streams were dropped by CDFG either because barriers make historically occupancy highly unlikely, because the record of occurrence likely reflects a hatchery outplanting, or because streams were duplicated in the Brown and Moyle list.

[5]CDFG repeated their survey of Brown and Moyle (1991) streams in the summer of 2002; however, those data were unavailable at the time of their analysis.

Table C.2.2.2. Historical presence of coho salmon in the SONCC ESU, as determined by Brown and Moyle (1991) and the California Department of Fish and Game's presence-by-broodyear investigation (as of February 2002). County classifications are based on the location of the mouth of the river system. Table modified from CDFG (2002).

	Brown and Moyle (1991) Calendar years 1987-1990				**CDFG (2002) Broodyears 1986-1991**				**CDFG (2002) Broodyears 1995-2000**			
County/River Basin	**# of streams**	**# of streams w/info.**	**coho present**	**%**	**# of streams**	**# of streams w/info.**	**coho present**	**(%)**	**# of streams**	**# of streams w/info.**	**coho present**	**%**
Del Norte County												
Coastal	9	1	1		8	5	3		8	8	6	
Smith River	41	2	2		41	21	7		41	39	14	
Klamath River	113	41	21		112	82	48		112	89	55	
Subtotal	163	44	24	54%	161	108	58	53%	161	136	75	55%
Humboldt County												
Coastal	34	7	7		33	16	14		33	32	18	
Redwood Creek	14	3	3		14	12	12		14	14	11	
Mad River	23	2	2		23	10	8		23	22	14	
Eel River	124	56	34		123	80	48		123	116	45	
Mattole River	38	3	3		38	9	3		38	35	16	
Subtotal	233	71	49	69%	231	127	85	67%	231	219	104	47%
ESU Total	396	115	73	63%	392	235	143	61%	392	355	179	50%

NMFS presence-absence analysis

Methods—Scientists at the NMFS Southwest Fisheries Science Center compiled a presence-absence database for the SONCC similar to that developed by CDFG. The dataset includes information for coho salmon streams listed on the Brown and Moyle (1991) list, as well as other streams for which we have found historical or recent evidence of coho salmon presence. The dataset is a composite of information contained in the NMFS (2001b) status review update, additional information gathered by NMFS since the 2001 status review was published, data used in the CDFG (2002) analysis, and additional data compiled by CDFG (Bill Jong, CDFG, North Coast Region, unpublished data) for streams not on the Brown and Moyle (1991) list. As such, the database combines information taken from primary sources such as stream surveys, data reports, and electronic files, as well as from secondary sources, including recent compilations of presence-absence data by Ellis (1997), Brownell et al. (1999), NMFS (2001b), CDFG (2002); and Bill Jong, CDFG (unpublished data). In many cases, were unable to obtain original sources underlying the various data compilations and so have generally relied on the accuracy of these secondary sources.

There are four significant differences between the data and analytical approach used by NMFS as compared with CDFG's (2002) status review. First, the NMFS analyzed data for all streams with some historical record of coho salmon presence, whereas CDFG restricted their analysis to those streams found on the Brown and Moyle (1991) list. Second, the NMFS database spans a slightly different time period: broodyears 1987 to 2001 (rather than 1986 to 2000). At the time these data were compiled, data from summer 2002 field surveys were only partially reported; thus, results from broodyear 2001 are preliminary. Third, unlike CDFG (2002), we did not infer presence in streams on the basis of occurrence in upstream tributaries. Although there is an intuitive logic to assigning presence to streams en route to a particular location, including these "inferred presence" values in the analysis tends to positively bias the overall estimate of percent occupancy because the same rationale for inference cannot be applied in the case of a recorded "absence." The magnitude of this bias on estimated occupancy rates for a given year depends on several factors including the proportion of streams sampled, the true occupancy rate for the year, and basin size, all of which effect how many inferences of presence can be made. And finally, in our analysis, we present summary information both by broodyear and by brood cycle (3-year aggregation). In contrast, in their broodyear analysis, CDFG (2002) calculated percent occupancy for 6-year time spans (two complete brood cycles); any observation of presence during that 6-year window resulted in a value of presence for the entire period.

Concerns have been expressed (CDFG 2003) about the validity of including certain streams cited as historical coho streams in various previously published status reviews. We have removed streams from our list that we have found to be in error, including those explicitly identified by CDFG as questionable. However, we have retained information provided by secondary sources in the absence of contradictory information. We have also compared our historical stream list with that developed by CDFG and have found that, although the NMFS stream list includes some streams not found on CDFG's list, most of these streams have limited if any data associated them. We estimate that observations associated with these streams constitute only about 1% of the more than 9,000 observations in the database, and the proportion of "presence" values in this subset is comparable to those observed for the entire dataset. Thus, even if

some of these streams are found to be in error, their inclusion likely has minimal effect on estimated occupancy rates for the ESU.

Results for the NMFS presence-absence analyses are presented by major watersheds or aggregations of adjacent watersheds (Table C.2.2.3). In general, results from larger watersheds are presented independently, whereas data from smaller coastal streams, where data were relatively sparse, are grouped together. In a few cases, individual smaller coastal streams with only a few observations were aggregated with adjacent larger streams if there was no logical geographic grouping of smaller streams. We did not perform statistical analyses of temporal trends in estimated occupancy rates because of the substantial variation in the sampling methods and intensities represented in the dataset, both at the level of individual observations (e.g., index reaches versus whole stream surveys) and among years (i.e., changes in the number of streams surveyed or the principle survey methods through time). Fitting a statistical model to these data without better understanding of the underlying error structure would be of questionable value and would give an illusion of analytical rigor that is likely not supported by the underlying data.

Results—On an annual basis, the estimated percentage of streams in the SONCC for which coho salmon presence was detected has generally fluctuated between 36% and 61% between broodyears 1986 and 2000 (Figure C.2.2.1). Data that have been reported for the 2001 broodyear suggest a strong year class, as indicated by an occupancy rate of more than 75%; however, the number of streams for which data have been reported is small compared to previous years. The data suggest that, for the period of record, occupancy rates in the SONCC were highest (54-61%) between broodyears1991 and 1997, and then declined between 1998 and 2000 (39-51%) before rebounding in 2001. The pattern is similar whether all historical coho streams or just those identified in Brown and Moyle (1991) are considered (Figure C.2.2.1).

When data were aggregated over complete brood cycles (3-year periods), the percentage of streams for which coho salmon presence was detected remained relatively constant (between 60% and 67%) between the 1987-1989 and 1996-1998 brood cycles (Table C.2.2.3). Percent occupancy for the 1999-2001 brood cycle was lower at 46%; however, interpretation of this apparent decline is complicated by two factors. First, the number of streams surveyed was higher than in any other period due to CDFG's intensive survey of the Brown and Moyle streams in the summer of 2001, a drought year. Second, reporting from the 2002 summer season (broodyear 2001) remains incomplete, and as noted above, preliminary data indicate that the 2001 broodyear was strong. Thus, it is likely that the percent occupancy for this period will increase after all data from CDFG's 2002 survey and other sources are analyzed. When analysis was restricted to streams on the Brown and Moyle (1991) list, the ESU-wide pattern was almost identical, with percent occupancy values being within 1%-2% for all time periods (data not shown). Overall, it appears that, although there is considerable year-to-year variation in estimated occupancy rates, there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to the present.

Table C.2.2.3. Percent of surveyed streams within the SONCC ESU for which coho salmon were detected for four time intervals: broodyears 1987-1989, 1990-1992, 1993-1995, 1996-1998, and 1999-2001. Streams include those for which historical or recent evidence of coho salmon presence exists. Based on NMFS and CDFG data (excluding inferred presences in CDFG data).

		1987-1989			**1990-1992**			**1993-1995**			**1996-1998**			**1999-2001**		
County and River Basins	Number of Streams with Historical Presence	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]
Del Norte (includes OR tributaries)																
Illinois River	9	0	-	-	2	100%	0%	2	50%	50%	7	100%	0%	4	75%	25%
Smith River-Winchuck River	57	20	20%	80%	19	42%	58%	45	53%	47%	28	32%	68%	44	43%	57%
Klamath River -Trinity River	210	128	66%	34%	127	72%	28%	139	68%	32%	135	62%	38%	133	55%	45%
Humboldt																
Redwood Creek	23	10	80%	20%	10	100%	0%	19	79%	21%	13	92%	08%	19	84%	16%
Stone/Big Lagoons	5	1	0%	100%	2	100%	0%	1	0	100%	2	50%	50%	5	20%	80%
Litte River - Strawberry Creek	9	8	100%	0%	9	100%	0%	6	100%	0%	5	100%	0%	6	83%	17%
Mad River	23	8	100%	0%	7	86%	14%	7	86%	14%	9	78%	22%	22	64%	36%
Humboldt Bay tributaries	48	20	95%	5%	16	94%	6%	32	97%	3%	17	88%	12%	24	63%	37%
Eel River	221	109	47%	53%	126	59%	41%	132	58%	42%	59	31%	69%	151	30%	70%
Bear River-Guthrie Creek	5	0	-	-	0	-	-	3	0%	100%	2	0%	100%	4	0%	100%
Mattole River-McNutt Gulch	56	5	60%	40%	11	36%	64%	21	71%	29%	42	79%	21%	41	37%	63%
ESU Total	666	309	60%	40%	329	67%	33%	407	66%	34%	319	60%	40%	453	45%	55%

[1] Total number of steams surveyed at least once within the three-year interval

[2] Percentage of surveyed streams where coho were present in one or more years during the interval

[3] Percentage of surveyed streams where coho were absent in all years of survey during the interval

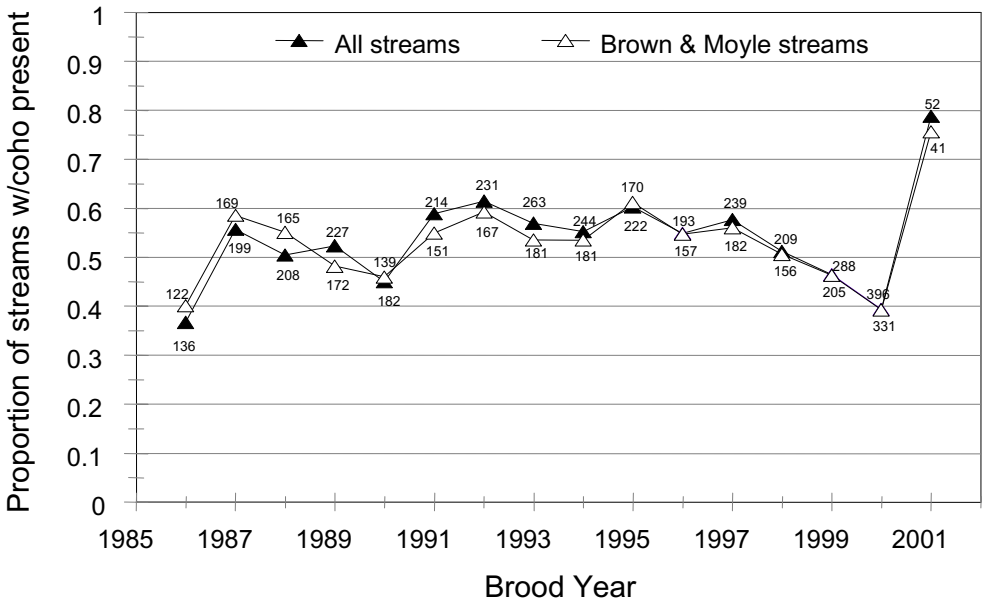


Figure C.2.2.1. Percent of streams surveyed for which coho salmon presence was detected, by broodyear, for all historical coho streams (solid triangles) and coho streams identified in Brown and Moyle's (1991) historical list (open triangles) within the SONCC ESU. Sample sizes (i.e. number of streams surveyed) are shown next to data points. Data are from combined NMFS and CDFG datasets (excluding inferred presence values in the CDFG data).

In general, the proportion of streams sampled within any individual watershed (or grouping of watersheds) was sufficiently small or variable among time periods to make interpretation of local trends difficult. The most notable exception was the Eel River, which showed occupancy rates declining from between 48% and 58% in the period between 1987 and 1995 to about 30% in the past two brood cycles. Similarly, the percentage of streams with coho salmon presence in the Klamath-Trinity system appears to have declined over the five brood cycles examined, though the magnitude of the decline is smaller: from between 66% and 71% in 1987 to 1995 to 62% and 55% in the past two brood cycles. In both cases, reporting from the 2001 broodyear is incomplete, and anecdotal reports suggest that inclusion of more data from the 2002 sampling year (2001 broodyear) may increase the observed percentages because of the relatively strong adult returns in the winter of 2001-2002. Thus, these apparent declines should be interpreted with caution. Still, the relatively low percentage of streams that still support coho salmon in the Eel River and the possible downward trend in the Klamath River basin, despite continued heavy hatchery influence, are cause for concern given that these are the largest river basins in the California portion of the SONCC and, if historical estimates are accurate (Table C.2.2.1), once accounted for well over half of the coho salmon produced in the California portion of the SONCC ESU.

The results of NMFS analysis are generally consistent with those of CDFG (2002), both suggesting a general decline in occupancy rates in from the late 1980s and early 1990s to the end of the 1990s, the significance of which remains somewhat uncertain because of non-systematic collection of presence-absence information and variation in sampling intensity (i.e., the number streams surveyed) through the period. NMFS (2001b) suggested that declines in

percent occupancy in the SONCC from 1989 to 2000 were significant; however, the addition of new data makes us more cautious in this interpretation. Though the trend remains apparent, the magnitude of change is less than the previous data indicated. A more exhaustive examination of stream surveys from the SONCC region compiled by CDFG has substantially increased the total number of observations in the dataset (especially in the earliest years) and those additional observations have been strongly weighted toward "absences." Regardless, there is no evidence suggesting that occupancy rates have increased since the original status review for SONCC coho salmon was published in 1995.

Adult time series

Reliable current time series of naturally produced adult migrants or spawners are not available for SONCC ESU rivers. Spawner surveys have been conducted annually by the California Department of Fish and Game on 4.5 miles of Sprowl Creek, tributary to the Eel River, since 1974 (except in 1976-1977) and on 2 miles of Cannon Creek, tributary to the Mad River, since 1981 (PFMC 2002b). However, these surveys are conducted primarily to generate minimum chinook counts and the likelihood of detecting coho salmon is influenced strongly by the frequency of sampling and environmental conditions (i.e., turbidity) during those surveys (CDFG 2003). Spawner surveys have been conducted by Jim Waldvogel (UC Cooperative Extension, unpublished data) on the West Branch Mill Creek, a tributary to the Smith River, from 1980 to 2001. Peak live/dead counts have fluctuated between 2 and 28 fish during this period, again making their use for trend analysis inappropriate. Surveys have also been conducted on the West Branch (4.7 miles) and East Branch (5.4 miles) of Mill Creek by Stimson Timber Company since 1993. Maximum live/dead counts recorded by Stimson on the West Branch averaged 62 fish between 1993 and 1996, declining to an average of 4 fish between 1997 and 2000. On East Branch, maximum live/dead counts averaged 32 fish between 1993 and 1996, declining to an average of 6 fish between 1997 and 2000 (Howard 1998; Paul Albro, Stimson Lumber Company, unpublished data). Howard (1998) notes that the reliability of these counts varies with flow conditions.

Juvenile time series

Methods—Juvenile density estimates have been made during summer at seven index sites within the Eel River basin over the past 8 to 18 years: Upper Indian Creek, Moody Creek, Piercy Creek, Dutch Charlie Creek, and Redwood Creek in the South Fork Eel River basin (Steven Levesque and David Wright, Campbell Timberland Management, unpublished data); and two sites on Hollow Tree Creek in the Middle Fork Eel Basin (Scott Harris, CDFG, unpublished data). We performed an analysis of juvenile density to determine whether such patterns observed in juveniles are consistent with those observed in the analysis of presence-absence information.

To estimate a trend, data were log-transformed and then normalized so that each data point was expressed as a deviation from the mean of that specific time series. The normalization was intended to prevent spurious trends that could arise from different methods of data collection. Following transformation, time series were aggregated, based on watershed structure, into groups thought to plausibly represent independent populations. Linear regression was used to estimate trends (i.e., slopes) for each aggregate dataset. Analysis was restricted to 1) sites

where a minimum of 8 years of data were available, and 2) putative populations where more than 65% of the observations were non-zero values.

Results—Aggregate trends were estimated separately for the South Fork Eel River and Middle Fork Eel River sites. In both cases, trends were positive, but not significantly different from 0 (South Fork: slope 0.053, 95% CI from -.074 to 0.180; Middle Fork: slope 0.016, 95% CI from -0.051 to 0.180).

Oregon populations

One effect of the OCSRI has been increased monitoring of salmon and habitats throughout the Oregon coastal region. Besides continuation of the abundance data series analyzed in the 1997 status update, Oregon has expanded its random survey monitoring to include areas south of Cape Blanco, including monitoring of spawner abundance, juvenile densities, and habitat condition.

Spawner abundance—In the Oregon portion of the ESU, spawner abundance is monitored only in the Rogue River Basin. Other small coastal basins have limited coho salmon habitat, and are not thought to have sustainable local coho salmon populations (Jacobs et al. 2002). Within the Rogue Basin, two methods are used to monitor adult abundance: beach-seine surveys conducted at Huntley Park in the upper estuary, and stratified-random spawning ground surveys (Jacobs et al. 2002). The Huntley Park seine estimates provide the best overall assessment of both naturally produced and hatchery coho salmon spawner abundance in the basin (Figure C.2.2.3). Spawner survey-based abundance estimates are also available for the basin since 1998, when the surveys were expanded south of Cape Blanco. These estimates are consistently lower than the seine-based estimates, which may be due in part to losses during upstream migration (Jacobs et al. 2002); however, ODFW considers the seine-based estimates to be more accurate as an overall assessment of spawner abundance (S. Jacobs, ODFW, pers. comm. October 2002). The spawning-ground surveys allow examination of the distribution of spawners among subbasins: in 2001, the majority of spawners were in main tributaries (Illinois and Applegate Rivers and Evans and Little Butte Creeks).

The occurrence of hatchery fish in natural spawning areas is also a consideration for the productivity of the natural population. Roughly half of the total spawning run in the Rogue River Basin is hatchery fish; however, many of these fish return to Cole Rivers Hatchery, rather than spawning in natural habitat. Based on fin-mark observations during spawning-ground surveys, the average percent of natural spawners that are of hatchery origin has ranged from less than 2% (2000) to nearly 20% (1998) in recent years. These hatchery spawners are largely concentrated in the mainstem tributaries, with very few hatchery fish observed in major tributaries (Jacobs et al. 2002).

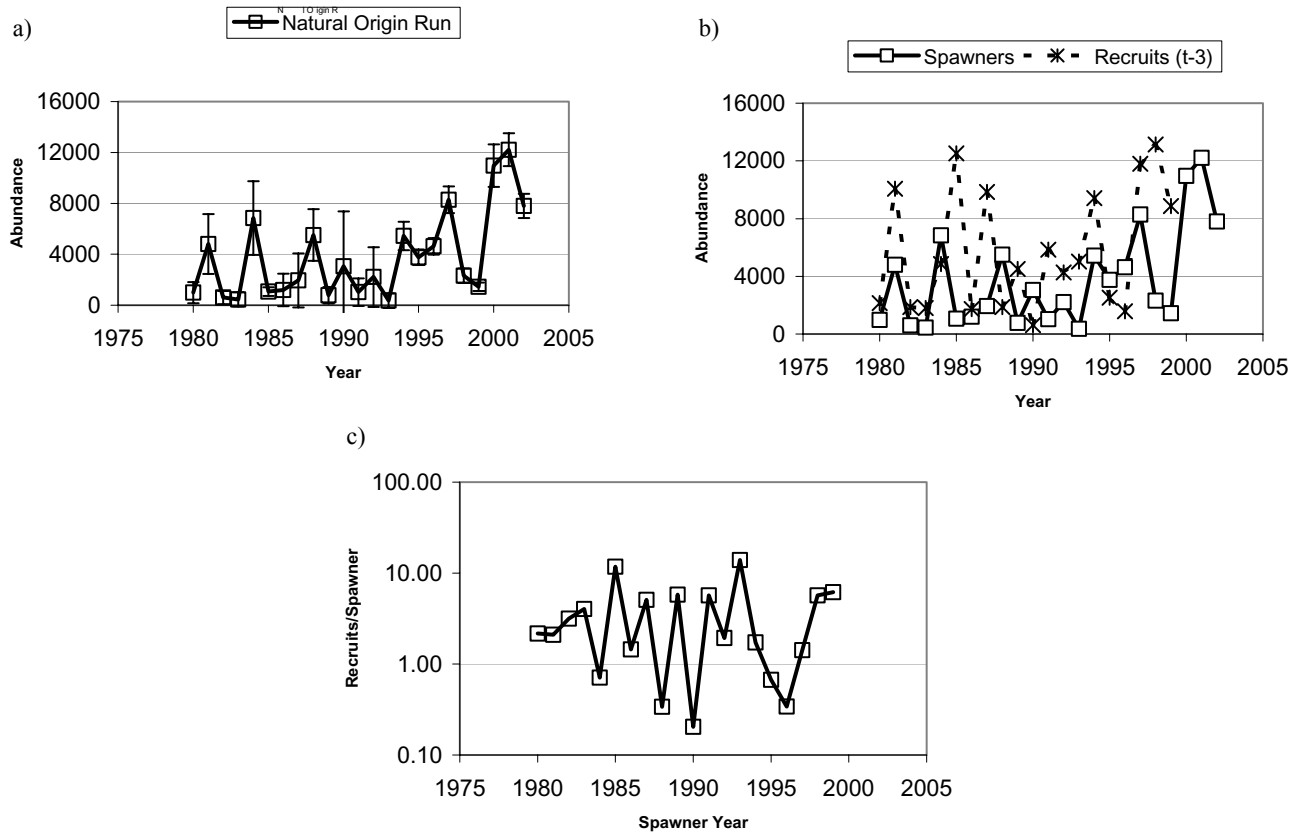


Figure C.2.2.3. Trends in Rogue River coho salmon populations, based on ODFW surveys at Huntley Park (Jacobs et al. 2002). a) Natural spawner abundance with 95% confidence interval; b) Pre-harvest recruits and spawner abundance; c) Recruits (lagged 3 years) per spawner (note logarithmic scale).

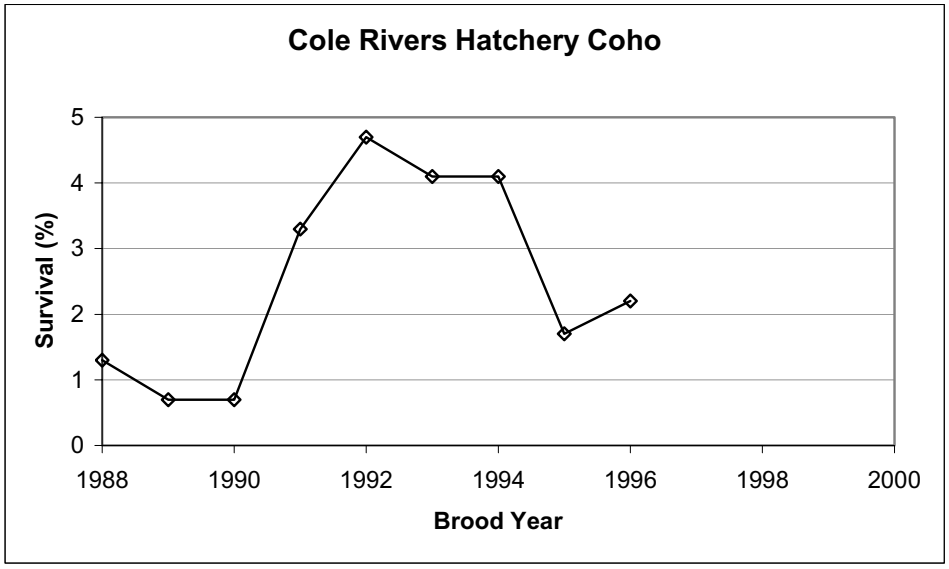


Figure C.2.2.4. Percent survival of CWT-marked coho salmon from Cole Rivers Hatchery, calculated from data in Lewis (2002).

Results—Mean spawner abundance and trends for Rogue River coho salmon are given in Table C.2.2.4. (Note that because estimates of hatchery-origin fish on the spawning ground are not available for most years, lambda was not computed for this population.) Both short- and long-term trends in naturally produced spawners are upward; however, this increasing trend in spawners results largely from reduced harvest, as trends in pre-harvest recruits are smaller (Figure C.2.2.3, Table C.2.2.4). Recruits per spawner fluctuate widely, with little apparent trend (Figure C.2.2.3). Fluctuations in naturally produced spawner abundance are generally in phase with survival of hatchery fish (Figure C.2.2.4), suggesting that ocean conditions play a large role in population dynamics. Note that hatchery-fish survival for the Rogue River stock is generally higher and follows a different pattern than the general OPI survival index (see Oregon Coast ESU discussion).

Juvenile density—Regular monitoring of juvenile coho salmon in the Oregon portion of the SONCC ESU began in 1998, and 4 years of data are currently available, as reported in Rodgers (2002). Several statistics are reported, including percent occupancy and mean density. Methods differ from the California surveys reported above, so direct comparison of results is problematic. The most comparable statistic to the California presence/absence data is "percentage of sites with at least one pool containing coho," which has been steadily increasing from about 30% in 1998 to 58% in 2001; this compares with a range of 52% to 80% for other parts of the Oregon coast. Percentage of pools per site containing coho salmon has also increased, reaching 41% (s.e. 4.9%) in 2001. Mean juvenile density has also increased over the 3 years. In 2001, overall mean density of juveniles in surveyed pools was 0.38 fish per square meter (fish·m^{-2}); this compares with a range of 0.27 to 0.50 fish·m^{-2} for other areas of the Oregon coast.

Table C.2.2.4 Abundance and trend estimates for Rogue River Basin coho salmon natural spawners, estimated from Huntley Park seine data (Jacobs et al. 2002) from 1980 to 2001. Shown are the most recent geometric mean (along with minimum and maximum values for the data series) and trend estimates for spawners and recruits, both long- and short-term, along with the probability that the true trend is decreasing.

Parameter	Value	95% C.I.	P(decrease)
Recent spawner abundance			
Last 3 years geometric mean	10147		
Last 3 years arithmetic mean	10326		
Last 3 years range	7800-12213		
Spawner Trend			
Short-term (1990-2002)	1.16	(1.01, 1.34)	0.02
Long-term (1980-2002)	1.08	(1.01, 1.15)	0.01
Pre-Harvest Recruit Trend			
Short-term (1990-2002)	1.08	(.94, 1.25)	0.12
Long-term (1980-2001)	1.02	(0.95, 1.08)	0.27

Habitat condition—The Oregon Plan Habitat Survey (OPHS) began in 1998, as part of the ODFW Aquatic Inventories Project begun in 1990. Information here is derived from the Survey's year 2000 report (Flitcroft et al. 2001). The survey selects 500-m to 1,000-m sites along streams according to a spatially balanced random selection pattern. The survey includes both summer and winter habitat sampling. In addition to characterization of the site's streamside and upland processes, specific attributes sampled are: large wood, pools, riparian structure, and substrate. The program has established benchmark thresholds as indicators of habitat quality:

- Pool area greater than 35% of total habitat area;
- Fine sediments in riffle units less than 12% of all sediments;
- Volume of large woody debris greater than 20 m^3 per 100 m stream length;
- Shade greater than 70%;
- Large riparian conifers more than 150 trees per 305 m stream length.

For the combined 1998-2000 surveys in the Oregon portion of the SONCC ESU, 6% of sites surveyed met none of the benchmarks, 29% met one, 38% met two, 20% met three, 5% met four, and 2% met all five benchmarks. No trends in habitat condition can yet be assessed from this data, but it will provide a basis for future assessment of changes in habitat quality.

C.2.2.3 New Comments

The Siskiyou County Farm Bureau (2002) submitted comments arguing that SONCC coho salmon should not be protected under ESA, particularly because the relationship of Iron Gate Hatchery fish in the Klamath River to the SONCC ESU remains uncertain. Their principal arguments is that widespread historical outplanting of juvenile coho salmon and incorporation of

non-native fish into hatchery broodstock make application of the ESU concept inappropriate; they argue that all West Coast coho salmon should be considered a single ESU.

The Siskiyou Project submitted comments supporting continued listing of coho salmon in the SONCC under ESA (Siskiyou Project 2002). They argue that 1) the status of native, naturally reproducing coho salmon in the SONCC remains unchanged since they were listed in 1997; 2) increases in adult coho salmon observed in 2001 and 2002 are mostly due to improved ocean conditions and reduced harvest, and are not indicative of long-term trends; 3) severe drought in the winter 2001-2002 and summer 2001 are likely to result in lower smolt production in spring 2002 and adult returns in 2003; 4) habitat already in poor condition is likely to deteriorate with increasing human demands for natural resources and inadequate regulations; and 5) continued large releases of hatchery coho salmon pose a threat to naturally produced fish through competition, mixed-stock fishing, and reduced fitness associated with interbreeding of hatchery and wild fish. The Siskiyou Project also included a report authored by Cindy Deacon Williams, private consultant, titled *Review of the status of Southern Oregon/Northern California coho with thoughts on recovery planning targets*. Ms. Williams' report presents basin-by-basin assessments of the status of coho salmon (using primarily previously published analyses), habitat conditions, and ongoing activities that pose risks to coho salmon. She also recommends numeric recovery criteria for SONCC coho salmon and argues that habitat targets are needed to ensure recovery.

The Douglas County Board of Commissioners submitted a report, *Viability of coho salmon populations on the Oregon and northern California coasts*, submitted to NMFS Protected Resources Division on 12 April 2002 and prepared by S.P. Cramer and Associates, Inc. (Cramer and Ackerman 2002). This report analyzes information available for both the Oregon Coastal Coho Salmon ESU and the SONCC ESU in several areas: trends in abundance and distribution, trends in survival, freshwater habitat condition, potential hatchery-wild interactions, changes in harvest regulation, and extinction risk modeling. Little of the information presented in the report is specific to the SONCC ESU. They cite changes in fishery management, increasing spawning escapements, reduced hatchery releases, habitat restoration, and evidence of successful rearing of fry outmigrants throughout the Oregon Coast, some information for the Rogue River basin, but no new information for California populations.

Daniel O'Hanlon (2002a,b), attorney at law, submitted comments on two occasions on behalf of Save Our Shasta and Scott Valley Towns (S.O.S.S), an organization of citizens concerned about the effects of ESA regulations. The latter submission includes comments submitted to the California Fish and Game Commission regarding the petition to list coho salmon in Northern California under the state Endangered Species Act, which include, by reference, a critique of CDFG's (2002) status review prepared by Dr. Charles Hanson. Though the critique is of the state's analysis of coho status, some the arguments are germane to the federal status review since the underlying data are comparable. The essential arguments from this collection of documents are 1) the limited data presented in the initial status reviews was insufficient to assess, in a scientifically rigorous way, the degree of extinction risk facing coho salmon in the SONCC; 2) there is no evidence of an immediate or near-term risk of extinction based on analysis of either presence-absence data or abundance trend data; presence-absence data have a number of weaknesses, and historical trend data (abundance and harvest) are

unreliable; and 3) existing regulatory structures are adequate to protect coho salmon; new regulations would hinder, rather than help coho recovery.

The Yurok Tribal Fisheries Program (2002) submitted recent data from various sampling efforts in the lower Klamath River and its tributaries. Included were data from downstream migrant traps, adult snorkel surveys, tribal harvest, and harvest catch-per-unit effort. Data on relative contribution of naturally produced and hatchery fish to tribal harvest and to catch at the lower Klamath and lower Trinity downstream migrant trapping sites are discussed in the section on New Hatchery/ESU Information below. Other data were incorporated into NMFS presence-absence analysis discussed above. None of the time series available met the minimum criterion of 8 years, which was decided upon by the BRT as the minimum needed for trend analysis.

C.2.2.4 New Hatchery Information

Weitkamp et al. (1995) identified four hatcheries that were producing and releasing coho salmon within the SONCC ESU during the mid 1990s: Mad River Hatchery, Trinity River Hatchery, Iron Gate Hatchery, and Cole Rivers Hatchery. Prairie Creek hatchery produced coho salmon for many years, but closed in 1992 (CDFG 2002). Rowdy Creek hatchery is a privately owned hatchery that has produced coho salmon in the past; however, the facility did not produce coho salmon in 1999 and 2000 due to lack of adult spawners (CDFG 2002), and no further production of coho salmon at this facility is planned (Andrew VanScoyk, Rowdy Creek Hatchery, pers. comm.).

Iron Gate Hatchery—Iron Gate Hatchery (IGH), located on the Klamath River near Hornbrook, California, approximately 306 km from the ocean, was founded in 1965 and is operated by the California Department of Fish and Game (CDFG). The hatchery was built by Pacific Power and Light Company to mitigate effects of the Iron Gate Project on wild salmonids, including coho salmon, that naturally occurred in the upper Klamath River (CDFG 2002; SHHAG 2003). The IGH coho stock was developed initially from eggs taken from Klaskanine Hatchery in Oregon, via Trinity River Hatchery in 1966. In an effort to increase returns to Iron Gate Hatchery, coho salmon from Cascade River (Columbia River) were released in 1966, 1967, 1969, and 1970 (CDFG 2002; CDFG 2003). Since 1977, only Klamath Basin fish have been released from IGH (CDFG 2003).

Annual releases of coho salmon from IGH have decreased from an average of approximately 147,000 fish from 1987-1991 to about 72,000 fish from 1997-1999 (Table C.2.2.5); this reduction in releases reflects effort on CDFG's part to more closely adhere to the IGH mitigation goal of 75,000 yearlings released per year. Adult returns averaged 1,120 fish between 1991 and 2000, and an average of 161 females have been spawned annually during this period.

The CDFG and NMFS Southwest Region Joint Hatchery Review Committee (2001) noted that no accurate estimates of the relative contribution of naturally produced vs. hatchery fish are available for the Klamath River basin. Beginning in 1995, coho salmon released from IGH have been marked with left maxillary clips; however, return information has been published for only a single year, 2000. These data indicate that 80% of 1,353 fish returning to IGH were

marked hatchery fish, with 98% being Iron Gate releases. A few fish from the Trinity and Cole Rivers (Rogue River, Oregon) hatcheries were also taken. The significance of this high percentage of hatchery fish with respect to total production in the Klamath Basin is uncertain since IGH lies near the upper end of the accessible habitat.

Table C.2.2.5. Average annual releases of coho salmon juveniles (fry and smolts) from selected hatcheries in the SONCC coho salmon ESU during release years 1987-1991, 1992-1996, and 1997-2002. Hatchery classification assigned by Salmon and Steelhead Hatchery Assessment Group (SHHAG 2003) is also shown.

	SSHAG	Average Annual Releases		
Hatchery	**Category**	**1987-1991**	**1992-1996**	**1997-2002**
Cochran Ponds (HFAC)		35,391[a]	na[b]	0[b]
Mad River[c]	4	372,863	91,632	82,129[d]
Prairie Creek		89,009[e]	0[f]	0[f]
Trinity River[g]	2b	496,813	385,369	527,715
Iron Gate (Klamath)[h]	2c	147,272	92,150	71,932[i]
Rowdy Creek[j]		0	12,534[k]	10,615[l]
Cole Rivers (Rogue)[m]	2a	271,492	239,534[n]	270,344[o]
Total		1,413,380	821,685	1,007,391

[a] Average from 2 years (1987-1988). Source: Weitkamp et al. 1995.
[b] Coho salmon were produced by the Humboldt Fish Action Council (HFAC) through the 1994 broodyear; release data for 1992 to 1996 are currently unavailable; no fish were released after 1996 (S. Holz, HFAC, pers. comm.)
[c] Sources: Weitkamp et al. 1995; Gallagher 1993-1995; Cartwright 1996-2001
[d] CDFG ceased spawning coho salmon at Mad River Hatchery in 1999; yearling were last released in 2001
[e] Average from 4 years (1987-1988, 1990-1991). Source: Weitkamp et al. 1995.
[f] Prairie Creek hatchery ceased producing coho salmon in 1992.
[g] Sources: Ramsden 1993-2002.
[h] Sources: Hiser 1993-1996; Rushton 1997-2002.
[i] Does not include releases from year 2002 (data not available)
[j] Source: A. Van Scoyk, Rowdy Creek Hatchery, unpublished data.
[k] Average from 2 years (1995-1996); data not available for 1992-1995.
[l] Rowdy Creek hatchery ceased releasing coho in year 2001.
[m] Source: Bill Waknitz, NMFS, pers. comm.
[n] Average from 1991-1995.
[o] Average from 1996-2002; includes juvenile coho salmon released to lakes.

Additional information about the composition of Klamath Basin stocks is available from tribal harvest and downstream migrant trap data collected by the Yurok Tribal Fisheries (2002).

Between 1997 and 2000, tribal harvest of coho salmon ranged from 42 to 135 fish and then increased to 895 in 2001. During this five-year period, hatchery fish constituted between 63% and 86% of the total fish harvested. Iron Gate Hatchery fish generally made up a small (8% or less) fraction of total hatchery fish captured, the exception being in 1997, when they constituted about 37% of the hatchery fish caught. In contrast, Trinity River Hatchery fish accounted for 87% to 95% of hatchery fish harvested in 1998-2001, and 40% of the hatchery fish captured in 1997.

In 1997 and 1998, Yurok Tribal Fisheries operated a downstream migrant trap in the lower Klamath River, below the confluence of the Klamath and Trinity rivers; thus the trap captured fish from both the Iron Gate and Trinity hatcheries. During 2 years of sampling, Trinity hatchery fish dominated the total catch accounting for 73% and 83% of all fish caught in 1997 and 1998, respectively. Iron Gate Hatchery fish accounted for around 5% of the catch in both years. Naturally produced coho salmon made up 22% of the total catch in 1997 and 12% of the catch in 1998. In 1998, a second trap was operated on the lower Trinity River. Only 9% of the smolts captured at this trap were naturally produced. Assuming that this proportion accurately reflected the relative contributions of naturally produced and hatchery Trinity River fish to catch at the Lower Klamath trap, then the percentages of naturally produced and hatchery fish exiting the Klamath River proper (above the Trinity confluence) were approximately 42% and 58%, respectively.

In previous status reviews, the BRT was uncertain about whether the use of non-native stocks to start the Iron Gate population was of sufficient importance to have lasting effects on the present population. Thus, they reached no conclusion about whether the hatchery stock should be included in the ESU (NMFS 1997). Subsequently, Iron Gate was determined to be a Category 2 hatchery (SSHAG 2003). For other SSHAG hatchery stock categorizations, see Appendix C.5.1.

Trinity River Hatchery—Trinity River Hatchery (TRH), located below Lewiston Dam approximately 248 km from the ocean, first began releasing coho salmon in 1960. The TRH facility originally used Trinity River fish for broodstock, though coho salmon from Eel River (1965), Cascade River (1966, 1967, and 1969), Alsea River (1970), and Noyo River (1970) have also been reared and released at the hatchery as well as elsewhere in the Trinity Basin.

Trinity River Hatchery produces the largest number of coho salmon of any production facility in California. CDFG's annual production target is 500,000 yearlings. Actual production averaged 496,813 from 1987-1991, decreased to 385,369 from 1992-1996, and then increased again to 527,715 fish from 1997-2002 (Table C.2.2.5). During the period 1991-2001, an average of 3,814 adult coho were trapped and 562 females were spawned at the TRH.

It is commonly assumed that there is little production of wild coho salmon in the Trinity River system, and available data generally support this assumption. Between 1997 and 2002, hatchery fish constituted between 89% and 97% of the fish (adults plus grilse) returning to the Willow Creek weir in the lower Trinity River (Sinnen 2002). Outmigrant trapping conducted on the lower Trinity River indicates that marked TRH fish made up 91%, 97%, and 65% of the catch in years 1998, 1999, and 2000, respectively (Yurok Tribal Fisheries 2002). Additionally, it appears that a significant fraction of the naturally produced fish are likely the progeny of hatchery strays. By subtracting the number of hatchery and naturally produced fish returning to TRH from counts at Willow Creek weir, Sinnen (2002) estimated that hatchery fish made up between 76% and 96% of fish that spawned within the Trinity River system upstream of the weir from 1997 to 2002. A potential source of bias in these estimates is that fact that Willow Creek weir typically washes out prior to the end of the coho adult migration season. There is some suggestion that wild Trinity River coho salmon return later in the season than TRH fish, which

would result in an overestimate of hatchery contribution to spawning in the wild (George Kautsky, Hoopa Valley Tribal Fisheries, pers. comm.); however, there are no data by which to assess whether such bias exists. Additionally, we are aware of no information from which to assess 1) the degree to which TRH fish that pass over the weir are straying into various sub-basins within the Trinity River (Hoopa Valley Tribe 2003), or 2) whether hatchery and wild fish have an equal probability of successfully spawning in the wild.

The BRT concluded that coho salmon from the Trinity River Hatchery should be considered part of the SONCC ESU since out-of-basin and out-of-ESU transfers ceased by 1970 and production since that time has been exclusively from fish within the basin. The lack of natural production within the Trinity Basin, however, remains a significant concern. The Trinity Hatchery is a Category 2 hatchery (SSHAG 2003).

Mad River Hatchery—Mad River Hatchery (MRH), located approximately 20 km upriver near the town of Blue Lake, first began producing coho salmon in 1970. The original broodstock (1970) was from the Noyo River, which lies outside of the SONCC ESU, and Noyo fish were released from the hatchery during 12 additional years between 1971 and 1996. Other stocks released from the hatchery include out-of-ESU transfers from the Trask River (1972), Alsea River (1973), Klaskanine River (1973), Green River (1979), and Sandy River (1980), as well as out-of-basin, within-ESU transfers from the Trinity River (1971), Klamath River (1981, 1983, 1986-1989), and Prairie Creek (1988, 1990).

Releases of Mad River fish declined substantially during the past decade, from an average of 372,8643 fish in 1987-1991 to just over 82,000 in the period from 1997-2001 (Table C.2.2.5). Production of coho salmon at MRH ceased after broodyear 1999, thus, the year 2001 releases represent the final year of hatchery production. Adult returns were low during the 1990s, with an average of 38 adults trapped and 16 females spawned during the period between 1991 and 1999. No information was available regarding the relative contribution of naturally produced and artificially propagated fish within the Mad River basin. However, concern about both out-of-ESU and out-of-basin stock transfers, as late as 1996, was sufficiently great that the Mad River Hatchery was excluded from the SONCC ESU by NMFS (1997). This conclusion has been rendered moot by the decision to cease producing coho salmon at the Mad River facility.

Rowdy Creek Hatchery—Rowdy Creek Hatchery is a privately owned hatchery in the Smith River Basin constructed in 1977. Production emphasis has been on chinook and steelhead, but small numbers of coho salmon were trapped and bred during the period 1990 to 1998. Only local coho salmon broodstock have been used at the Rowdy Creek facility (NMFS 1997).

Annual releases of coho salmon yearlings averaged 12,534 between 1995 and 1996, and 15,923 from 1997 to 2000, when releases were terminated (Table C.2.2.5). Adult returns to the hatchery averaged just 26 fish in the 11 years that coho salmon were trapped (A. Van Scoyk, Rowdy Creek Hatchery, unpublished data). No information was available on the relative contribution of Rowdy Creek Hatchery coho salmon to the Smith River population as a whole, but it was undoubtedly a minor component during the period of operation.

In its status review update, the BRT (NMFS 1997) concluded that the Rowdy Creek Hatchery population should be considered part of the ESU, but that it was not essential for ESU recovery. This conclusion has been rendered moot by the decision to cease producing coho salmon at the facility.

Cole Rivers Hatchery—The Cole Rivers Hatchery has raised Rogue River (Oregon stock #52) coho salmon since 1973 to mitigate for lost production due to construction of Lost Creek Dam. This stock was developed from local salmon trapped in the river, and has no history of out-of-basin fish being incorporated. Recent releases (1996-2002) have averaged 270,000 per year, compared to a 1991-1995 average of 240,000 per year (Table C.2.2.5); the increase is due to inclusion in the data of large-sized coho salmon released to lakes in the basin in recent years (Bill Waknitz, NMFS, pers. comm.). Spawning of hatchery fish in nature is essentially limited to mainstem tributaries and (to a lesser extent) the Applegate River, and interbreeding with natural fish is limited by separation in spawning time (Jacobs et al. 2002). The hatchery is rated as a Category 1 hatchery (SSHAG 2003).

Summary

Artificial propagation of coho salmon within the SONCC has been substantially reduced in the past 8 to 10 years, with the exception of Cole Rivers Hatchery on the Rogue River and the Trinity River Hatchery. Annual releases from the Cole Rivers and Trinity hatcheries have recently averaged 270,000 and 528,000 fish, respectively. Production has ceased at one major facility (Mad River), as well as well as several minor facilities (Rowdy Creek, Eel River, and Mattole River). Production at Iron Gate Hatchery on the Klamath River has been reduced by approximately 50%. Genetic risks associated with out-of-basin and out-of-ESU stock transfers have largely been eliminated. However, two significant genetic concerns remain: 1) the potential for domestication selection in hatchery populations such as Trinity River, where there is little or no infusion of wild genes, and 2) out-of-basin straying by large numbers of hatchery coho.

Harvest impacts

Historically, ocean harvest of SONCC coho salmon has occurred in coho- and chinook-directed commercial and recreational fisheries off the coasts of California and Oregon. Significant changes in harvest management have occurred since the late 1980s, which have resulted in substantial reductions in ocean harvest of SONCC coho salmon. In establishing fishing seasons and regulations each year, the Pacific Fishery Management Council (PFMC) considers the potential impacts on various ESA-listed stocks within the region. Because there are no data on exploitation rates on wild SONCC coho salmon, Rogue and Klamath River (RK) hatchery stocks are used as a fishery surrogate stock for estimating exploitation rates on SONCC coho. The PFMC estimates that most ocean harvest of RK coho salmon (and presumably SONCC coho salmon) occurs south of Humbug Mountain, Oregon, which lies near the northern boundary of the SONCC ESU.

During the 1970s and early 1980s, commercial fishing seasons for coho salmon south of Humbug Mountain generally lasted from four to five months or more (PFMC 2003). These seasons were substantially shortened in the late 1980s and early 1990s, particularly between

Humbug Mountain and Point Arena, California due to changes in allocation fall chinook salmon to tribal and non-tribal fall fisheries in the Klamath Management Zone. Retention of coho salmon in ocean commercial fisheries south of Cape Falcon, Oregon, has been prohibited since 1993 (PFMC 2002b). In 1994, retention of coho salmon in ocean recreational fisheries was prohibited from Cape Falcon south to Horse Mountain, California, and this prohibition was extended to include all California waters in 1995. The retention prohibition has remained in effect south of Humbug Mountain since that time.

Mass-marking (adipose fin clips) of hatchery coho salmon throughout much of the Oregon Production Index area has led to the implementation of mark-selective recreational fisheries for hatchery fish along portions of the coast north of Humbug Mountain beginning in 1998 and continuing through 2002. Marked fish may be legally retained, while unmarked fish must be released unharmed. SONCC-origin coho salmon that migrate north of Cape Blanco experience incidental morality due to hooking and handling in this fishery; however, total incidental mortality from this fishery and chinook-directed fisheries north of Humbug Mountain has been estimated to be less than 7% of the total mortality of RK hatchery coho salmon since 1999 (PFMC 1999-2003).

In 1999, NMFS issued a biological opinion establishing a consultation standard requiring that overall annual ocean exploitation rate not exceed 13% on RK stocks. To conform to this standard, the Pacific Fishery Management Council (PFMC) adopted fishing seasons in 1999-2002 for which the projected coastwide marine exploitation rate on RK stocks ranged between 3.0 and 7.7%. During that time, an estimated 93% to 97% of this mortality has occurred in chinook-directed fisheries south of Humbug Mountain (PFMC 1999-2003).

Estimates of ocean exploitation rates on SONCC coho salmon for years prior to their listing under ESA are not available. Harvest estimates for various landing ports in California are available dating back to the early 1950s and indicate that annual harvest in the commercial fishery ranged averaged about 163,000 between 1952 and 1991 (PFMC 2003). Between 1962 and 1993, recreational harvest in California averaged about 34,000 fish. In both cases, these totals represent fish a mixture of fish both naturally produced and hatchery fish originating from Oregon and California. Neither escapement estimates nor estimates of the contribution of SONCC fish to total harvest, from which exploitation rates could be derived, are available. However, there is no doubt that ocean exploitation rates have dropped substantially in response to the non-retention regulations put in place in 1994 as well as general reductions in chinook-directed effort.

Directed river harvest of coho salmon has not been allowed within the SONCC ESU since 1994, with the exception of sanctioned tribal harvest for subsistence, ceremonial, and commercial purposes by the Yurok, Hoopa Valley, and Karuk tribes (CDFG 2002). Harvest data are only available for the Yurok Tribe (2002), which reports that annual harvest of coho salmon from reservation lands on the lower Klamath River has averaged 244 fish (67% marked hatchery fish) between 1997 and 2001, though this average is strongly influenced by a harvest of almost 900 fish in 2001. In the other four years, harvest did not exceed 135 fish. Mortality associated with incidental or illegal catch of naturally produced coho salmon in SONCC rivers is uncertain, but believed to be low (CDFG 2002).

C.2.2.5 Comparison with Previous Data

New data for the SONCC coho salmon ESU includes expansion of presence-absence analyses, a limited analysis of juvenile abundance in the Eel River basin, a few indices of spawner abundance in the Smith, Mad, and Eel river basins, and substantially expanded monitoring of adults, juveniles, and habitat in southern Oregon. None of these data contradict conclusions reached previously by the BRT. Nor do any of recent data (1995 to present) suggest any marked change, either positive or negative, in the abundance or distribution of coho salmon within the SONCC ESU. Coho salmon populations continued to be depressed relative to historical numbers, and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. Although the 2001 broodyear appears to be the one of the strongest perhaps of the last decade, it follows a number of relatively weak years. The Rogue River stock is an exception; there has been an average increase in spawners over the last several years, despite 2 low years (1998, 1999).

Risk factors identified in previous status reviews, including severe declines from historical run sizes, the apparent frequency of local extinctions, long-term trends that are clearly downward, and degraded freshwater habitat and associated reduction in carrying capacity continue to be of concern to the BRT. Termination of hatchery production of coho salmon at the Mad River and Rowdy Creek facilities has eliminated potential adverse risk associated with hatchery releases from these facilities. Likewise, restrictions on recreational and commercial harvest of coho salmon since 1994 have undoubtedly had a substantial positive impact on coho salmon adult returns to SONCC streams. An additional risk factor that has been identified within the SONCC ESU is predation resulting from the illegal introduction of non-native Sacramento pikeminnow (*Ptychocheilus grandis*) to the Eel River basin (NMFS 1998). Sacramento pikeminnow were introduced to the Eel River via Pillsbury Lake in the early 1980s and have subsequently spread to most areas within the basin. The rapid expansion of pikeminnow populations is believed to have been facilitated by alterations in habitat conditions (particularly increased water temperatures) that favor pikeminnow (Brown et al. 1994; NMFS 1998).

C.2.3 CENTRAL CALIFORNIA COAST COHO SALMON

Primary contributors: Brian C. Spence and Eric P. Bjorkstedt
(Southwest Fisheries Science Center – Santa Cruz Lab)

C.2.3.1 Previous BRT Conclusions

The Central California Coast (CCC) coho salmon Evolutionarily Significant Unit extends from Punta Gorda in Northern California south to and including the San Lorenzo River in Central California (Weitkamp et al. 1995). The status of coho salmon throughout their West Coast range, including the CCC ESU, was formally assessed in 1995 (Weitkamp et al. 1995). Two subsequent status review updates with information pertaining to the CCC ESU were published by NMFS in 1996 (NMFS 1996a, b). Analyses from those reviews regarding extinction risk, risk factors, and hatchery influences is summarized in the following sections.

Status indicators and major risk factors

Data on abundance and population trends of coho salmon within the CCC ESU were limited. Historical time series of spawner abundance for individual river systems were unavailable. Brown et al. (1994) presented several historical point estimates of coho salmon spawner abundance (excluding ocean catch) for the entire state of California for 1940 and for various rivers and regions in the early 1960s and mid 1980s (Table C.2.3.1). Coho salmon were estimated to number between 200,000 and 500,000 statewide in the 1940s (E. Gerstung, CDFG, pers. comm., cited in Brown et al. 1994). Coho salmon spawning escapement was estimated to have declined to about 99,400 fish by the mid-1960s, with approximately 56,100 (56%) originating from streams within the CCC ESU (Table C.2.3.1). In the mid-1980s, spawning escapement was estimated to have dropped to approximately 30,480 in California and 18,050 (59%) within the CCC ESU. Employing the "20-fish rule" (see status review update for Southern OR-Northern CA Coast coho salmon for details), Brown et al. (1994) estimated wild and naturalized coho salmon populations at 6,160 (47% of the statewide total) for the CCC ESU during the late 1980s (Table C.2.3.1). All of these estimates are considered to be "best guesses" based on a combination of limited catch statistics, hatchery records, and personal observations of local biologists (Brown et al. 1994).

Further information regarding status was obtained from Brown et al.'s (1994) analysis of recent (1987-1991) occurrence of coho salmon in streams historically known to support populations. Of 133 historical coho salmon streams in the CCC ESU for which recent data were available, 62 (47%) were determined to still support coho runs while 71 (53%) apparently no longer support coho salmon (Table C.2.3.2). A subsequent analysis of surveys from 1995-1996 found a somewhat higher (57%) percentage of occupied streams (NMFS 1996b, based on pers. comm. with P. Adams, NMFS Southwest Fisheries Science Center).

Nehlsen et al. (1991) provided no specific information on individual coho salmon populations in their 1991 status review, but concluded that salmon stocks in small coastal streams north of San Francisco were at moderate risk of extinction and those in coastal streams south of San Francisco Bay were at high risk of extinction. A subsequent status review by the

Humboldt Chapter of the American Fisheries Society (Higgins et al. 1992) found four populations (Pudding Creek, Garcia River, Gualala River, and Russian River) to be at high risk of extinction and five (Ten Mile, Noyo, Big, Navarro, and Albion rivers) as stocks of concern.

Table C.2.3.1. Historical estimates of coho salmon spawner abundance for various rivers and regions within the Central California Coast Evolutionarily Significant Unit.

	Estimated Escapement		
	CDFG (1965)[a]	Wahle & Pearson (1987)[b]	Brown et al. (1994)[c]
River/Region	**1963**	**1984-1985**	**1987-1991**
Ten Mile River	6,000	2,000	160[d]
Noyo River	6,000	2,000	3,740
Big River	6,000	2,000	280
Navarro River	7,000	2,000	300
Garcia River	2,000	500	
Other Mendocino County	10,000	7,000[e]	470[f]
Gualala River	4,000	1,000	200
Russian River	5,000	1,000	255
Other Sonoma County	1,000		180
Marin County	5,000		435
San Mateo & Santa Cruz Counties	4,100	550	140
San Mateo County	1,000		
Santa Cruz County (excl. San	1,500	50	
San Lorenzo River	1,600	500	
ESU Total	56,100	18,050	6,160
California Statewide Total[e]	99,400	30,480	13,240

[a] Values excludes ocean catch.
[b] Estimates are for wild or naturalized fish; hatchery returns excluded.
[c] Estimates are for wild or naturalized fish; hatchery returns excluded. For streams without recent spawner estimates (or estimates lower than 20 fish), assumes 20 spawners.
[d] Indicates high probability that natural production is by wild fish rather than naturalized hatchery stocks.
[e] Value may include Marin and Sonoma County fish.
[f] Appears to include Garcia River fish.
[g] Estimated number of coho salmon for CCC ESU and California portion of the SONCC ESU combined.

Risk factors identified by the BRT included extremely low contemporary abundance compared to historical abundance, widespread local extinctions, clear downward trends in abundance, extensive habitat degradation, and associated decreases in carrying capacity. Additionally, the BRT concluded that the main stocks of coho salmon in the CCC ESU have been heavily influenced by hatcheries and that there were relatively few native coho salmon left in the ESU (Weitkamp et al. 1995). Most existing stocks have a history of hatchery planting, with many out-of-ESU stock transfers. A subsequent status review (NMFS 1996a), which focused on existing hatcheries, concluded that, despite the historical introduction of non-native fish, the Scott Creek (Kingfisher Flat) and Noyo River broodstocks have regularly incorporated

wild broodstock and, thus, were unlikely to differ from naturally spawning fish within the ESU. Recent droughts and unfavorable ocean conditions were identified as natural factors contributing to reduced run size.

Table C.2.3.2. Historical presence of coho salmon in the CCC ESU, as determined by Brown et al. (1994) and the California Department of Fish and Game's analysis of recent presence (1995-2001). County classifications are based on the location of the mouth of the river system. Data from CDFG (2002). Note that methods for estimating occupancy rates differed between Brown et al. (1994) and CDFG (2002); thus, direct comparisons across time periods are inappropriate.

	Brown et al. (1994) Calendar years 1987-1990				**CDFG (2002) Years 1995-2001**				
County/River Basin	**no. of streams**	**no. of streams w/info.**	**coho present**	**%**	**no. of streams surveyed in 2001**	**no. of streams w/coho present**	**no. of streams w/coho assumed present**	**no. of streams w/coho not detected in 2001**	**Percent present (1995-2001)**
Mendocino Co.									
Coastal	44	35	13	37%	30	11	10	19	52%
Ten Mile River	11	10	7	79%	11	9	0	2	82%
Noyo River	13	12	11	92%	8	7	5	1	92%
Big River	16	13	11	85%	8	3	6	5	64%
Navarro River	19	8	4	50%	14	6	1	8	47%
Subtotal	103	78	46	59%	71	36	22	35	62%
Sonoma County									
Coastal	10	2	1	50%	4	0	0	4	0%
Gualala River	11	2	1	50%	10	0	0	10	0%
Russian River	32	24	2	8%	29	1	1	28	0%
Subtotal	53	28	4	14%	43	1	1	42	4%
Marin County									
Coastal[a]	10	7	7	100%	15	6	0	9	40%
Subtotal	10	7	7	100%	15	6	0	9	40%
Tribs. to S.F. Bay									
Coastal	7	7	0	0%	0	0	0	0	0%
Subtotal	7	7	0	0%	0	0	0	0	0%
South of S.F. Bay									
Coastal	13	13	5	38%					
Subtotal	13	13	5	38%					
ESU Total	186	133	62	47%	135	43	23	92	42%

[a] CDFG (2002) included five tributaries of Salmon Creek, a Sonoma County stream that empties into Tomales Bay, in their totals for Marin County.

Previous BRT conclusions

Based on the data presented above, the BRT concluded that all coho salmon stocks in the CCC ESU were depressed relative to historical abundance and that most extant populations have been heavily influenced by hatchery operations. They unanimously concluded that natural populations of coho salmon in this ESU were in danger of extinction (Weitkamp et al. 1995). After considering new information on coho salmon presence within the ESU, the majority of the BRT concluded that the ESU was in danger of extinction, while a minority concluded the ESU was not presently in danger of extinction but was likely to become so in the foreseeable future (NMFS 1996b).

Listing status

Coho salmon in the CCC ESU were listed as threatened in October 1996.

C.2.3.2 New Data and Updated Analyses

Significant new information on recent abundance and distribution of coho salmon within CCC ESU has become available, much of which has been summarized in two recent status reviews (NMFS 2001b; CDFG 2002). Most of these data are of two types: 1) compilations of presence-absence information for coho salmon throughout the CCC during the period 1987 to the present, and 2) new data on densities of juvenile coho salmon collected at a number of index reaches surveyed by private timber companies, CDFG, and other researchers. Excepting adult counts made at the Noyo Egg Collecting Station, which are both incomplete counts and strongly influenced by hatchery returns, there are no current time series of adult abundance within this ESU that span 8 or more years. Outmigrating smolts have been trapped at two trapping facilities in Caspar Creek and Little River since the mid-1980s; however, these are partial counts and only recently have mark-recapture studies been performed that allow correction for capture efficiency at these two sites. Thus, these smolt counts can only be considered indices of abundance.

Two analyses of presence-absence data have recently been published. CDFG (2002) performed an analysis that focused on recent (1995-2001) presence of coho salmon in streams identified as historical producers of coho salmon by Brown and Moyle (1991). NMFS (2001b) published an updated status review that analyzed coho salmon presence in streams throughout the CCC during the period 1989 to 2000. Scientists at NMFS' Southwest Fisheries Science Center have continued to compile information of coho salmon presence-absence and have incorporated data into a database that is now summarized by broodyear (rather than year of sampling) and covers broodyears 1986-2001. Data from CDFG's 2001 field survey of the Brown and Moyle (1991) streams has been incorporated into this database. Analyses presented in the present status review update supercede those presented in NMFS (2001b).

CDFG presence-absence analysis

Methods—Methods used by CDFG (2002) for analyzing presence-absence information in the CCC differed from those used for the SONCC analysis. Analysis focused on results from

CDFG's 2001 summer juvenile sampling effort in which 135 of 173 streams identified by Brown and Moyle (1991) as historical coho salmon streams within the CCC ESU were sampled. Additionally, CDFG assumed presence of coho salmon in any stream for which presence had been detected during any 3 consecutive years during the period 1995-2001. An estimate of percent coho salmon presence was calculated by totaling the number of streams for which presence was either observed or assumed, and dividing by the total number of streams surveyed, inclusive of those where presence was assumed. No formal statistical analysis of trends was performed because of the lack of comparable data from previous time periods.

Results—For the CCC ESU as a whole, CDFG (2002) estimated that coho salmon were present in 42% of streams historically known to contain coho salmon. Estimated occupancy was highest in Mendocino County (62%), followed by Marin County (40%), Sonoma County (4%), and San Francisco Bay tributaries (0%) (Table C.2.3.2). Because of differences in the specific streams considered and methods for estimating occupancy rates, these numbers are not directly comparable with those derived by Brown et al. (1994). Nevertheless, the regional and overall ESU patterns are generally concordant for the two studies, indicating substantial variation in occupancy rates across the ESU with lower occupancy rates in the southern portion of the ESU (Table C.2.3.2).

NMFS presence-absence analysis

Methods—Scientists at NMFS' Southwest Fisheries Science Center compiled survey information from streams with historical or recent evidence of coho salmon presence within the CCC ESU. Data were provided primarily by the California Department of Fish and Game, private landowners, consultants, academic researchers, and others who have conducted sampling within the CCC during the years 1988 to 2002. The majority of data come from summer juvenile surveys, though information from downstream migrant trapping and adult spawner surveys were also included. Observations of presence or absence for a particular stream were assigned to the appropriate broodyear based on the life stages observed (or expected in the case of absences). The resulting dataset spans broodyears 1987 to 2001, though data from the 2002 summer field season (broodyear 2001) were not fully reported at the time the analysis was performed.

Results for NMFS' presence-absence analysis are presented by major watersheds or aggregations of adjacent watersheds. Results from larger watersheds are typically presented independently, whereas data from contiguous smaller coastal streams, where data were relatively sparse, are grouped together. In a few cases, individual smaller coastal streams with only a few observations were aggregated with adjacent larger streams if there was no logical geographic grouping of smaller streams.

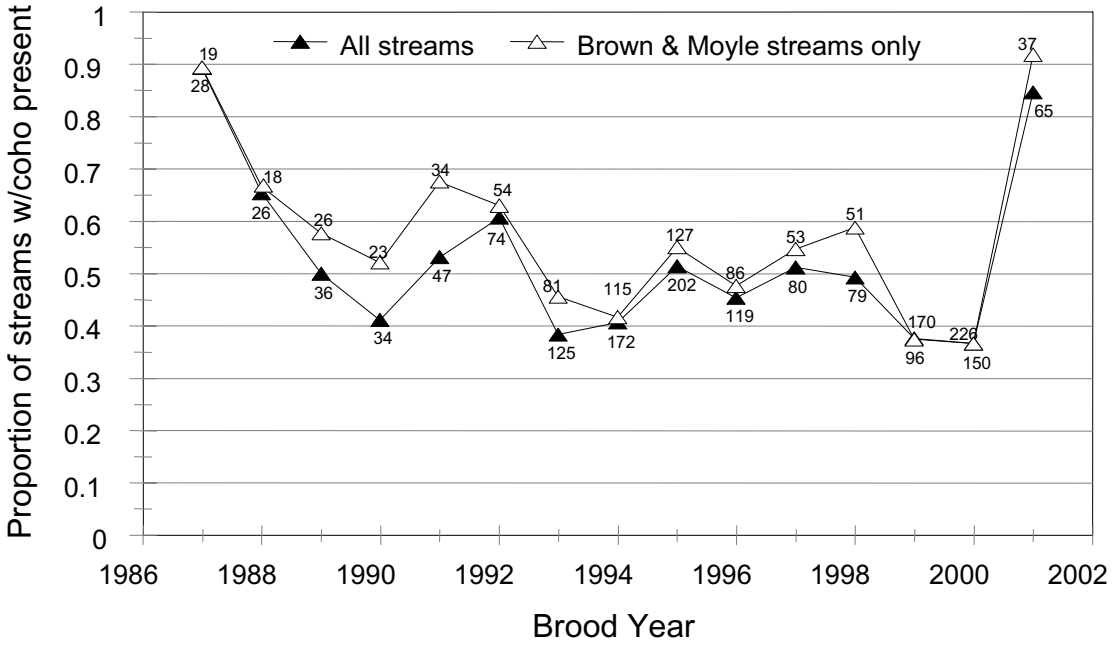


Figure C.2.3.1. Percent of streams surveyed for which coho salmon presence was detected, by broodyear, for all historical coho streams (solid triangles) and coho streams identified in Brown and Moyle's (1991) historical list (open triangles) within the CCC ESU. Sample sizes (i.e. number of streams surveyed) are shown above next to data points. Data are from combined NMFS and CDFG datasets.

Results—The estimated percentage of streams in which coho salmon were detected shows a general downward trend from 1987 to 2000, followed by a substantial increase in 2001 (Figure C.2.3.1). Several caveats, however, warrant discussion. First, the number of streams surveyed per year also shows a general increase from 1987 to 2000; thus, there may be a confounding influence of sampling size if sites surveyed in the first half of the time period are skewed disproportionately toward observations in streams where presence was more likely. Second, sample size from broodyear 2001 was relatively small and the data were weighted heavily toward certain geographic areas (Mendocino County and systems south of the Russian River). The data for broodyear 2001 included almost no observations from watersheds from the Navarro River to the Russian River, or tributaries to San Francisco Bay, areas where coho salmon have been scarce or absent in recent years. Thus, while 2001 appears to have been a relatively strong year for coho salmon in the CCC as a whole, the high percentage of streams where presence was detected shown in Figure C.2.3.1 is likely inflated.

Two other patterns were noteworthy. First, compared with percent presence values for the SONCC ESU, values in the CCC were more highly variable and showed a somewhat more cyclical pattern. In general, percent occupancy was relatively low in broodyears 1990, 1993, 1996, and 1999, suggesting that this brood lineage is in the poorest condition. In contrast, during the 1990s, percent occupancy tended to be high in broodyears 1992, 1995, 1998, and 2001, suggesting that this is the strongest brood lineage of the three. Second, there is a general tendency for percent occupancy to be slightly higher (2%-15%) for the Brown and Moyle streams compared with the ESU as a whole. We speculate that this pattern may reflect the fact that increased concern over CCC coho salmon in the mid-1990s prompted increased sampling of

streams in the CCC, including streams other than those traditionally known to support coho salmon. Lower occupancy rates at these sites might be expected if they represent habitats that are generally less suitable for coho salmon.

When data are aggregated over brood cycles (3-year periods), the percentage of streams with coho salmon detected shows a similar downward trend, from 72% in 1987-1989, to 62% in 1990-1992, to less than 55% in the last three brood cycles (Table C.2.3.3). Again there are confounding influences of increased sampling fraction through time and incomplete reporting for the 2001 broodyear. Nevertheless, it appears that the percent of historical streams occupied continued to decline from the late 1980s to the mid-1990s and remains below 50% for the ESU as a whole. Additionally, coho salmon appear to be extinct or nearing extinction in several geographic areas including the Garcia River, the Gualala River, the Russian River, and San Francisco Bay tributaries. There is also evidence that some populations that still persist in the southern portion of the range, including Waddell and Gazos creeks, have lost one or more brood lineages (Smith 2001).

Results from our presence-absence analysis are generally concordant with CDFG's analysis. The two studies show consistent regional patterns suggesting that within the CCC the proportion of streams occupied is highest in Mendocino County, but that populations in streams in the southern portion of the range (excluding portions of Marin County) have suffered substantial reductions in range. NMFS analysis is more suggestive of a continued decline in percent occupancy from the late 1980s to the present; however, increased sampling in recent years may be confounding any trends.

Adult time series

No time series of adult abundance free of hatchery influence and spanning 8 or more years are available for the CCC ESU. Adult counts from the Noyo Egg Collecting Station (ECS) dating back to 1962 represent a mixture of naturally produced and hatchery fish, and counts are incomplete most years because trap operation was sporadic during the season and typically ceased after broodstock needs were met. Thus, at best they represent an index of abundance. Assuming that these counts reflect general population trends, there appears to have been a significant decline in abundance of coho salmon in the South Fork Noyo River beginning in 1977 (Figure C.2.3.2). No formal analysis of trends was conducted because of the uncertainty of the relationship between catch statistics and population size, as well as the relative contribution of hatchery fish to total numbers during the entire period of record.

Smolt time series

California Department of Fish and Game personnel have trapped outmigrating smolts at Caspar Creek and Little River since 1986. These counts are partial counts, uncorrected for capture efficiency. As such, they provide only indices of abundance. However, they likely capture gross changes in smolt abundance over the years (Figure C.2.3.3). For Caspar Creek, the highest smolt counts occurred in the late 1980s and early 1990s, decreased in the mid-1990s, and then increased in the past three years to levels approaching those of the late 1980s (Figure C.2.2.3). For Little River, a similar pattern was observed from the late-1980s to the mid-1990s;

Table C.2.3.3. Percent of surveyed streams within the CCC ESU for which coho salmon were detected for four time intervals: broodyears 1987-1989, 1990-1992, 1993-1995, 1996-1998, and 1999-2001. Streams include those for which historical or recent evidence of coho salmon presence exists (based on combined NMFS and CDFG data).

		1987-1989			1990-1992			1993-1995			1996-1998			1999-2001		
County and River Basins	**Number of Streams with Historical Presence**	**Number Surveyed[a]**	**Coho Present[b]**	**Coho Absent[c]**	**Number Surveyed[a]**	**Coho Present[b]**	**Coho Absent[c]**	**Number Surveyed[a]**	**Coho Present[b]**	**Coho Absent[c]**	**Number Surveyed[a]**	**Coho Present[b]**	**Coho Absent[c]**	**Number Surveyed[a]**	**Coho Present[b]**	**Coho Absent[c]**
Mendocino																
Coastal (Punta Gorda to Abolabodiah Cr.)	24	4	75%	25%	6	50%	50%	16	50%	50%	11	18%	82%	19	32%	68%
Ten Mile River	25	6	50%	50%	15	53%	47%	17	65%	35%	14	57%	43%	16	94%	6%
Pudding Cr. to Noyo River	43	4	75%	25%	8	88%	12%	35	66%	34%	15	80%	20%	38	68%	32%
Coastal (Hare Cr. to Russian Gulch)	14	8	100%	0%	4	100%	0%	9	67%	33%	9	67%	33%	4	75%	25%
Big and Little Rivers	28	5	20%	80%	7	57%	43%	20	75%	25%	16	81%	19%	16	38%	62%
Albion River	16	3	100%	0%	3	100%	0%	15	80%	20%	1	100%	0%	14	86%	14%
Little Salmon & Big Salmon Cr.	6	0	-	-	3	100%	0%	4	75%	25%	4	75%	25%	4	100%	0%
Navarro River	30	1	100%	0%	1	0%	100%	24	58%	42%	6	67%	33%	23	52%	48%
Coastal (Greenwood Cr. to Brush Cr.)	8	3	0%	100%	2	50%	50%	8	13%	87%	0	-	-	8	0%	100%
Garcia River to Digger Cr.	8	3	100%	0%	2	0%	100%	8	13%	87%	5	20%	80%	7	0%	100%
Sonoma																
Gualala River	15	1	100%	0%	1	0%	100%	11	0%	100%	1	0%	100%	11	9%	91%
Fort Ross to Russian River	55	5	40%	60%	14	50%	50%	37	54%	46%	29	24%	76%	37	11%	89%
Marin																
Tomales Bay Rivers	25	3	100%	0%	4	100%	0%	14	36%	64%	10	90%	10%	21	57%	43%
Coastal (Redwood Cr. to Bolinas Lagoon)	6	0	-	-	1	100%	0%	2	50%	50%	4	75%	25%	5	100%	0%
San Francisco Bay																
SF Bay Rivers	6	0	-	-	4	0%	100%	6	0%	100%	4	0%	100%	0	-	-
San Mateo/Santa Cruz																
Coastal (SF Bay to Aptos Creek)	17	7	100%	0%	7	100%	0%	13	69%	31%	14	57%	43%	12	67%	33%
Monterey																
Coastal (Carmel R. to Big Sur R.)	2	0	-	-	0	-	-	2	0%	100%	0	-	-	2	0%	100%
ESU Total	**328**	**53**	**72%**	**28%**	**82**	**63%**	**37%**	**241**	**54%**	**46%**	**143**	**54%**	**46%**	**237**	**48%**	**52%**

[a] Total number of steams surveyed at least once within the three-year interval

[b] Percentage of surveyed streams where coho were present in one or more years during the interval

[c] Percentage of surveyed streams where coho were absent in all years of survey during the interval

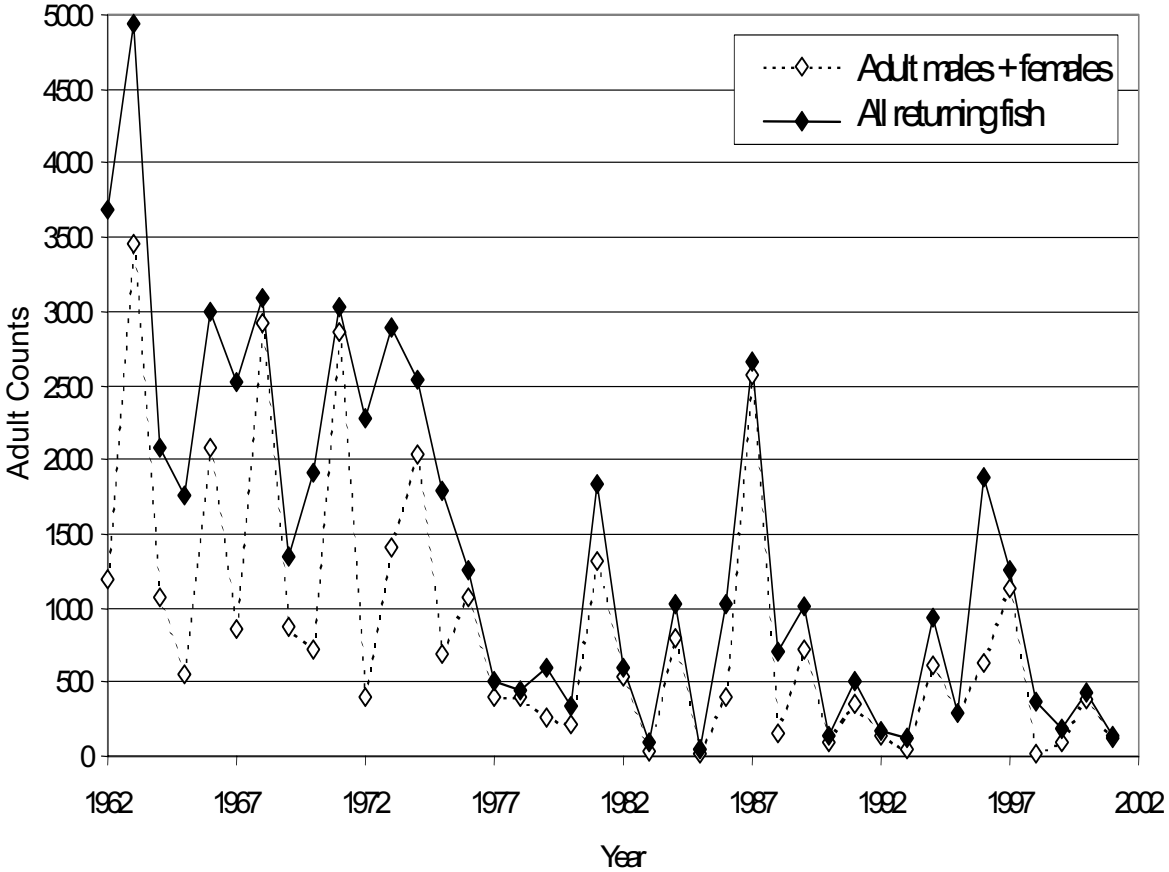


Figure C.2.3.2. Counts of adult coho salmon at Noyo Egg Collecting Station from 1962 to 2002. Solid line with closed symbol indicates total fish captured (including grilse); dashed line with open symbols indicates adult males and females only. Counts are partial counts and thus are only a crude index of adult abundance. Data source: Grass 2002.

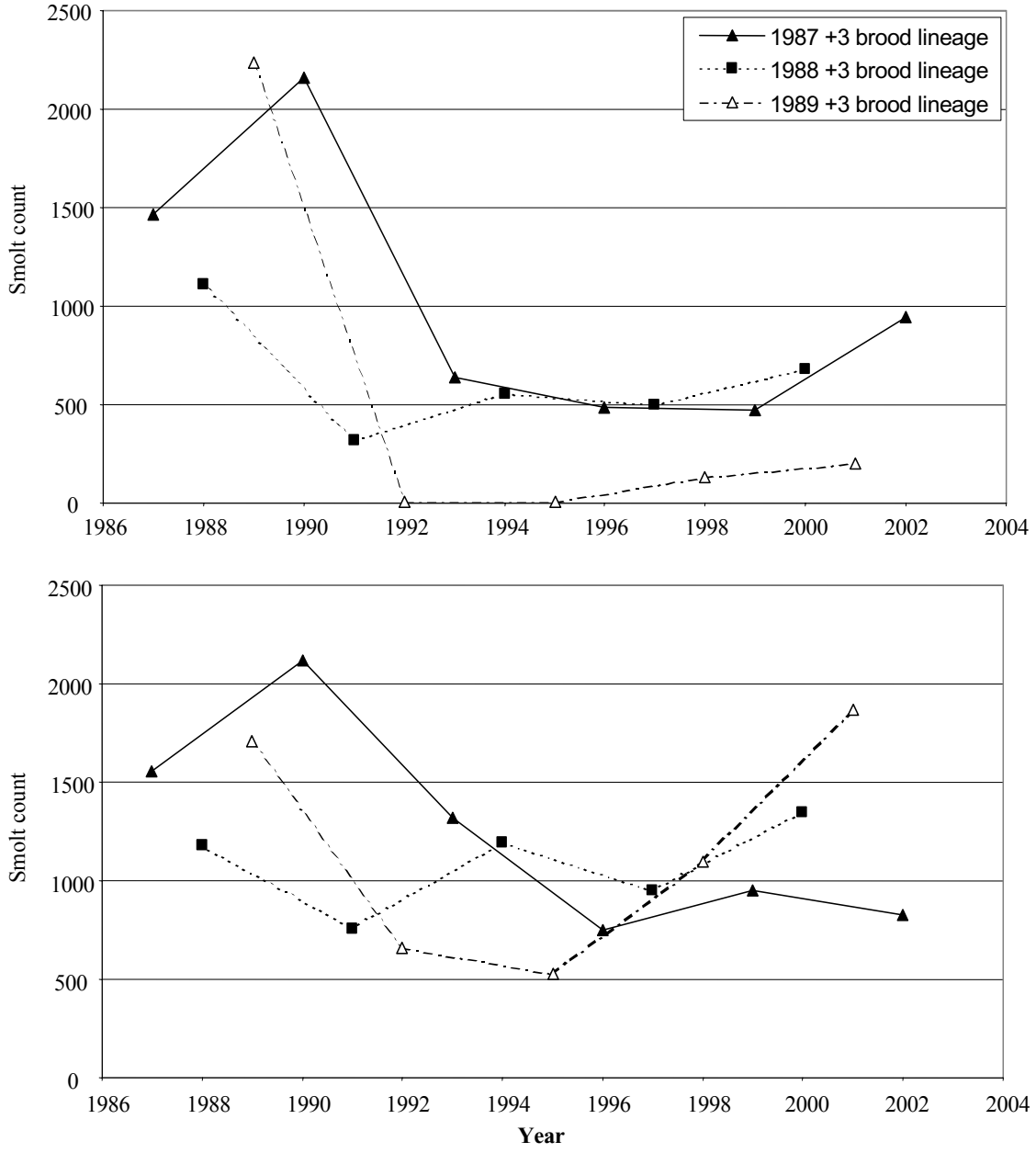


Figure C.2.3.3. Coho salmon smolt counts at a) Little River and b) Caspar Creek, Mendocino County. Lines track brood lineages. Data are counts of smolts uncorrected for trap efficiency and thus should be viewed as coarse indices of abundance. Data source: Scott Harris, CDFG, unpublished data.

Table C.2.3.4. Population trend analysis for Caspar Creek and Little River smolt outmigrant data. Trends are based on smolt counts uncorrected for trap efficiency (see text). Data source: Scott Harris, CDFG, unpublished data.

	Geometric Means[a]				
Stream	**Recent 3-year mean**	**3-year min.**	**3-year max.**	**Lambda[b]**	**Long-term trend[b]**
Caspar Cr.	1,278 (829-1,871)	723 (530-953)	1,383 (1,182-2,121)	1.002 (0.851, 1.178)	-0.017 (-0.081, 0.048)
Little R.	504 (198-946)	94 (4-640)	1,750 (1,111-2,161)	0.919 (0.669, 1.347)	-0.063 (-0.358, 0.232)

[a] Values parentheses for geometric means are the range of values observed over the three-year period.

[b] Values in parentheses for lambda and trends are lower and upper bounds for 95% confidence limits.

however, only a slight increase in numbers has been observed in the last three years of records. Smolt counts were higher in each year from 1986 to 1989 than in any year since (Figure C.2.2.3). When individual brood lineages are tracked, Little River shows a decline in all three brood lineages over the period of record. In contrast, Caspar Creek shows a decline in the 1987 brood lineage, relatively consistent numbers in the 1988 brood lineage, and a decrease in the early to mid-1990s followed by an increase over the last two brood cycles to levels comparable to those observed in 1989 (Figure C.2.2.3). For both locations, the estimated long-term trend is negative but not significantly different from 0 (Table C.2.3.4). Likewise, lambda values are not significantly different from 1.

Juvenile time series

Methods—While recent estimates of adult and smolt abundance are scarce for the CCC ESU, estimates (or indices) of juvenile density during summer have been made at more than 50 index sites within the CCC in the past 8 to 18 years. Methods for analyzing these data are described in detail in the SONCC coho salmon status review update. Briefly, data from individual sampling sites were ln-transformed and normalized to prevent spurious trends arising from different data collection methods or reporting units. Data were then grouped into units thought to represent plausible independent populations based on watershed structure. Trends were then estimated for putative populations by estimating the slope (and associated 95% confidence intervals) for the aggregated data. Analysis was restricted to 1) sites where a minimum of 6 years of data were available, and 2) putative populations where more than 65% of all observations were non-zero values.

Nine geographic areas (putative populations) were represented in the aggregated data including Pudding Creek, Noyo River, Caspar Creek, Big River, Little River, Big Salmon Creek, Lagunitas Creek, Redwood Creek, and coastal streams south of San Francisco Bay, including Waddell, Scott, and Gazos creeks. Spatially, these sites cover much of the CCC ESU; however, several key watersheds are not represented, including the Ten Mile, Navarro, Garcia, Gualala,

and Russian Rivers. Although considerable sampling has been done in the Ten Mile River basin, the high proportion of zero values precluded analysis of these data.

Results—Overall, analysis of juvenile data provided little evidence of either positive or negative trends for the putative populations examined. Estimated slopes were negative for six populations and positive for three; however, none of the estimated slopes differed significantly from zero (Table C.2.3.5).

Table C.2.3.5. Trend slopes and confidence intervals for nine putative coho populations in the CCC ESU.

			95% confidence interval	
Watershed	**No. Sites**	**Aggregate Slope**	**Lower bound**	**Upper bound**
Pudding Creek	1	-0.019	-0.103	0.065
Noyo River	8	-0.091	-0.195	0.013
Caspar Creek	2	-0.039	-0.109	0.030
Little River	2	-0.044	-0.118	0.029
Big River	2	0.146	-0.001	0.293
Big Salmon Creek	5	-0.005	-0.110	0.100
Lagunitas Creek	3	0.095	-0.123	0.312
Redwood Creek	1	0.091	-0.345	0.527
Waddell/Scott/Gazos creeks	3	-0.111	-0.239	0.018

C.2.3.3 New Comments

Homer T. McCrary, vice president of Big Creek Lumber, submitted 375 pages comprised primarily of excerpts from historical documents related to operation of hatcheries in Santa Cruz County from the early 1900s to 1990. The expressed intent of this compilation was "to assist the efforts of resource professionals, scientists, regulators, fisheries restoration advocates and all interested parties in establishing a more complete historical perspective on salmonid populations." Quantitative information regarding hatchery and stocking histories is discussed in the Harvest Impact section.

C.2.3.4 New Hatchery Information

The BRT (Weitkamp et al. 1995) identified four production facilities that had recently produced coho salmon for release in the CCC ESU: the Noyo Egg Collecting Station (reared at Mad River Hatchery) and Don Clausen (Warm Springs) hatchery, both operated by CDFG; Big Creek Hatchery (Kingfisher Flat Hatchery), operated by the Monterey Bay Salmon and Trout Program; and the Silver-King ocean ranching operation. The latter facility closed in the late 1980s.

Noyo Egg Collecting Station—The Noyo Egg Collecting Station (ECS), located on the South Fork Noyo River approximately 17 km inland of Fort Bragg, began operating in 1961 and has collected coho salmon in all but a few years since that time. Fish have historically been reared at

the Mad River Hatchery, Don Clausen (Warm Springs) Hatchery, and the Silverado Fish Transfer Station. There are no records of broodstock from other locations being propagated with Noyo fish for release back into the Noyo system, but a few out-of-ESU transfers directly into the Noyo system have been recorded, including Alsea and Klaskanine, OR stocks (SSHAG 2003).

Average annual release of coho salmon yearlings was 108,000 from 1987-1991 (Weitkamp et al. 1995), declined to about 52,000 between 1992 and 1996, and then increased again to about 72,000 fish between 1997 and 2002, inclusive of 2 years where no yearlings were released (Table C.2.3.6). Releases have been made exclusively to the ECS or elsewhere in the South Fork Noyo drainage in the past decade. Between 1991 and 2001, adult returns averaged 572 individuals, though these represent incomplete counts in most years, as counting typically ceased after broodstock needs were met (Grass 2002). On average, 91 females were spawned annually during this 11-year period (Grass 1992-2002).

There are no basin-wide estimates of natural and artificial production for the Noyo Basin as a whole; however, marking of coho salmon juveniles released from the Noyo ECS on the South Fork began in 1997, and returns have been monitored since the 1998-1999 spawning season. In the 1998, 1999, and 2000 broodyears, marked hatchery fish constituted 85%, 70%, and 80%, respectively, of returning adults captured at the ECS.

The BRT (NMFS 1996a) concluded that, although exotic stocks have occasionally been introduced into the Noyo system, the regular incorporation of local natural fish into the hatchery population made the likelihood that this population differs substantially from naturally spawning fish in the ESU is low and, therefore, included them in the ESU. Since CCC coho salmon were listed, no significant changes in hatchery practices have occurred. The Noyo ECS operation has been classified as a Category 1 hatchery (SSHAG 2003).

Don Clausen (Warm Springs) Hatchery—The Don Clausen Hatchery (a.k.a. Warm Springs stock), located on Dry Creek in the Russian River system 72 km upstream of the mouth, began operating in 1980. Initial broodstock used were from the Noyo River system, and Noyo fish were planted heavily from 1981 to 1996.

Average annual releases of coho salmon from the hatchery decreased from just over 123,000 in the 1987-1991 period to about 57,000 in the years between 1992 and 1996, and Noyo River broodstock continued to constitute about 30% of the releases during the latter period. Production of coho salmon at the facility ceased entirely after 1996 (Table C.2.3.6). Adult returns averaged 245 fish between 1991 and 1996, but following the cessation of releases, no more than four coho salmon have been trapped at the hatchery in any subsequent year.

Because the Warm Spring population was originally derived from Noyo River stock and continued to receive transfers from the Noyo system throughout its operation, the BRT concluded that the hatchery population was not a part of the ESU.

Beginning in 2001, however, a captive broodstock program was initiated at the Don Clausen facility. A total of 337 juveniles were electro-fished from Green Valley and Mark West Springs creeks, two Russian River tributaries that still appear to support coho salmon, as well as

Olema Creek, a tributary to Lagunitas Creek. Specific mating protocols for these fish have not yet been determined. The captive broodstock program proposes to eventually release 50,000 fingerlings and 50,000 yearlings into five Russian River tributaries. Under the captive broodstock program, the Don Clausen Hatchery has been classified as a Category 1 hatchery (SSHAG 2003).

Kingfisher Flat (Big Creek) Hatchery—The Monterey Bay Salmon and Trout Program (MBSTP) has operated Kingfisher Flat Hatchery, located on Big Creek, a tributary to Scott Creek, since 1976. The facility is near the site of the former Big Creek Hatchery, which was operated from 1927 to 1942, when a flood destroyed the facility. An additional facility in Santa Cruz County, the Brookdale Hatchery on the San Lorenzo River, operated from 1905 to 1953. Both the Big Creek and Brookdale hatcheries were supplied with eggs taken at an egg-collection facility located on Scott Creek; additional eggs were provided from other hatcheries around the state. Production of coho salmon at both hatcheries was sporadic. Releases of Sisson (Mt. Shasta) coho salmon were made in Scott Creek and other Santa Cruz County streams in 1913, 1915, and 1917. In subsequent years, releases from both facilities back into Scott Creek in included both Scott Creek fish (1929, 1930, 1934, and 1936-1939), as well as fish from Ft. Seward, Mendocino County (1932), and Prairie Creek, Humboldt County (1933, 1935, and 1939). Throughout these years, only fry were released (generally during July through

Table C.2.3.6. Average annual releases of coho salmon juveniles (fry and smolts) from hatcheries in the CCC coho salmon ESU during release years 1987-1991, 1992-1996, and 1997-2002.

Hatchery	SSHAG Cat.	Annual Average Releases		
		1987-1991	**1992-1996**	**1997-2002**
Monterey Bay Salmon and Trout	1	25,764[a]	8,645[b]	3,622[b]
Silver-King		95,074[c]	0[d]	0[d]
Noyo Egg Collecting Station	1	107,918[a]	52,012[e]	72,363[e]
Don Clausen (Warm Springs) Hatchery	1	123,157[a]	56,891[f]	0[f]
Total		351,913	108,903	72,363

[a] Source: Weitkamp et al. 1995.
[b] No coho released in 1991, 1994, 1997 and 2000; all releases are smolts except for 10,095 fry released in 1996; smolts from San Lorenzo River, Noyo River, and Prairie Creek reared at Big Creek and released into San Lorenzo River are excluded from totals. Sources: MBSTP 1992-1996; Anderson 1996; Jerry Ayers, CDFG, unpublished data.
[c] Average from 4 years of data (1984-1988). Source: Weitkamp et al. 1995.
[d] Ceased operating in the 1980s.
[e] No yearling coho were released in 1995, 2000, or 2001. Sources: Grass 1992-2002.
[f] Releases included both Warm Springs Hatchery and Noyo River ECS fish.. Warm Springs Hatchery ceased releasing coho salmon in 1996. Sources: Cartwright 1994; Williams 1993; Quinones 1994-1997; CDFG Hatchery Staff 2000.

September), and numbers of fish were relatively small. In the 10 years between 1929 and 1939, during which coho salmon were planted in Scott Creek, the total fry release averaged about 34,000 fish. During the Silver-King operation, broodstock was obtained from Oregon, Washington, British Columbia, and Alaska.

Since 1976, when MBSTP began operating the Kingfisher Flat Hatchery, only local broodstock has been released back into Scott Creek; some Noyo, Prairie Creek, and San Lorenzo

coho salmon were reared at the hatchery in the early 1990s, but were released into the San Lorenzo River rather than Scott Creek. Mating protocols at the hatchery follow a priority scheme in which wild x wild broodstock are used in years of relatively high abundance, wild x hatchery crosses are done when wild fish are less available, and hatchery x hatchery crosses are made when wild fish are unavailable (D. Streig, MBSTP, pers. comm.). Under the current management plan, up to 30 females and 45 males can be taken with the restriction that the first 10 spawning pairs observed must be allowed to spawn undisturbed in their natural habitat, and then only one in four females may be taken to spawn. In recent years, few or no fish have been taken, due to low abundance; however, in 2001, 123 coho were observed and 26 "wild" females were taken for spawning. Of the 123 coho observed, 40% were marked hatchery fish. There are no other data available to assess the relative contribution of hatchery versus naturally produced coho salmon.

In its 1996 coho status review update, the BRT concluded that the Kingfisher Flat (Scott Creek) hatchery population should be considered part of the ESU and was essential for ESU recovery (NMFS 1996a). This was based on the fact that there was regular incorporation of local broodstock into the hatchery population in the years that coho were produced between 1905 and 1943, and there have been no out-of-basin or out-of-ESU transfers since the hatchery was restarted in 1976. The MBSTP operation has been classified as a Category 1 hatchery (SSHAG 2003). For other SSHAG categorizations of hatchery stocks, see Appendix C.5.1.

A captive broodstock program for Scott Creek will be initiated at the NMFS Santa Cruz Laboratory in 2003.

Summary

Artificial propagation of coho salmon within the CCC ESU has been reduced since this ESU was listed in 1996 (Table C.2.3.6). The Don Clausen Hatchery has ceased production of coho salmon, and releases from the Noyo ECS operation declined over the past 6 years, in part because coho were not produced during 2 of those 6 years. The Monterey Bay Salmon and Trout Program has produced few coho salmon for release in the last 6 years due to low adult returns to Scott Creek. Genetic risks associated with out-of-basin transfers appear minimal. However, potential genetic modification in hatchery stocks resulting from domestication selection or low effective population size remains a concern.

Harvest impacts

Harvest of CCC-origin coho salmon historically occurred in coho- and chinook-directed commercial and recreational fisheries off the coast of California. Coho landing information for various ports in California are available dating back to the 1950s for commercial harvest and the early 1960s for recreational harvest; however, there are no historical estimates of either harvest or exploitation rates specific to CCC coho salmon. Likewise, there is no direct information available about the ocean distribution of coho salmon; however, it is likely that most

CCC-origin coho salmon remain in waters off of California and southern Oregon.[6] Thus, harvest management within this region is most relevant for evaluating harvest impacts.

Through the mid-1980s, the season for directed commercial harvest of coho salmon typically lasted three to almost five months throughout California. In the late 1980s and early 1990s, the commercial salmon seasons throughout California were generally shorter, particular in the region south of Pt. Delgada. By 1992, the commercial coho salmon season was closed completely from the Oregon border south to Horse Mountain, California, and open only 7 days from Pt. Arena to San Pedro. Retention of coho salmon by commercial fishers south of Cape Falcon, Oregon, including all of California, has been prohibited since 1993 (PFMC 2002b). Likewise, retention of coho salmon in recreational fisheries was prohibited in 1994 from Cape Falcon, Oregon, south to Horse Mountain, California. This prohibition was extended to include all California waters in 1996 (PFMC 2003). Non-retention regulations in both commercial and recreational fisheries remain in place throughout coastal California and southern Oregon, but selective fishing for marked hatchery coho salmon has been allowed north of Humbug Mountain, OR since 1999, and some incidental mortality of CCC coho salmon may occur in this fishery. Additionally, coho salmon are also incidentally caught or hooked in chinook fisheries off of California.

Although no estimates of incidental mortality associated with chinook fisheries are available (PFMC 2003), non-retention regulations have undoubtedly resulted in a substantial reduction in harvest-related mortality since 1993. The PFMC (2003) estimates that statewide commercial harvest of coho salmon averaged about 163,000 fish between 1952 and 1991; since 1992 there have been no known landings of coho salmon. Ocean recreational harvest of coho salmon averaged about 34,000 fish from 1962 to 1993. Total estimated incidental and illegal harvest of coho salmon has not exceeded 1000 fish in any year since non-retention regulations were put in place.

There is no legal inside harvest of coho salmon within the CCC ESU; any fishery mortality results from incidental catch-and-release hooking mortality in other fisheries. There are no estimates of inside harvest or mortality of coho salmon in the CCC ESU (PFMC 2003); however, CDFG (2003) considers the potential for significant incidental mortality (and poaching) to be low because of the minimal overlap between the coho migration season and the steelhead season (CDFG 2003).

C.2.3.5 Comparison with Previous Data

New data for the CCC coho salmon ESU includes expansion of presence-absence analyses, an analysis of juvenile abundance in 13 river basins, smolt counts from two streams in the central portion of the ESU, and one adult time series for a population with mixed wild and hatchery fish. The presence-absence analysis suggests possible continued decline of coho salmon between the late 1980s and the late 1990s, a pattern that is mirrored in the limited smolt and adult counts. Juvenile time series suggest no obvious recent change in status, but most

[6] Rogue/Klamath hatchery stocks, which serve as fishery surrogate stocks for SONCC coho salmon are generally distributed south of Humbug Mountain, Oregon. It is likely that CCC coho salmon exhibit a more southerly ocean distribution.

observations underlying that analysis were made in the period from 1993 to 2002. Coho salmon populations continue to be depressed relative to historical numbers, and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. A number of coho populations in the southern portion of the range appear either extinct or nearly so, including those in the Gualala, Garcia, and Russian Rivers, as well as smaller coastal streams in San Francisco Bay and South of San Francisco Bay. Although the 2001 broodyear appears to relatively strong, data were not yet available from many of the most at-risk populations within the CCC.

No new information has been provided that suggests additional risks beyond those identified in previous status reviews. Termination of hatchery production at the Don Clausen (Warm Springs) Hatchery and reductions in production at the Noyo and Kingfisher Flat (Big Creek) facilities suggest a decrease in potential risks associated with hatcheries; however, the lack of substantive information regarding the relative contribution of hatchery and naturally produced fish at these facilities adds uncertainty as to the potential risks these operations may pose to the genetic integrity of the Noyo River and Scott Creek stocks. Restrictions on recreational and commercial harvest of coho salmon since 1993-1994 have substantially reduced exploitation rate on CCC coho salmon.

C.2.4 LOWER COLUMBIA RIVER COHO SALMON

Primary contributor: Paul McElhany
(Northwest Fisheries Science Center)

C.2.4.1 Summary of Previous BRT Conclusions

The status of Lower Columbia River coho salmon was initially reviewed by the National Marine Fisheries Service (NMFS) in 1996 (NMFS 1996b) and the most recent review occur in 2001 (NMFS 2001a). In the 2001 review, the Biological Review Team (BRT) was very concerned that the vast majority (over 90%) of the historical populations in the Lower Columbia River coho salmon ESU appear to be either extirpated or nearly so. The two populations with any significant production (Sandy and Clackamas) were at appreciable risk because of low abundance, declining trends and failure to respond after a dramatic reduction in harvest. The large number of hatchery coho salmon in the ESU was also considered an important risk factor. The majority of the 2001 BRT votes were for "at risk of extinction" with a substantial minority in "likely to become endangered."

Current Listing Status—candidate species

C.2.4.2 New Data and Updated Analyses

New data include spawner abundance estimates through 2002 for Clackamas and Sandy populations (the previous status review had data just through 1999). In addition, the Oregon Department of Fish and Wildlife (ODFW) conducted surveys of Oregon Lower Columbia River coho salmon using a stratified random sampling design in 2002, which provided the first abundance estimates for lower tributary populations (previously only limited index surveys were available. Estimates of the fraction of hatchery-origin spawners accompany the new abundance estimates. In Washington, no surveys of natural-origin adult coho salmon abundance are conducted. Updated information through 2002 on natural-origin smolt production from Cedar, Mill, Germany, and Abernathy creeks and the upper Cowlitz River were provided by the Washington Department of Fish and Wildlife (WDFW).

New analyses include the tentative designation of demographically independent populations, the recalculation of metrics reviewed by previous BRTs with additional years of data, estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish, a new stock assessment of Clackamas River coho by ODFW (Zhou and Chilcote 2003), and estimates of current and historically available kilometers of stream.

Historical population structure—As part of its effort to develop viability criteria for Lower Columbia River salmon and steelhead, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations of Endangered Species Act-listed salmon and steelhead in the Lower Columbia River (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Based on the WLC-TRT's framework for chinook and

steelhead, the BRT tentatively designated populations of Lower Columbia River coho salmon (Figure C.2.4.1). A working group at the Northwest Fisheries Science Center hypothesized that the Lower Columbia River coho salmon ESU historically consisted of 23 populations. These population designations have not yet been reviewed by the WLC-TRT. With the exception of the Clackamas coho, the populations shown in Figure C.2.4.1 are used as the units for the new analyses in this report.

Previous BRT and ODFW analyses have treated the coho in the Clackamas River as a single population (see previous status review updates for more complete discussion and references). However, recent analysis by ODFW (Zhou and Chilcote 2003) supports the hypothesis that coho salmon in the Clackamas River consist of two populations, an early run and a late run. The late run population is believed to be descendant of the native Clackamas River population, and the early run is believed to descend from hatchery fish introduced from Columbia River populations outside the Clackamas River basin. There is uncertainty about the population structure of Clackamas River coho; therefore, in this report, analyses on Clackamas River coho are conducted under both the single population and two population hypotheses for comparison.

For other salmonid species, the WLC-TRT partitioned Lower Columbia River populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2003). These analyses suggest that a viable ESU would require a number of viable populations in each of these strata. Coho salmon do not have the major life-history variation seen in Lower Columbia River steelhead or chinook, and would thus be divided into strata based only on ecological zones. The strata and associated populations for coho salmon are identified in Table C.2.4.1.

Abundance and trends

Recent abundance of natural-origin spawners, and recent fraction of hatchery-origin spawners for Lower Columbia River coho salmon populations are summarized in Table C.2.4.1. Natural-origin fish are defined as those whose parents that spawned in the wild, while hatchery-origin fish are defined as those whose parents were spawned in a hatchery. Some populations (e.g. North Fork Lewis River) are above impassible barriers and are completely extirpated. Most of the other populations, except for the Clackamas and Sandy Rivers are believed to have very little, if any, natural production. References for abundance time series and related data are in Appendix C.5.2.

Clackamas—The Clackamas River population above the North Fork Dam is one of only two populations in the ESU for which natural production trends can be estimated. The portion of the population above the dam has a relatively low fraction of hatchery-origin spawners, while the area below the dam is dominated by hatchery-origin spawners (Table C.2.4.1). The recent average number of coho salmon above the dam is shown in Table C.2.4.2, and counts of total adults and natural-origin adults passing the North Fork dam is shown in Figure C.2.4.2. Prior to 1973, hatchery-origin adults and juveniles were released above North Fork Dam, and the time series from 1957-1972 contains an unknown fraction of hatchery-origin spawners. Since almost all Lower Columbia River coho salmon females and most males spawn at 3 years of age, a strong

cohort structure is produced. Figure C.2.4.3 shows the three adult cohorts on the Clackamas. As discussed in the section on population structure, multiple hypotheses exist regarding the number of historical and current populations in the Clackamas basin. Zhou and Chilcote (2003) partitioned current Clackamas River coho above North Fork into two populations (Figure C.2.4.4). Figure C.2.4.5 shows the number of juvenile coho outmigrants passing the North Fork Dam from 1957-2002.

Table C.2.4.1. Recent abundance of natural-origin spawners and recent fraction of hatchery-origin spawners for Lower Columbia River coho salmon populations. The ecological zones are based on ecological community and hydrodynamic patterns. Abundance and hatchery fraction are based on ODFW and Portland General Electric (PGE) data. ND - no data available.

Ecological Zone	Putative Population	2002 Total Spawners	2002 Hatchery Fraction (%)	2002 Natural-origin Smolts
Coastal	Youngs Bay	4,473 (combined Youngs bay and Big Creek)	91	ND
	Big Creek			ND
	Grays River	ND	ND	ND
	Elochoman	ND	ND	ND
	Clatskanie	229	60	ND
	Mill, Germany, Abernathy	ND	ND	22,700
	Scappoose	458	0	ND
Cascade	Cispus	ND	ND	168,281
	Tilton	ND	ND	
	Upper Cowlitz	ND	ND	
	Lower Cowlitz	ND	ND	ND
	North Fork Toutle	ND	ND	ND
	South Fork Toutle	ND	ND	ND
	Coweeman	ND	ND	ND
	Kalama	ND	ND	ND
	North Fork Lewis	ND	ND	32,695 (Cedar Creek only)
	East Fork Lewis	ND	ND	ND
	Clackamas	1,001 (above North Fork) 2,402 (below North Fork)	12 (above N. Fork) 78 (below N. Fork)	ND
	Salmon Creek	ND		ND
	Sandy	310 (above Marmont) 271 (below Marmot)	0 (above Marmot) 97 (below Marmot)	ND
	Washougal	ND	ND	ND
Gorge	Lower Gorge Tributaries	ND	ND	ND
	White Salmon	ND	ND	ND
	Upper Gorge Tributaries	1,317 (Combined Hood River and Oregon only upper gorge)	>65*	ND
	Hood River			ND

*Contain an unknown (i.e. unmarked) additional fraction of hatchery-origin coho from upstream releases.

Table C.2.4.2. Recent abundance estimates for subset of Lower Columbia coho populations.

Population		Years for Recent Means	Recent Geometric Mean	Recent Arithmetic Mean
Clackamas (above North Fork Dam)	Total	2000 – 2002	2,122	2,453
	Early Run	1996-1999	302	531
	Late Run	1996-1999	35	100
Sandy (above Marmot Dam)		2000 – 2002	643	739

The long-term trends and growth rate (λ) estimates over the entire time series for the total count at North Fork Dam and the early run portion have been slightly positive and the short-term trends and λ have been slightly negative (Tables C.2.4.3 and C.2.4.4).

Table C.2.4.3. Long-term trend and growth rate for subset of Lower Columbia coho salmon populations (95% C.I. are in parentheses). The long-term analysis used the entire data set (see Table C.2.4.2 for years). The λ calculation estimates the natural growth rate after accounting for hatchery-origin spawners. Since the fraction of hatchery-origin spawners prior to 1973 in the Clackamas River is unknown, λ estimates for the Clackamas River use data from 1973 onward. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners: Hatchery = 0 - hatchery fish are assumed to have zero reproductive success; Hatchery = Wild - hatchery fish are assumed to have the same reproductive success as natural-origin fish.

Population		Years for Trend	Trend of Total Spawners	Years for λ	Median Growth Rate (λ)	
					Hatchery = 0	Hatchery = Wild
Clackamas (above North Fork Dam)	Total	1957 – 2002	1.009 (0.994 – 1.024)	1973 – 2002	1.028 (0.898 – 1.177)	1.026 (0.897 – 1.174)
	Early Run	1973 – 1998	1.080 (1.015 – 1.149)	1973 – 1998	1.085 (0.944 – 1.248)	1.085 (0.944 – 1.248)
	Late Run	1973 – 1998	0.926 (0.863 – 0.993)	1973 – 1998	0.958 (0.834 – 1.102)	0.958 (0.834 – 1.102)
Sandy		1977 – 2002	0.997 (0.941 – 1.056)	1977 – 2002	1.012 (0.874 – 1.172)	1.012 (0.874 – 1.172)

Table C.2.4.4. Short-term trend and growth rate for subset of Lower Columbia coho populations (95% C.I. are in parentheses). Short-term data sets include data from 1990 to the most recent available year. The λ calculation estimates the natural growth rate after accounting for hatchery-origin spawners. The λ estimate is calculated under two hypotheses about the reproductive success of hatchery-origin spawners: Hatchery = 0 - hatchery fish are assumed to have zero reproductive success; Hatchery = Wild - hatchery fish are assumed to have the same reproductive success as natural-origin fish.

Population		Years for Trend	Trend of Total Spawners	Years for λ	Median Growth Rate (λ)	
					Hatchery = 0	Hatchery = Wild
Clackamas (above North Fork Dam)	Total	1990 – 2002	0.949 (0.832 – 1.083)	1990 – 2002	0.975 (0.852 – 1.116)	0.970 (0.848 – 1.110)
	Early Run	1990 – 1998	0.884 (0.601 – 1.302)	1990 – 1998	0.902 (0.785 – 1.037)	0.902 (0.785 – 1.037)

	Late Run	1990 – 1998	0.734 (0.406 – 1.325)	1990 – 1998	0.843 (0.734 – 0.969)	0.843 (0.734 – 0.969)
Sandy		1990 – 2002	0.964 (0.841 – 1.105)	1977 – 2002	0.979 (0.845 – 1.133)	0.978 (0.845 – 1.132)

The late run portion of the North Fork Dam count (hypothesized to be the remains of the historical Clackamas River coho population) shows negative trends and growth rates over both the long and short term. However, the confidence intervals on trend and growth rate are large, so there is a great deal of uncertainty. Both the long-term and short-term trends and λ have relatively high probabilities of being less than one (Tables C.2.4.5 and C.2.4.6).

Table C.2.4.5. Probability that the long-term abundance trend or growth rate of Lower Columbia River coho salmon is less than one: Hatchery = 0 - hatchery fish are assumed to have zero reproductive success; Hatchery = Wild - hatchery fish are assumed to have the same reproductive success as natural-origin fish.

Population		**Years for Trend**	**Prob. Trend <1**	**Years for λ**	**Prob. λ < 1**	
					Hatchery = 0	**Hatchery = Wild**
Clackamas (above North Fork Dam)	Total	1957 – 2002	0.123	1973 – 2002	0.283	0.296
	Early Run	1993 – 1998	0.008	1973 – 1998	0.148	0.148
	Late Run	1973 – 1998	0.984	1973 – 1998	0.724	0.724
Sandy		1977 – 2002	0.544	1977 – 2002	0.426	0.427

Table C.2.4.6. Probability that the short-term abundance trend or growth rate of Lower Columbia River coho salmon is less than one: Hatchery = 0 - hatchery fish are assumed to have zero reproductive success; Hatchery = Wild - hatchery fish are assumed to have the same reproductive success as natural-origin fish.

Population		**Years for Trend**	**Prob. Trend <1**	**Years for λ**	**Prob. λ < 1**	
					Hatchery = 0	**Hatchery = Wild**
Clackamas (above North Fork Dam)	Total	1990 – 2002	0.799	1990 – 2002	0.582	0.600
	Early Run	1990 – 1998	0.762	1990 – 1998	0.711	0.711
	Late Run	1990 – 1998	0.872	1990 – 1998	0.836	0.836
Sandy		1990 – 2002	0.716	1990 – 2002	0.564	0.566

Since the late 1980s, the number of pre-harvest recruits has declined relative to the number of spawners (Figures C.2.4.6 and C.2.4.7). Despite upturns in the last 2 years, the population has had more years below replacement since 1990 than above. Thus, even with the dramatic reductions in harvest rate (Figure C.2.4.8), the population failed to respond during the

1990s because of this recruitment failure. Although the recent increases in recruitment are encouraging, the population has not regained earlier levels and is unknown if they will persist. The recent increases in recruitment are attributable in some part to increased marine survival and marine survival cannot predict with any certainty.

Based on stock assessment analysis under the assumption that the ClackamasRiver coho consist of two populations, Zhou and Chilcote (2003) concluded that the early (introduced) run had a relatively low risk of extinction, whereas the late (native) run had a relatively high risk of extinction.

Sandy—The Sandy River population above Marmot Dam and the Clackamas River population(s) above North Fork Dam are the only populations in the ESU for which natural production trends can be estimated. The portion of the Sandy River population above Marmot Dam has almost no hatchery-origin spawners, while the area below the dam is dominated by hatchery-origin spawners (Table C.2.4.1). The recent average number of coho salmon above Marmot Dam is shown in Table C.2.4.2. Figure C.2.4.8 shows the total adult count passing the dam, while Figure C.2.4.9 shows the three adult cohorts on the Sandy River.

The long-term and short-term trends for the counts at Marmot Dams are both slightly negative (Tables C.2.4.3 and C.2.4.4). The long-term λ is slightly positive and the short-term λ is slightly negative (Tables C.2.4.3 and C.2.4.4). However, the confidence intervals on trend and growth rate are large, so there is a great deal of uncertainty. Both the long-term and short-term trends and λ have relatively high probabilities of being less than one (Tables C.2.4.5 and C.2.4.6).

The late 1980s recruitment failure observed in the Clackamas is also present in the Sandy River population (Figures C.2.4.10 and C.2.4.11). If anything, it may be more pronounced in the Sandy River system, and overall coho salmon abundance levels are lower. Again, despite reductions in harvest (Figure C.2.4.12), the Sandy River coho population has failed to recover to earlier recruitment levels, despite the encouraging returns in 2000 and 2001. The 2002 return showed a decline from 2000 and 2001 abundance levels (Figure C.2.4.8).

Other Oregon populations

ODFW initiated a large effort in 2002 to obtain abundance estimates of Lower Columbia coho salmon using a random stratified sampling protocol similar to that used to estimate abundance of Oregon coastal coho salmon. Results from this survey are presented in Table C.2.4.1. These surveys indicate that Oregon Lower Columbia River coho salmon are dominated by hatchery-origin spawners, but there are some potential pockets of natural production (e.g. Scappoose Creek). With only data for one year, it is difficult reach conclusions about the abundance of coho salmon in Oregon populations down stream of the Willamette River. Marine survival for Lower Columbia River coho salmon returning in 2002 was relatively high and the Lower Columbia River tributary counts in 2002 are likely to be higher than in low marine survival years.

Prior to 2002, ODFW conducted coho salmon spawner surveys in lower Colombia River We combined these surveys to obtain spawners-per-mile information at the scale of our population units (Figures C.2.4.13- C.2.4.16). In many years over the last two decades, these surveys have observed no natural-origin coho salmon spawners. Based on the spawners-per-mile survey data, previous assessments have concluded that coho salmon in these populations are extinct or nearly so (ODFW 1995a, NMFS 2001b).

Washington populations

The Washington side of this ESU is also dominated by hatchery production, and there are no populations known to be naturally self-sustaining. A study by NRC (1996) indicated that 97% of 425 fish surveyed on the spawning grounds were first-generation hatchery fish. There are no estimates of spawner abundance for Washington Lower Columbia River coho salmon populations. However, WDFW has recently conducted some trapping of juvenile outmigrant coho (Table C.2.4.7). These data indicate that some natural production is occurring in the Lewis River and Mill-Germany-Abernathy Creeks populations, but there is no direct way to determine if these populations would be naturally self-sustaining in the absence of hatchery-origin spawners. WDFW suggests that juvenile outmigrant production seen in the monitored streams is typical of other Washington Lower Columbia River streams and that a fairly substantial number of natural-origin spawners may return to the Lower Columbia River each year. Preliminary calculations by WDFW suggest that the natural pre-harvest recruitment from the monitored streams alone may be 17,000 adults (assuming 4% marine survival) (Haymes 2003).

The area above Cowlitz Falls is also capable of natural outmigrant production (Table C.2.4.7). However, these populations are not considered currently self-sustaining (Rawding, pers. comm.). The upper Cowlitz River is blocked to anadromous passage by three dams. Currently, adult coho salmon (some of hatchery origin) are collected below the lower dam (Mayfield Dam) and trucked to the area above the upper dam (Cowlitz Falls Dam). There is no appreciable downstream passage through the dams, so juvenile outmigrants are collected at Cowlitz Falls Dam and trucked below Mayfield Dam. At this time, collection efficiency of outmigrating juveniles at Cowlitz Falls is so low (40-60%) that the spawners could not replace themselves (i.e. fewer adult coho salmon return from the relatively low number of outmigrants that are released below Mayfield Dam than are planted above Cowlitz Falls Dam). Thus, the populations are maintained by hatchery production (in addition to the trap and haul operation).

Table C.2.4.7: Estimates of natural coho salmon juvenile outmigrants from Washington Lower Columbia River streams. Estimates are based on expansions from smolt traps, not total census. Cedar Creek is a tributary of the North Fork Lewis River population. Mill, Germany and Abernathy Creeks are combined into a single population unit for BRT analysis. The Cowlitz River above Cowlitz Falls is partitioned into three independent populations (Upper Cowlitz, Cispus, and Tilton Rivers). The East Fork Lewis River estimate shows a range based on uncertainties about trap efficiency.

Out-migrant Year	Cedar Creek	Mill Creek	Abernathy Creek	Germany Creek	East Fork Lewis River	Cowlitz River above Cowlitz Falls
1997						17,490

1998	38,354					196,520
1999	27,987					88,788
2000	20,282				4,514-9,028	236,960
2001	20,695	6,324	6,991	8,157		796,948
2002	32,695	9,500	6,200	7,000		168,281

C.2.4.3 New Hatchery Information

Hatchery production

The Lower Columbia River coho salmon ESU is dominated by hatchery production. Recent coho salmon releases in the Columbia River basin (including releases upstream of the ESU boundary) are shown in Table C.2.4.8. The total expected return of hatchery coho salmon to the Columbia basin in 2002 was over a million adults (ODFW News Release, 13 September, 2002; at the time of this report, final 2002 return data are not available).

Table C.2.4.8. Total coho salmon hatchery releases into the Columbia River basin (from DART website http://www.cqs.washington.edu/dart/hatch.html made available by the Fish Passage Center).

Year	Hatchery Releases
2000	29,902,509
2001	25,730,650
2002	20,011,742

Loss of habitat from barriers

Steel and Sheer (2002) analyzed the number of stream km historically and currently available to salmon populations in the Lower Columbia River (Table C.2.4.9). Stream kilometers usable by salmon are determined based on simple gradient cut-offs and on the presence of impassable barriers. This approach overestimates the number of usable stream kilometers, as it does not take into consideration aspects of habitat quality other than gradient. However, the analysis does indicate that the number of kilometers of stream habitat currently accessible is greatly reduced from the historical condition for some populations.

Table C.2.4.9. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0.5% and 4%. The current-to-historical habitat ratio is the percent of the historical habitat that is currently available. This table does not consider habitat quality. The Upper Cowlitz, Cispus and Tilton habitats are listed in this analysis as currently inaccessible because volitional passage is not possible. However, a trap-and-haul reintroduction program for these populations has been initiated.

Population	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current/ Historical Habitat Ratio

Youngs Bay	178	195	91
Grays River	133	133	100
Big Creek	92	129	71
Elochoman River	85	116	74
Clatskanie River	159	159	100
Mill, Germany, Abernathy Creeks	117	123	96
Scappoose Creek	122	157	78
Cispus River	0	76	0
Tilton River	0	93	0
Upper Cowlitz River	4	276	1
Lower Cowlitz River	418	919	45
North Fork Toutle River	209	330	63
South Fork Toutle River	82	92	89
Coweeman River	61	71	86
Kalama River	78	83	94
North Fork Lewis River	115	525	22
East Fork Lewis River	239	315	76
Clackamas River	568	613	93
Salmon Creek	222	252	88
Sandy River	227	286	79
Washougal River	84	164	51
Lower Gorge Tributaries	34	35	99
Upper Gorge Tributaries	23	27	84
White Salmon River	0	71	0
Hood River	35	35	100
Total	3,286	5,272	62

ESU summary

Based on the updated information provided in this report, the information contained in previous Lower Columbia River status reviews, and preliminary analyses by the WLC-TRT, we have tentatively identified the number of historical and currently viable populations. Only two putative populations have demonstrated appreciable levels of natural production (Clackamas River, Sandy River). There is only very limited information on the remainder of the 21 putative populations, but most were considered extirpated, or nearly so, during the low marine survival period of the 1990s (reviewed in NMFS 2001a). Recently initiated spawner surveys by ODFW and juvenile outmigrant trapping by WDFW indicate there is some natural production in the Lower Columbia River. However, the majority of populations remain dominated by hatchery-origin spawners, and there is little data to indicate they would naturally persist in the long term. Of the two populations where natural production can be evaluated, both have experienced recruitment failure over the last decade. Recent abundances of the two populations are relatively low (especially the Sandy River), placing them in a range where environmental, demographic and genetic stochacity can be significant risk factors.

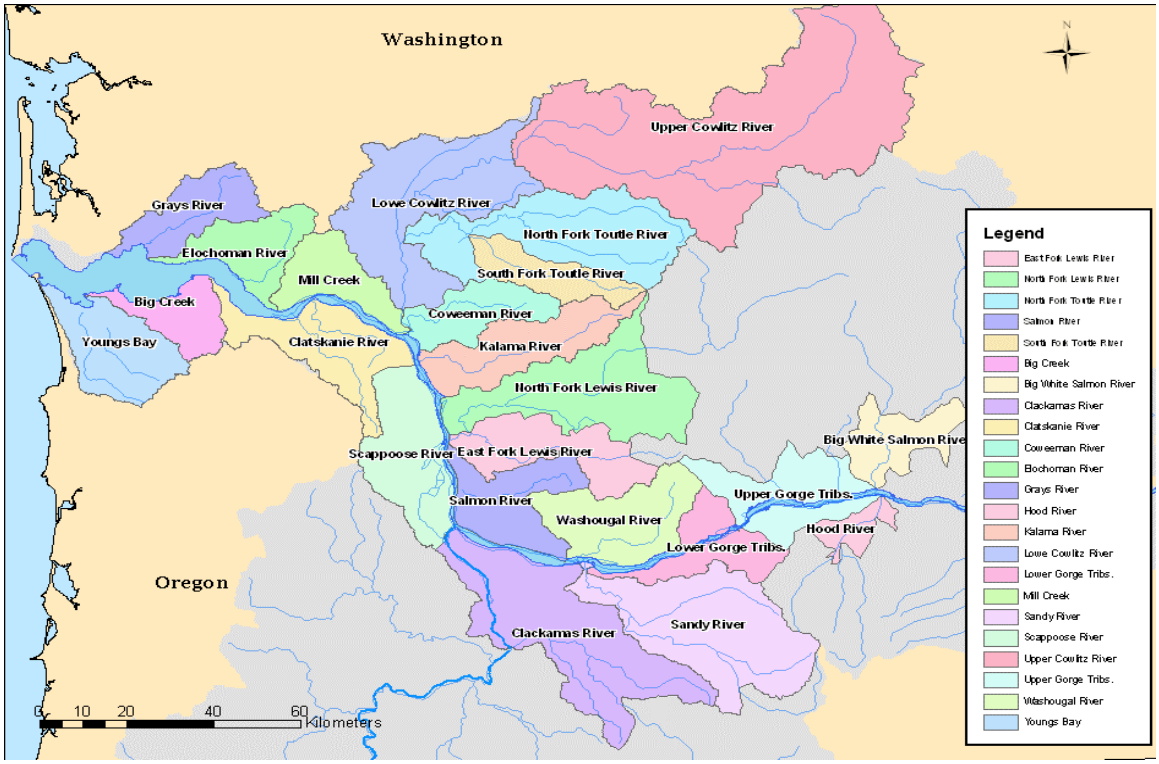


Figure C.2.4.1. Tentative historical populations of Lower Columbia River coho salmon. Based on work by WLC-TRT for chinook and steelhead (Myers et al. 2002).

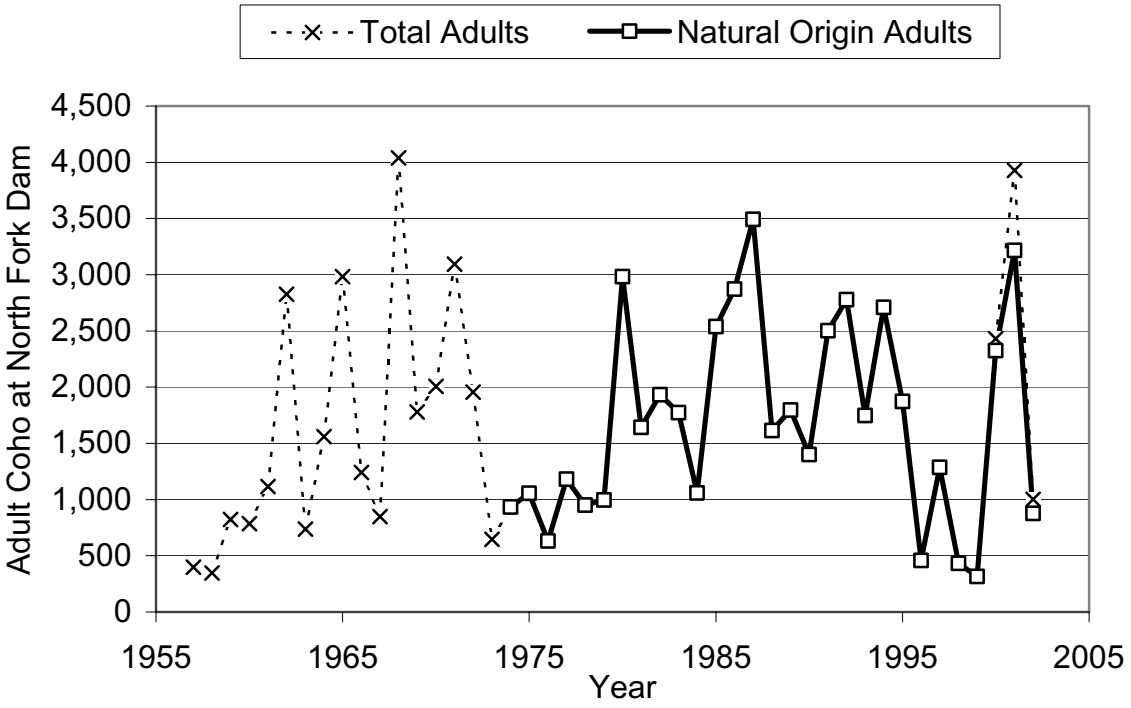


Figure C.2.4.2. Clackamas North Fork Dam counts of adult (three-year-old) coho salmon.

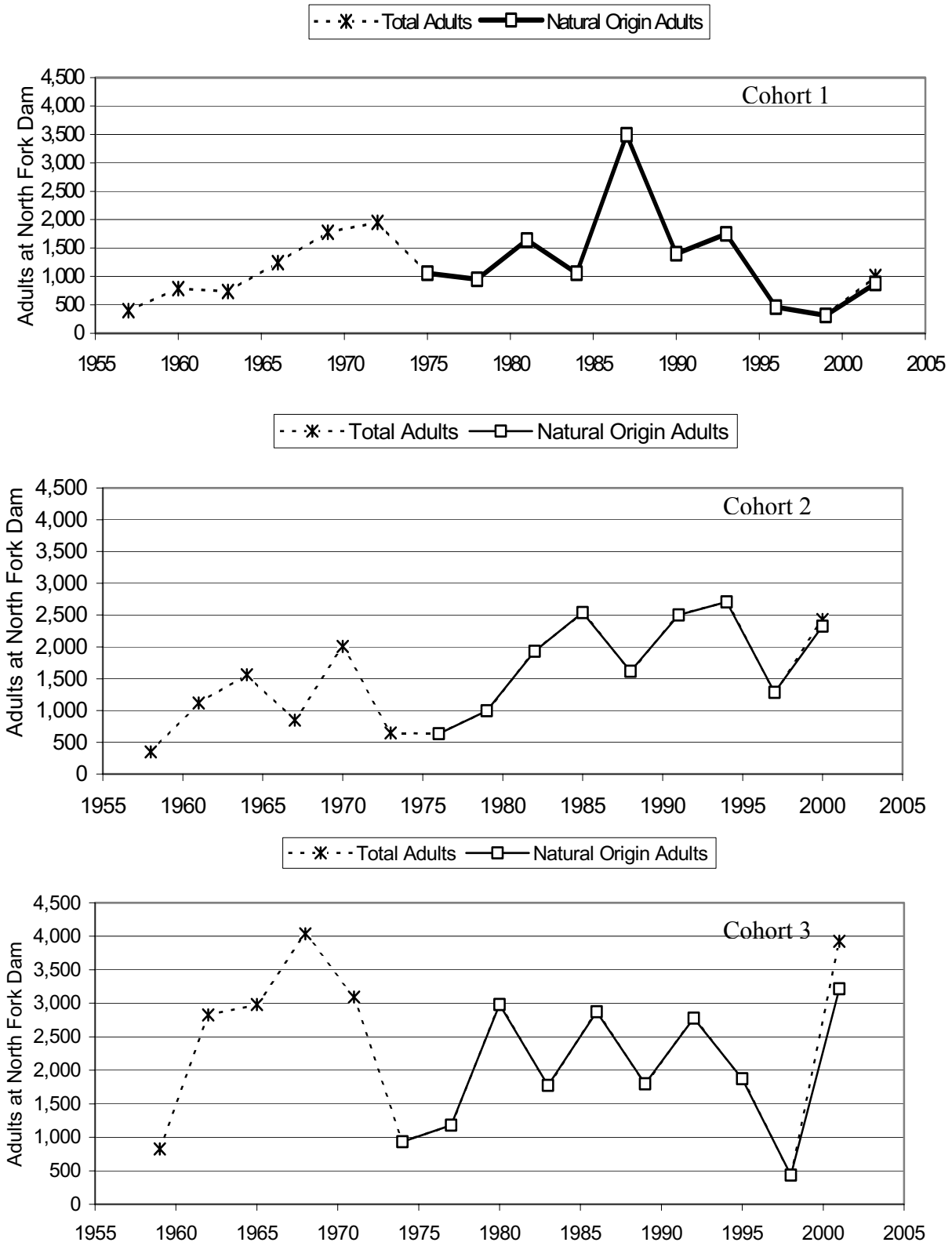


Figure C.2.4.3. Clackamas North Fork Dam counts of adult (three-year-old) coho salmon by cohort.

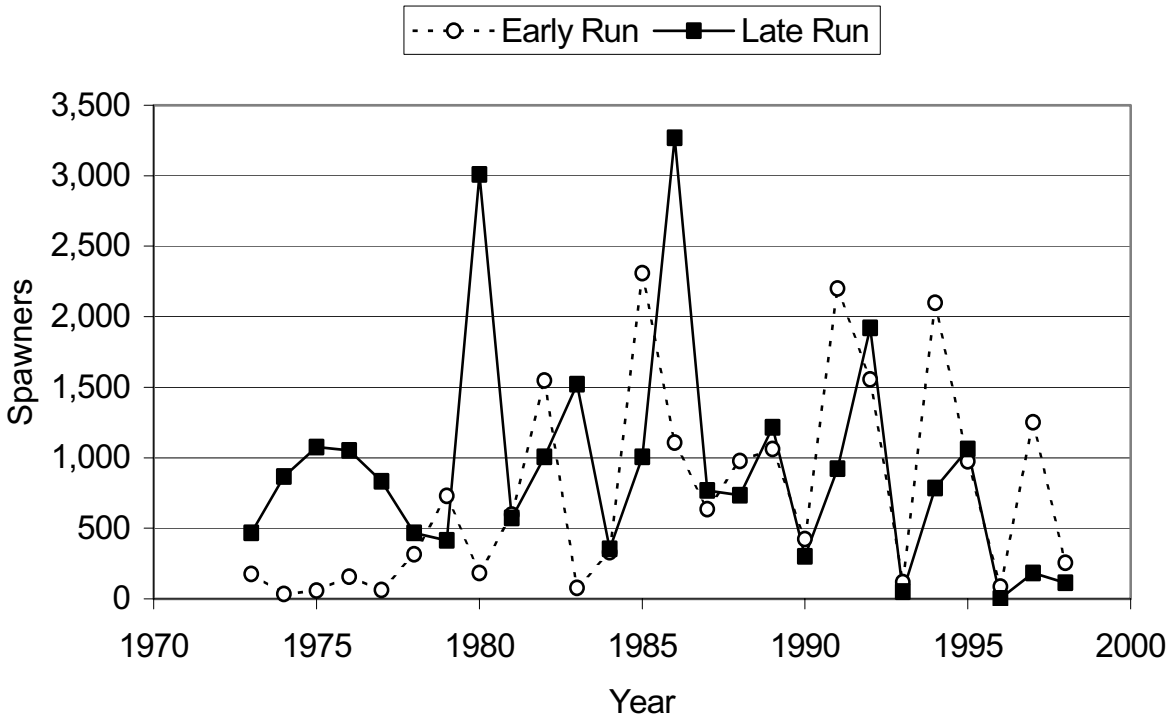


Figure C.2.4.4. Clackamas River early-run and late-run coho salmon. Run designation is based on a maximum likelihood approach assuming two populations with different mean run times (Zhou and Chilcote 2003).

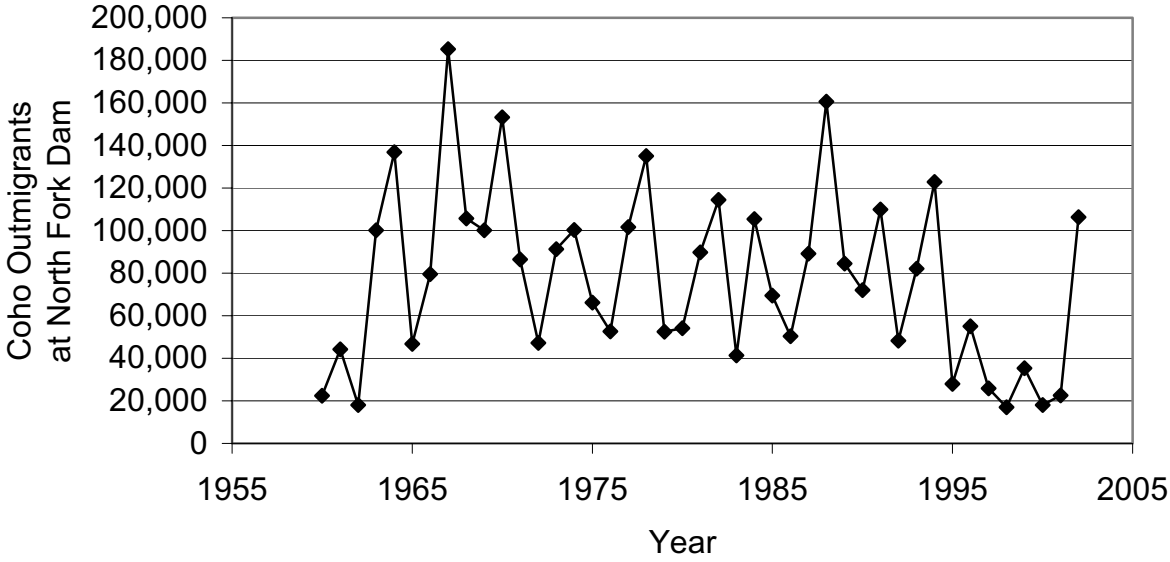


Figure C.2.4.5. Total outmigrating juvenile coho passing Clackamas North Fork Dam (Doug Cramer, pers. comm., June 5, 2003).

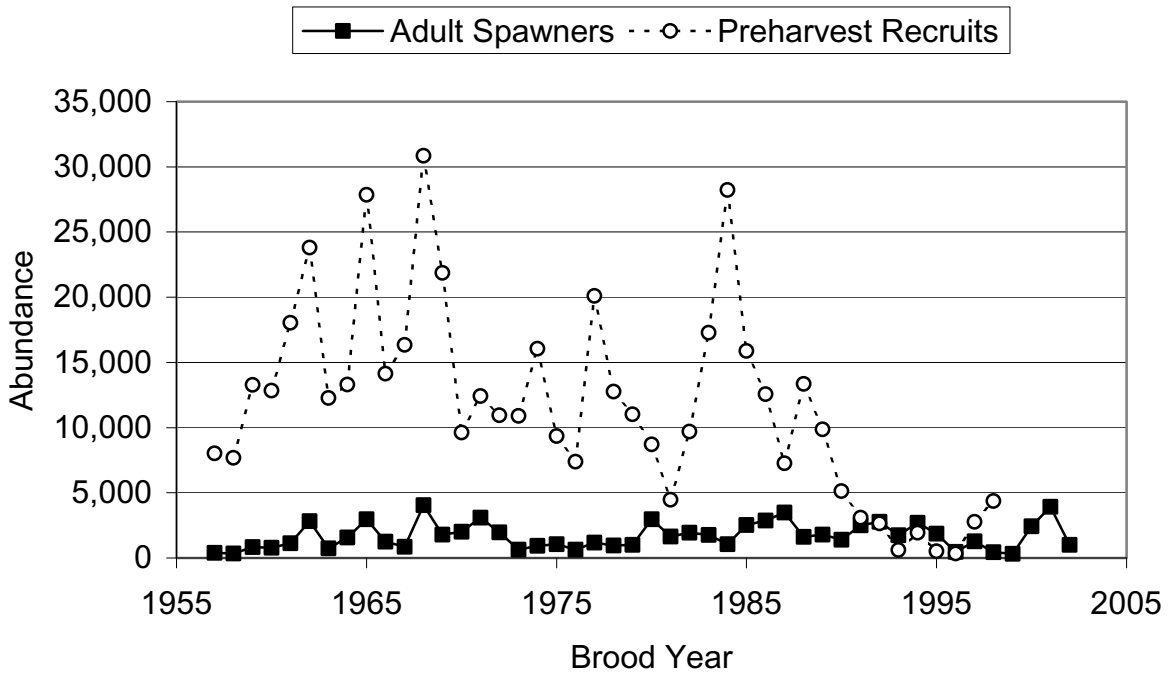


Figure C.2.4.5. Estimate of pre-harvest coho salmon recruits and spawners in the Clackamas River. Based on adult counts at North Fork Dam.

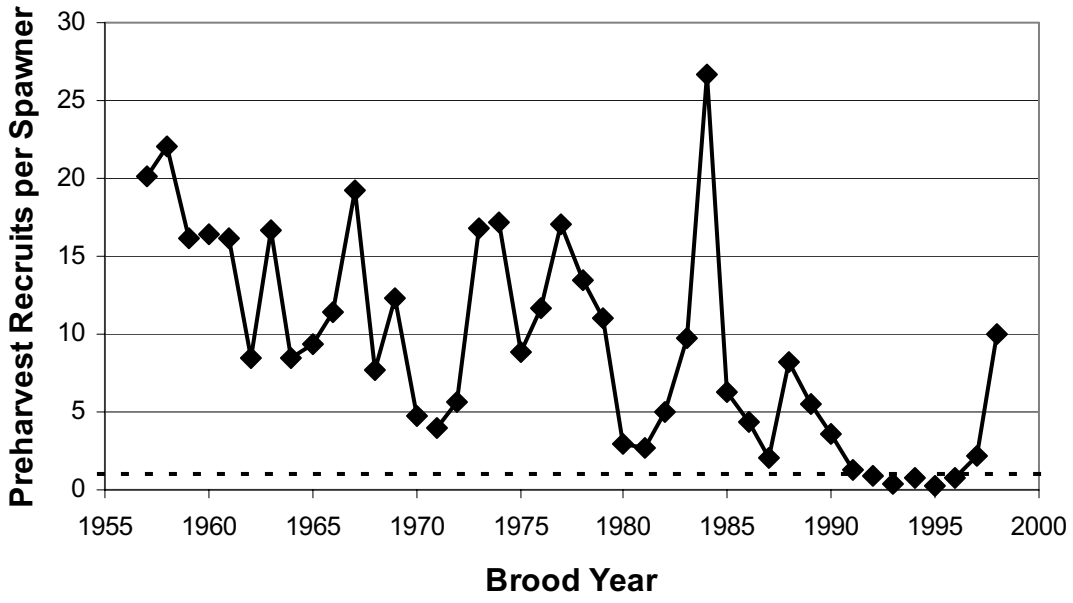


Figure C.2.4.6. Estimate of pre-harvest coho salmon recruits-per-spawner in the Clackamas River. Based on adult counts at North Fork Dam. The dashed line indicates the replacement level.

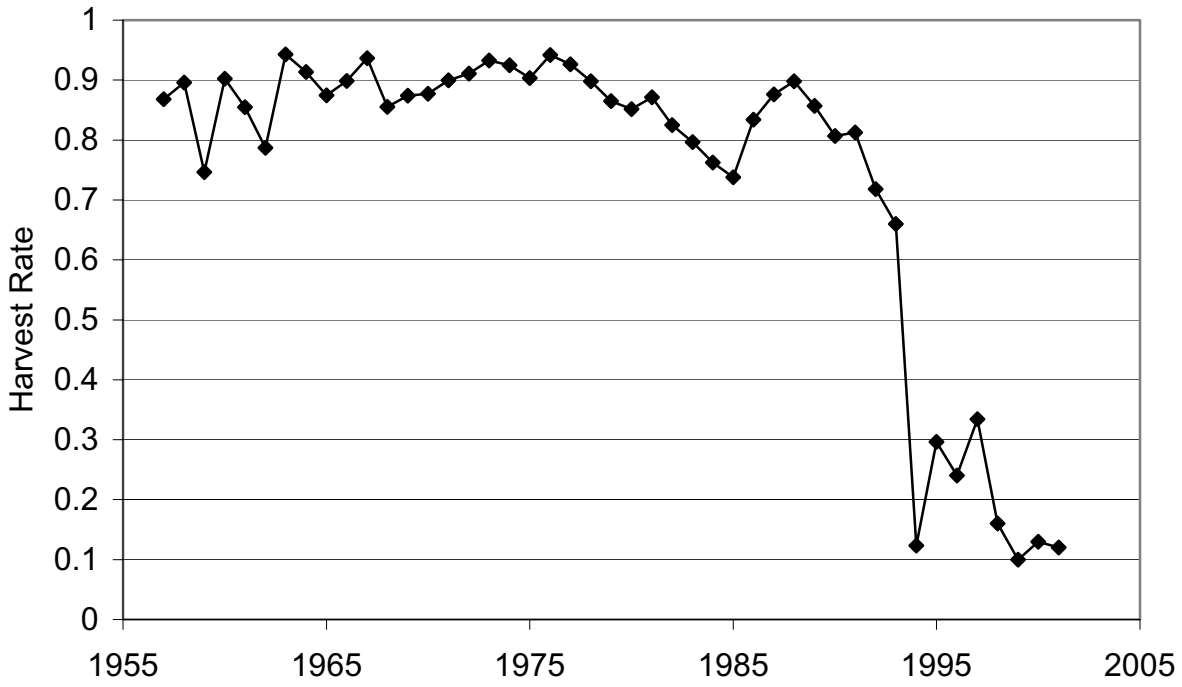


Figure C.2.4.7. Clackamas River natural-origin coho salmon harvest rate (M. Chilcote, pers. comm.). The reduction in harvest rate was achieved by a switch to retention-only marked hatchery fish and timing the fishery to protect natural runs.

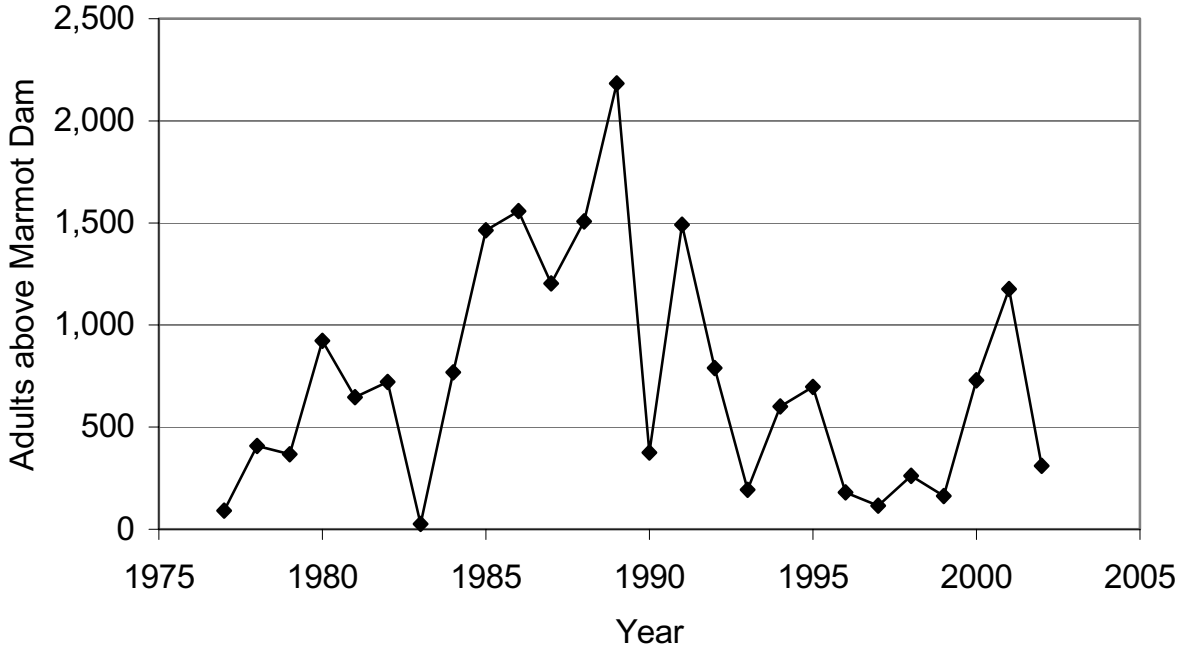


Figure C.2.4.8. Count of adult (≥3 years old) coho salmon at the Marmot Dam on the Sandy River. Almost all spawners above Marmot Dam are natural origin. For no year is the proportion of hatchery-origin spawners estimated to be greater than 2.5%.

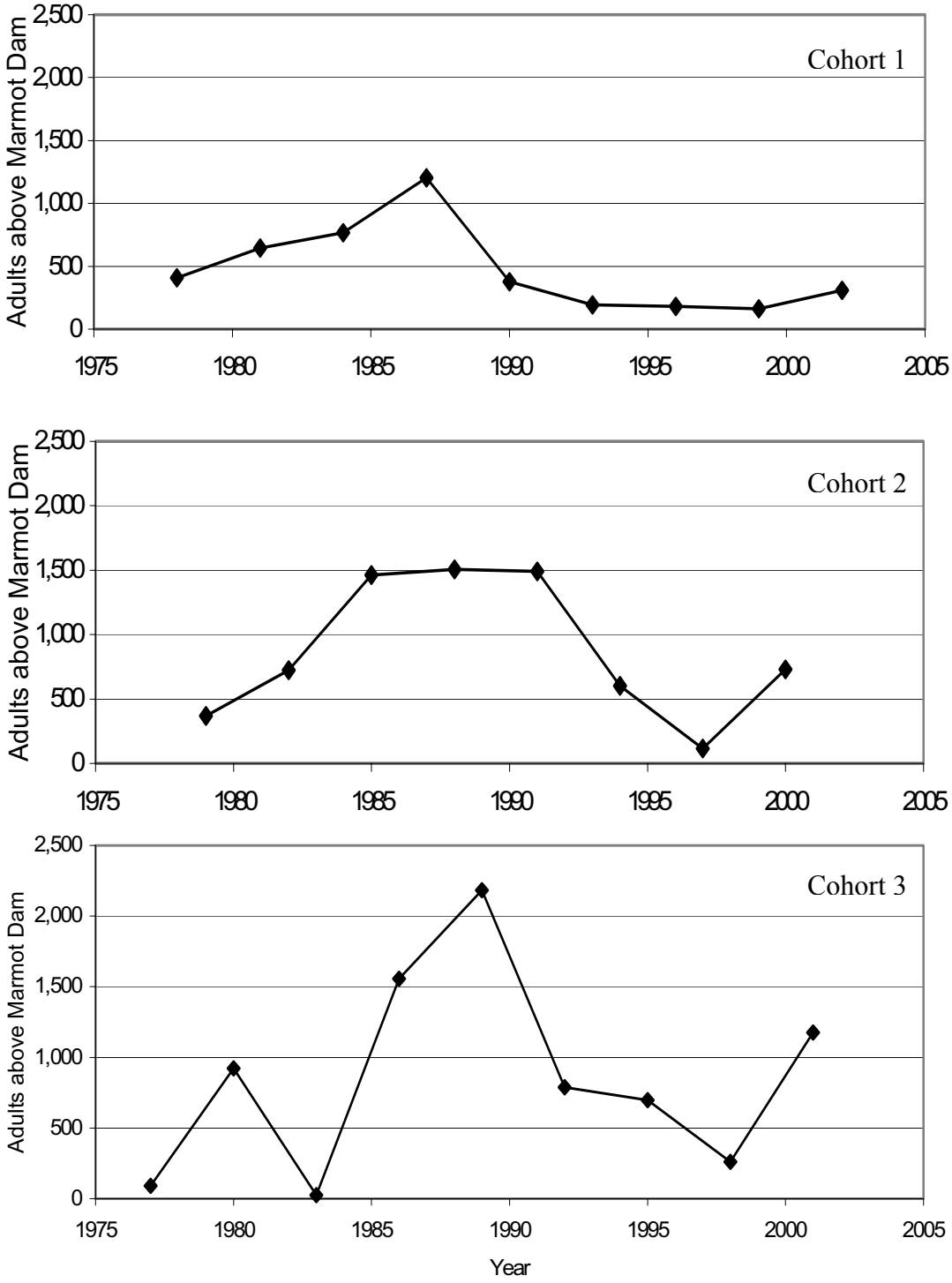


Figure C.2.4.9. Count of adult (≥3 years old) coho salmon at the Marmot Dam on the Sandy River by cohort. Almost all spawners above Marmot Dam are natural origin. For no year is the proportion of hatchery-origin spawners estimated to be greater than 2.5%.

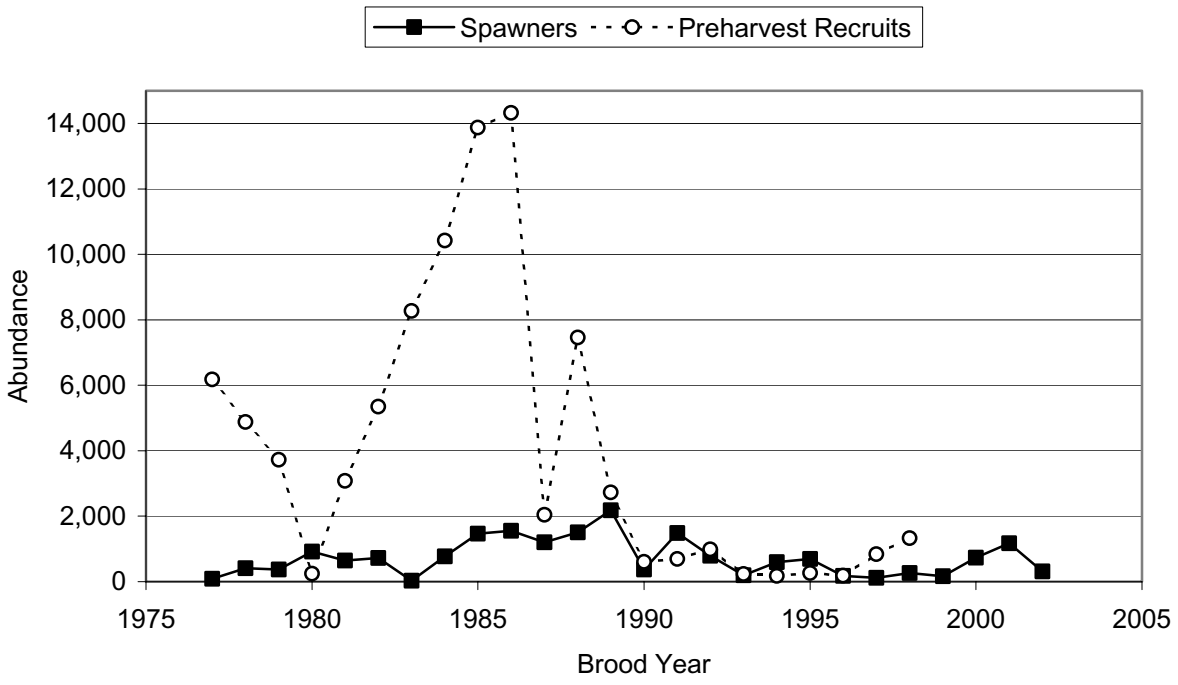


Figure C.2.4.10. Estimate of pre-harvest coho salmon recruits and spawners in the Sandy River. Based on adult counts at Marmot Dam.

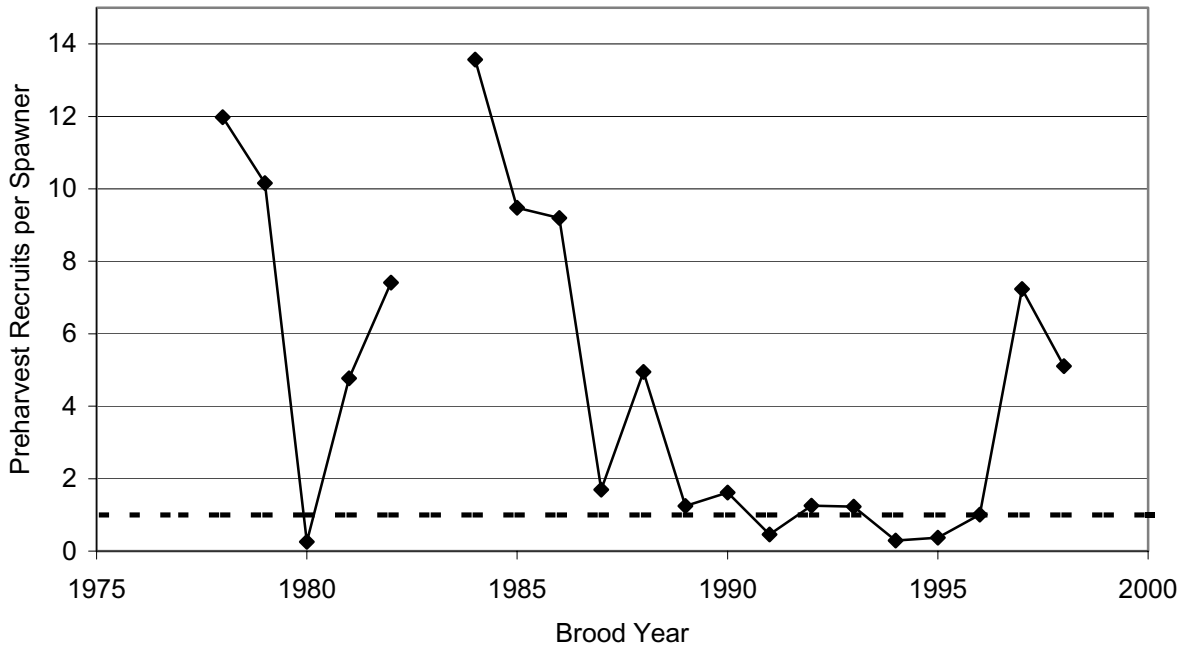


Figure C.2.4.11. Estimate of pre-harvest coho salmon recruits-per-spawners in the Sandy River. Based on adult counts at Marmot Dam. The dashed line indicates the replacement level. The 1977 brood-year pre-harvest recruits-per-spawner estimate is 68 and the 1983 brood-year estimate is 318.

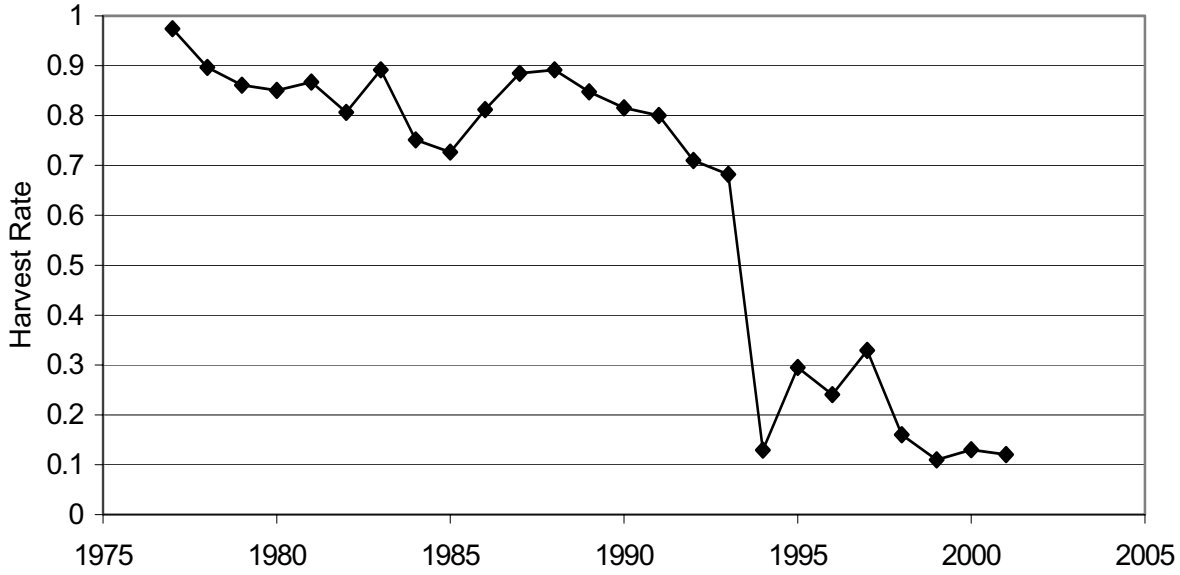


Figure C.2.4.12. Sandy River natural-origin coho salmon harvest rate (M. Chilcote, pers. comm.). The reduction in harvest rate was achieved by switch to retention only marked hatchery fish and timing the fishery to protect natural runs.

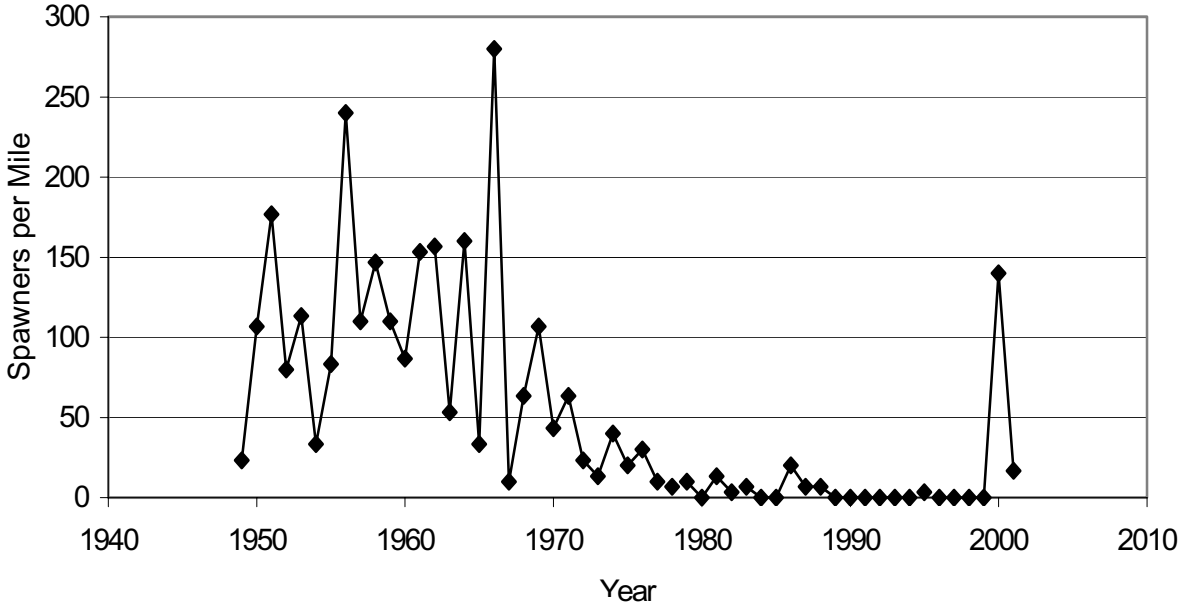


Figure C.2.4.13. Youngs Bay coho salmon spawners-per-mile.

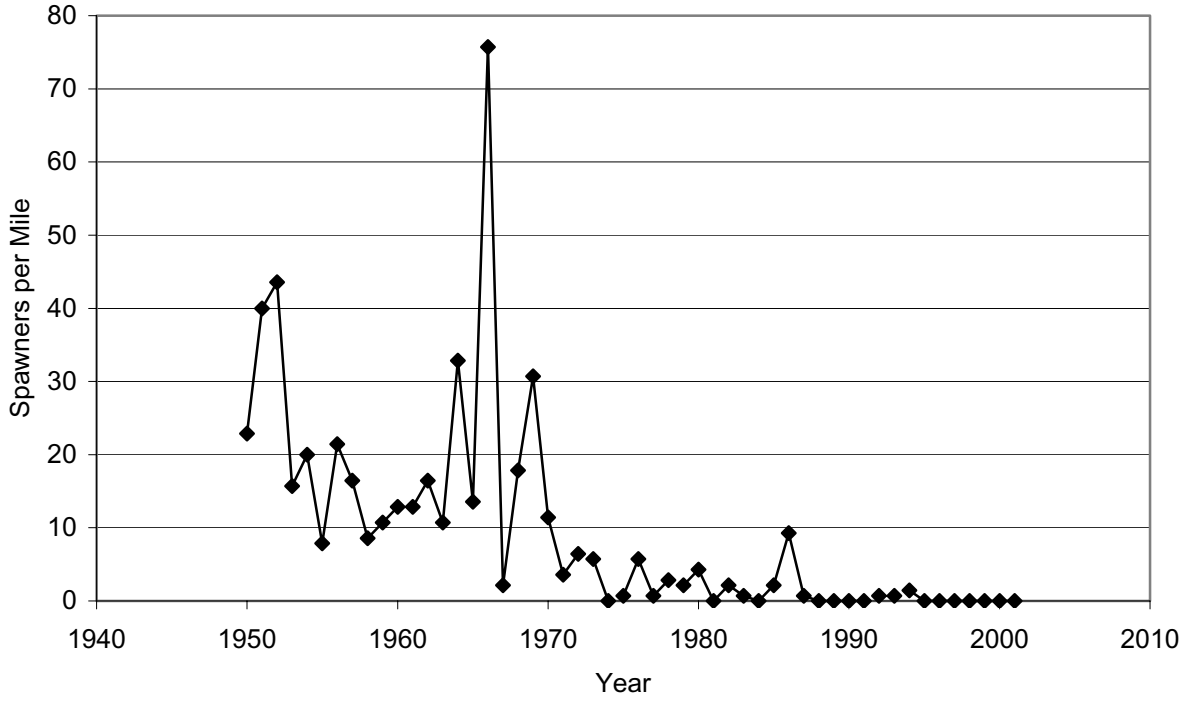


Figure C.2.4.14. Big Creek coho salmon spawners-per-mile.

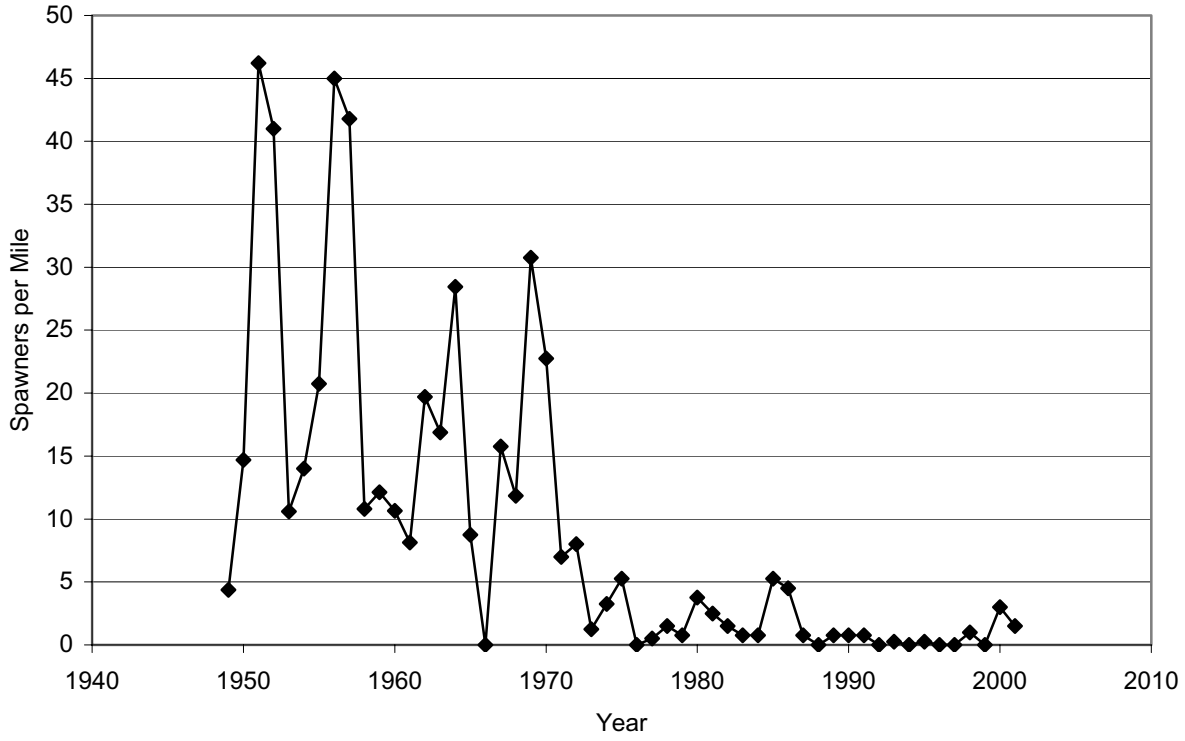


Figure C.2.4.15. Clatskanie River coho salmon spawners-per-mile.

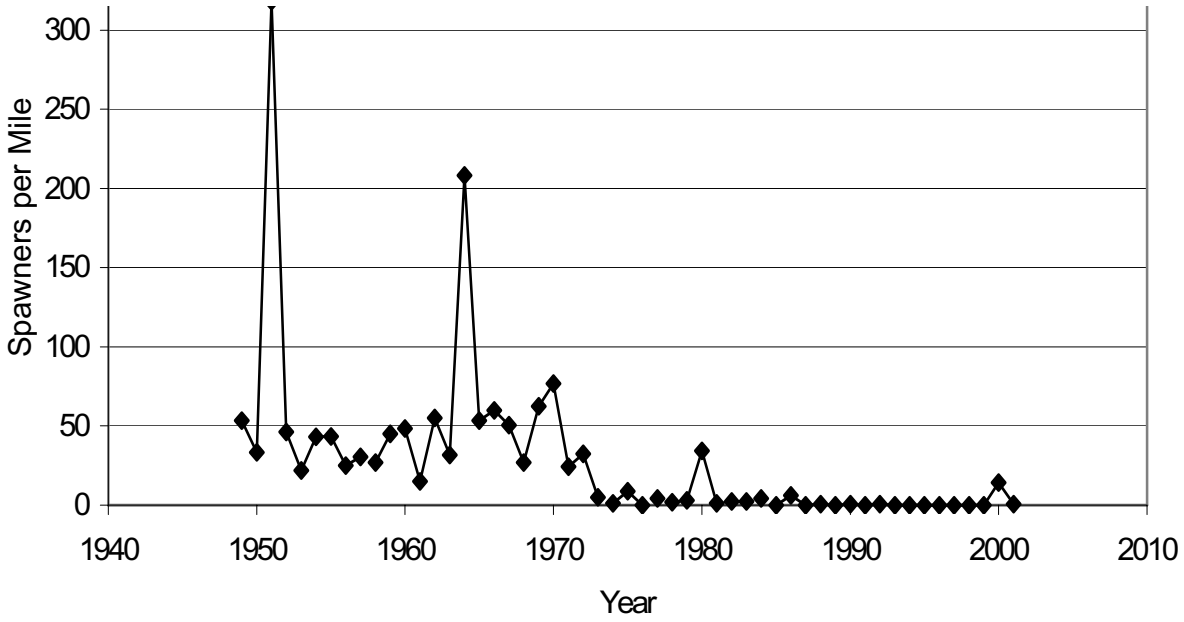


Figure C.2.4.16. Scappoose River spawners-per-mile.

C.3 COHO SALMON BRT CONCLUSIONS

Oregon Coast coho salmon ESU

This ESU continues to present challenges to those assessing extinction risk. The BRT found several positive features compared to the previous assessment in 1997. Adult spawners for the ESU in 2001 and 2002 exceeded the number observed for any year in the past several decades, and pre-harvest run size rivaled some of the high values seen in the 1970s. Some notable increases in spawners have occurred in many streams in the northern part of the ESU, which was the most depressed area at the time of the last status review evaluation. Hatchery reforms have continued, and the fraction of natural spawners that are first-generation hatchery fish has been reduced in many areas compared to highs in the early to mid 1990s.

On the other hand, the recent years of good returns were preceded by three years of low spawner escapements—the result of three consecutive years of recruitment failure, in which the natural spawners did not replace themselves the next generation, even in the absence of any directed harvest. These three years of recruitment failure, which immediately followed the last status review in 1997, are the only such instances that have been observed in the entire time series of data collected for Oregon Coast coho salmon. Whereas the recent increases in spawner escapement have resulted in long-term trends in spawners that are generally positive, the long-term trends in productivity in this ESU are still strongly negative.

The BRT votes reflected ongoing concerns for the long-term health of this ESU: a majority (56%) of the FEMAT votes were cast in the "likely to become endangered" category, with a substantial minority (44%) falling in the "not likely to become endangered" category (Table C.3.1). Although the BRT considered the significantly higher returns in recent years to be encouraging, most members felt that the factors responsible for the increases were more likely to be unusually favorable marine productivity conditions than improvements in freshwater productivity. The majority of BRT members felt that to have a high degree of confidence that the ESU is healthy, high spawner escapements should be maintained for a number of years, and the freshwater habitat should demonstrate the capability of supporting high juvenile production from years of high spawner abundance. As indicated in the risk matrix results, the BRT considered the decline in productivity to be the most serious concern for this ESU (mean score 3.2; Table C.3.2). With all directed harvest for these populations already eliminated, harvest management can no longer compensate for declining productivity by reducing harvest rates. The BRT was concerned that if the long-term decline in productivity reflects deteriorating conditions in freshwater habitat, this ESU could face very serious risks of local extinctions during the next cycle of poor ocean conditions. With the cushion provided by strong returns in the last 2-3 years, the BRT had much less concern about short-term risks associated with abundance (mean score 1.9).

A minority of the BRT felt that the large number of spawners in the last few years demonstrate that this ESU is not currently at significant risk of extinction or likely to become endangered. Furthermore, these members felt that the recent years of high escapement, following closely on the heels of the years of recruitment failure, demonstrate that populations in this ESU have the resilience to bounce back from years of depressed runs.

Southern Oregon/Northern California Coasts coho salmon ESU

A majority (67%) of BRT votes fell into the "likely to become endangered" category, while votes in the "endangered" category outnumbered those in the "not warranted" categories by 2-to-1 (Table C.3.1). The BRT found moderately high risks for abundance and growth rate/production, with mean matrix scores of 3.5 to 3.8, respectively, for these two categories. Risks to spatial structure (mean score = 3.1) and diversity (mean score = 2.8) were considered moderate by the BRT (Table C.3.2).

The BRT remained concerned about low population abundance throughout the ESU relative to historical numbers and long-term downward trends in abundance; however, the paucity of data on escapement of naturally produced spawners in most basins continued to hinder assessment of risk. A reliable time series of adult abundance is available only for the Rogue River. These data indicate that long-term (22-year) and short-term (10-year) trends in mean spawner abundance are upward in the Rogue; however, the positive trends reflect effects of reduced harvest (rather than improved freshwater conditions) since trends in pre-harvest recruits are flat. Less-reliable indices of spawner abundance in several California populations reveal no apparent trends in some populations and suggest possible continued declines in others. Additionally, the BRT considered the relatively low occupancy rates of historical coho salmon streams (between 37% and 61% from broodyear 1986 to 2000) as an indication of continued low abundance in the California portion of this ESU. The relatively strong 2001 broodyear, likely the result of favorable conditions in both freshwater and marine environments, was viewed as a positive sign, but was a single strong year following more than a decade of generally poor years.

The moderate risk matrix scores for spatial structure reflected a balancing of several factors. On the negative side was the modest percentage of historical streams still occupied by coho salmon (suggestive of local extirpations or depressed populations). The BRT also remains concerned about the possibility that losses of local populations have been masked in basins with high hatchery output, including the Trinity, Klamath, and Rogue systems. The extent to which strays from hatcheries in these systems are contributing to natural production remains uncertain; however, it is generally believed that hatchery fish and progeny of hatchery fish constitute the majority of production in the Trinity River, and may be a significant concern in parts of the Klamath and Rogue systems a well. On the positive side, extant populations can still be found in all major river basins within the ESU. Additionally, the relatively high occupancy rate of historical streams observed in broodyear 2001 suggests that much habitat remains accessible to coho salmon. The BRT's concern for the large number of hatchery fish in the Rogue, Klamath, and Trinity systems was also evident in the moderate risk rating for diversity.

Central California coho salmon ESU

A large majority (74%) of the BRT votes fell into the "endangered" category, with the remainder falling into the "likely to become endangered" category (Table C.3.1). The BRT found CCC coho salmon to be at very high risk in three of four risk categories, with mean scores of 4.8, 4.5, and 4.7 for abundance, growth rate/productivity, and spatial structure, respectively (Table C.3.2). Scores for diversity (mean 3.6) indicated BRT members considered CCC coho

salmon to be at moderate or increasing risk with respect to this risk category. Principal concerns of the BRT continue to be low abundance and long-term downward trends in abundance of coho salmon throughout the ESU, as well as extirpation or near extirpation of populations across most of the southern two-thirds of the historical range of the ESU, including several major river basins. Potential loss of genetic diversity associated with range reductions or loss of one or more brood lineages, coupled with historical influence of hatchery fish, were primary risks to diversity identified by the BRT. Improved oceanic conditions coupled with favorable stream flows apparently contributed to a strong year class in broodyear 2001, as evidenced by an increase in detected occupancy of historical streams. However, data were lacking for many river basins in the southern two-thirds of the ESU where populations are considered at greatest risk. Although viewed as a positive sign, the strong year follows more than a decade of relatively poor returns. The lack of current estimates of naturally produced spawners for any populations within the ESU—and hence the need to use primarily presence-absence information to assess risk—continues to concern the BRT.

Lower Columbia River coho salmon ESU

The status of this ESU was reviewed by the BRT in 2000, so relatively little new information was available. A majority (68%) of the likelihood votes for Lower Columbia River coho salmon fell in the "danger of extinction" category, with the remainder falling in the "likely to become endangered" category (Table C.3.1). As indicated by the risk matrix totals (Table C.3.2), the BRT had major concerns for this ESU in all VSP risk categories (mean scores ranged from 4.2 for spatial structure/connectivity and growth rate/productivity to 4.5 for diversity). The most serious overall concern was the scarcity of naturally produced spawners throughout the ESU, with attendant risks associated with small population, loss of diversity, and fragmentation and isolation of the remaining naturally produced fish. In the only two populations with significant natural production (Sandy and Clackamas), short and long-term trends are negative and productivity (as gauged by preharvest recruits) is down sharply from recent (1980s) levels. On the positive side, adult returns in 2000 and 2001 were up noticeably in some areas, and evidence for limited natural production has been found in some areas outside the Sandy and Clackamas.

The paucity of naturally produced spawners in this ESU can be contrasted with the very large number of hatchery-produced adults. Although the scale of the hatchery programs, and the great disparity in relative numbers of hatchery and wild fish, produce many genetic and ecological threats to the natural populations, collectively these hatchery populations contain a great deal of genetic resources that might be tapped to help promote restoration of more widespread naturally spawning populations.

Table C.3.1. Tally of FEMAT vote distribution regarding the status of 4 coho salmon ESUs reviewed by the coho salmon BRT. Each of 13 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Oregon Coast	0	73	57
S. Oregon / N. California Coasts	29	87	14
Central California	96	34	0
Lower Columbia River	88	42	0

Table C.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 4 coho salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Oregon Coast	1.9 (1-3)	3.2 (2-4)	2.3 (1-3)	2.5 (2-3)
S. Oregon / N. California Coasts	3.8 (2-5)	3.5 (2-5)	3.1 (2-4)	2.8 (2-4)
Central California	4.8 (4-5)	4.5 (4-5)	4.7 (4-5)	3.6 (2-5)
Lower Columbia River	4.4 (4-5)	4.2 (3-5)	4.2 (2-5)	4.5 (4-5)

C.4 REFERENCES

Anderson, K. R. 1996. CDFG memorandum dated July 1996, Hatchery planting records from 1992 for Monterey Bay Salmon and Trout Cooperative Salmonid Rearing Program. CDFG, Region 3, South District. 1 p. + attachments.

Brown, L. R. and P. B. Moyle. 1991. Status of coho salmon in California. Report to the National Marine Fisheries Service. Department of Wildlife and Fisheries Biology, University of California, Davis, CA 95616.

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14: 237-261.

Brownell, N. F., W. K. Kier, and M. L. Reber. 1999. Historical and current presence and absence of coho salmon, *Oncorhynchus kisutch*, in the Northern California portion of the Southern Oregon-Northern California Evolutionary Significant Unit. Prepared by Kier Associates for the National Marine Fisheries Service, Southwest Fisheries Science Center pursuant to Service Order 40-ABNF-7-01479. 43 p. + appendices.

Bryant, G. J. 1994. Status review of coho salmon in Scott Creek and Waddell Creek, Santa Cruz County, California. Natl. Mar. Fish. Serv., SW Region, Protected Species Management Division, 102 p. (Available from NMFS, Southwest Region, 501 W. Ocean Blvd., Suite 4200, Long Beach, CA 90802.)

Cartwright, W. F. 1994. Annual report: Warm Springs Salmon and Steelhead Hatchery, 1992-1993. Region 3, Inland Fisheries Administrative Report No. 94-5. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 1996. Annual report: Mad River Salmon and Steelhead Hatchery, 1995-1996. Region 1, Inland Fisheries Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 1997. Annual report: Mad River Salmon and Steelhead Hatchery, 1996-1997. Region 1, Inland Fisheries Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 1998. Annual report: Mad River Salmon and Steelhead Hatchery, 1998-1999. Region 1, Inland Fisheries Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 1999. Annual report: Mad River Salmon and Steelhead Hatchery, 1998-1999. North Coast, Northern California Region, Land and Facilities Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 2000. Annual report: Mad River Salmon and Steelhead Hatchery, 1999-2000. North Coast, Northern California Region, Land and Facilities Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Cartwright, W. F. 2001. Annual report: Mad River Salmon and Steelhead Hatchery, 2000-2001. North Coast, Northern California Region, Land and Facilities Administrative Report No. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan, Volume III: Supporting data, Part B: Inventory, salmon-steelhead marine resources. 679 p.

CDFG (California Department of Fish and Game). 1994. Petition to the California Board of Forestry to list coho salmon (*Oncorhynchus kisutch*) as a sensitive species. Prepared by the California Department of Fish and Game. Sacramento, CA. 110 p.

CDFG (California Department of Fish and Game). 2000. Annual report: Warm Springs Salmon and Steelhead Hatchery, 1999-2000. Central Coast Region, Wildlife and Inland Fisheries Division Administrative Report. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California.

CDFG (California Department of Fish and Game) and NMFS (National Marine Fisheries Service) Southwest Region Joint Hatchery Review Committee. 2001. Final report on anadromous salmonid fish hatcheries in California. Review draft. June 27, 2001. 34 p. + appendices.

CDFG (California Department of Fish and Game). 2002. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission. Candidate Species Status Review Report 2002-3. 232 p. + appendices.

CDFG (California Department of Fish and Game). 2003. March 20, 2003 letter from Robert C. Hight to Dr. Michael F. Tillman, containing review of February 2003 draft of "Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead." 28 p.

Chilcote, M. (In press). The adverse reproductive consequences of supplementing natural steelhead populations in Oregon with hatchery fish. *Trans. Amer. Fish Soc.*

Cramer, S. P., and N. K. Ackerman. 2002. Viability of coho salmon populations on the Oregon and Northern California coasts. S. P. Cramer and Associates, Gresham, Oregon. 79 p.

Crone, R. A., and C. E. Bond. 1976. Life history of coho salmon, *Oncorhynchus kisutch*, in Sashin Creek, southeastern Alaska. Fish. Bull., U.S., 74(4):897-923.

Einum, S. and I. A. Fleming. 2001. Implications of stocking: ecological interactions between wild and released salmonids. Nordic J. Freshwat. Res. 75: 56-70.

Ellis, R. H. 1997. Comments to the National Marine Fisheries Service regarding the proposed listing of coho salmon as threatened in the Southern Oregon/Northern California ESU. Submitted on behalf of: California Forestry Association and California Forest Research Council, Sacramento, CA. 41 p.

Flagg, T. A. and Nash, C. E. 1999. A conceptual framework for conservation hatchery strategies for Pacific salmonids. U.S. Dept. of Commer. NOAA Tech. Memo. NMFS-NWFSC-38.

Flagg, T. A., B. A. Berejikian, J. E. Colt, W. W. Dickhoff, L. W. Harrell, D. J Maynard, C. E. Nash, M. S. Strom, R. N. Iwamoto, and C. V. W. Mahnken. 2000. Ecological and behavioral impacts of artificial production strategies on the abundance of wild salmon populations. U.S. Department of Commer., NOAA Tech. Memo. NMFS-NWFSC-41.

Flitcroft, R., K. Jones, K. Reis, and B. Thom. 2001. Oregon Plan for Salmon and Watersheds, Monitoring Report No. OPSW-ODFW-2001-5. Oregon Dept. Fish and Wildlife, Portland, Oregon. 41 pp.

Fulop, J., J. Whisler, and B. Morgan. 1998. 1995 and 1996 Oregon lower Columbia River coho spawning ground surveys and 1996 and 1997 coho juvenile survey results. ODFW.

Gallagher, K. I. 1993. Annual report: Mad River Salmon and Steelhead Hatchery, 1992-1993. Region 1, Inland Fisheries Administrative Report No. ??. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Gallagher, K. I. 1994. Annual report: Mad River Salmon and Steelhead Hatchery, 1991-1992. Region 1, Inland Fisheries Administrative Report No. 94-3. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Gallagher, K. I. 1994. Annual report: Mad River Salmon and Steelhead Hatchery, 1993-1994. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Gallagher, K. I. 1995. Annual report: Mad River Salmon and Steelhead Hatchery, 1994-1995. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Gilbert, C. H. 1912. Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus.* Fish Bull., U.S. 32:3-22.

Godfrey, H., K. A. Henry, and S. Machidori. 1975. Distribution and abundance of coho salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 31, 80 p.

Grass, A. 1992. Annual report: Noyo River Egg Collecting Station, 1992-1993. Region 3, Inland Fisheries Administrative Report No. 92-14. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California.

Grass, A. 1993. Annual report: Noyo River Egg Collecting Station, 1992-1993. Region 3, Inland Fisheries Administrative Report No. 93-4. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 1995. Annual report: Noyo River Egg Collecting Station, 1994-1995. Region 3, Inland Fisheries Division, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 1995. Annual report: Noyo River Egg Collecting Station, 1993-1994. Region 3, Inland Fisheries Administrative Report No. 95-4. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 1996. Annual report: Noyo River Egg Collecting Station, 1995-1996. Region 3, Inland Fisheries Division, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 1997. Annual report: Noyo River Egg Collecting Station, 1996-1997. Region 3, Inland Fisheries Division, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 1998. Annual report: Noyo River Egg Collecting Station, 1997-1998. Region 3, Inland Fisheries Division, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California. (Draft).

Grass, A. 2000. Annual report: Noyo River Egg Collecting Station, 1999-2000. Central Coast Region, Habitat and Native Fish Division, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California.

Grass, A. 2001. Annual report: Noyo River Egg Collecting Station, 2000-2001. Central Coast Region, Lands and Facilities Branch, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California.

Grass, A. 2002. Annual report: Noyo River Egg Collecting Station, 2001-2002. Central Coast Region, Lands and Facilities Branch, Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California.

Haymes, J. 2003. Draft WDFW response to NMFS coho status review update 03-21-2003.

Higgins, P., S. Dobush, and D. Fuller. 1992. Factors in Northern California threatening stocks with extinction. Humboldt Chapter of the American Fisheries Society. Arcata, CA. 26 p.

Hiser, C. A. 1993. Annual report: Iron Gate Salmon and Steelhead Hatchery, 1991-1992. Region 1, Inland Fisheries Administrative Report No. 93-2. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Hiser, C. A. 1994. Annual report: Iron Gate Salmon and Steelhead Hatchery, 1992-1993. Region 1, Inland Fisheries Administrative Report No. 94-8. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Hiser, C. A. 1995. Annual report: Iron Gate Salmon and Steelhead Hatchery, 1993-1994. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Hiser, C. A. 1996. Annual report: Iron Gate Salmon and Steelhead Hatchery, 1994-1995. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Hoopa Valley Tribe. 2003. March 20, 2003 letter from Mike Orcutt to Dr. Michael F. Tillman, containing review of February 2003 draft of "Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead." 2 p.

Howard, C. F. 1998. Fall salmonid spawning escapement estimates for Rock creek and Mill creek: fourth interim report (1993/94 – 1997/98). Prepared for Stimson Lumber Company, Miller Redwood Division, Crescent City, CA. 5 p.

IMST (Independent Multi-disciplinary Science Team). 1999. Defining and Evaluating Recovery of OCN Coho Salmon Stocks: Implications for rebuilding stocks under the Oregon Plan for Salmon and Watersheds. Technical Report 1999-2 to the Oregon Plan for Salmon and Watersheds. Governor's Natural Resources Office. Salem, Oregon

IMST (Independent Multi-disciplinary Science Team). 2000. Conservation Hatcheries and Supplementation Strategies for Recovery of Wild Stocks of Salmonids: Report of a Workshop. Technical Report 2000-1 to the Oregon Plan for Salmon and Watersheds. Oregon Watershed Enhancement Board. Salem, Oregon.

IMST (Independent Multi-disciplinary Science Team). 2001. The Scientific Basis for artificial propagation in the recovery of wild anadromous salmonids in Oregon. Technical Report 2000-1 to the Oregon Plan for Salmon and Watersheds. Governor's Natural Resources Office, Salem, Oregon.

IMST (Independent Multi-disciplinary Science Team). 2002a. Recovery of Wild Salmonids in Western Oregon Lowlands. Technical Report 2002-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, Oregon.

IMST (Independent Multi-disciplinary Science Team). 2002b. Charter and Operating Procedures. Revised September 26, 2002. http:www.fsl.orst.edu/imst/index.htm.

ISG (Independent Scientific Group). 2000. Return to the river: and ecological vision for the recovery of Columbia River salmon. Prepared for the Northwest Power Planning Council. Portland, Oregon.

Jacobs, S., J. Firman, G. Susac, E. Brown, B. Riggers, and K. Tempel. 2000. Status of Oregon coastal stocks of anadromous salmonids. Monitoring Program Report No. OPSW-ODFW-2000-3, Oregon Department of Fish and Wildlife, Portland, OR.

Jacobs, S., J. Firman and G. Susac. 2001. Status of the Oregon coastal stocks of anadromous salmonids, 1999-2000; Monitoring Program Report Number OPSW-ODFW-2001-3, Oregon Department of Fish and Wildlife, Portland.

Jacobs, S., J. Firman, G. Susac, D. Stewart, and J. Weybright. 2002. Status of coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002. Oregon Plan for Salmon and Watersheds, Monitoring Report No. OPSW-ODFW-2002-3. Oregon Dept. Fish and Wildlife, Portland, Oregon. 93 pp.

Johnson, O. W., T. A. Flagg, D. J. Maynard, G. B. Milner, and F. W. Waknitz. 1991. Status review for lower Columbia River coho salmon. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-202, 94 p.

Laufle, J. C., G. B. Pauley, and M. F. Shepard. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest): coho salmon. U.S. Fish and Wildl. Serv. Biol. Rep. 82(11.48), 18 p.

Lawson, P. W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries (Bethesda) 18(8):6-10.

Lewis, M. A. 2002. Stock assessment of anadromous salmonids, 2001. Oregon Plan for Salmon and Watersheds, Monitoring Report No. OPSW-ODFW-2002-4. Oregon Dept. Fish and Wildlife, Portland, Oregon. 57 pp.

MBSTP (Monterey Bay Salmon and Trout Project). 1996. Final report: Cooperative Fish Rearing Program. Prepared by Dave Streig, Monterey Bay Salmon and Trout Program, 825 Big Creek Road, Davenport, CA, 95017. 5 p.

MBSTP (Monterey Bay Salmon and Trout Project). 1995. Annual report: Cooperative Fish Rearing Program. Prepared by Dave Streig, Monterey Bay Salmon and Trout Program, 825 Big Creek Road, Davenport, CA, 95017. 4 p.

MBSTP (Monterey Bay Salmon and Trout Project). 1994. Annual report: Cooperative Fish Rearing Program. Prepared by Dave Streig, Monterey Bay Salmon and Trout Program, 825 Big Creek Road, Davenport, CA, 95017. 7 p.

MBSTP (Monterey Bay Salmon and Trout Project). 1993. Annual report: Cooperative Fish Rearing Program. Prepared by Dave Streig, Monterey Bay Salmon and Trout Program, 825 Big Creek Road, Davenport, CA, 95017. 6 p.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

Morgan, B., J. Whisler, and J. Fulop. 1998. 1997 Oregon Lower Columbia River Coho Spawning Ground Surveys and 1998 Coho Juvenile Survey Results. ODFW.

Myers, J. M., C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2): 4-21.

Nickelson T. and P. Lawson. 1998. Population viability of coho salmon *Oncorhynchus kisutch* in Oregon coastal basins: Application of a habitat-based life cycle model. Can. J. Fish. Aquat. Sci. 55: 2383-2392.

Nickelson, T. 2001. Population Assessment: Oregon coast coho salmon ESU. Oregon Department of Fish and Wildlife, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1996a. Supplemental report of the Biological Review Team on central California coast coho salmon. Memorandum from M. Schiewe to W. Stelle, dated 17 October, 1996, 4 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Portland, OR 97232.)

NMFS (National Marine Fisheries Service). 1996b. Status review update for coho salmon from Washington, Oregon, and California. Draft document prepared by the West Coast Coho salmon Biological Review Team, 20 December 1996, 47 p. plus tables, figures and appendices.

NMFS (National Marine Fisheries Service). 1997. Status review update for coho salmon from the Oregon and Northern California coasts. West Coast coho salmon Biological Review Team, 28 Mar. 1997. 70 p. + appendices.

NMFS (National Marine Fisheries Service). 1998. Factors contributing to the decline of chinook salmon: an addendum to the 1996 West Coast steelhead factors for decline report. Protected Resource Division, National Marine Fisheries Service, Portland, OR. 70 p.

NMFS (National Marine Fisheries Service). 2001a. Status review update for Lower Columbia River Coho Salmon. West Coast coho salmon Biological Review Team, May 2001. 67 p.

NMFS (National Marine Fisheries Service). 2001b. Status review update for coho salmon (*Oncorhynchus kisutch*) from the Central California Coast and the California portion of the Southern-Oregon/Northern California Coasts Evolutionarily Significant Units. Prepared by the Southwest Fisheries Science Center, Santa Cruz Laboratory.

NRC (National Research Council). 1996. Upstream: Salmon and society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy of Science, Washington, D.C.

NWPPC (Northwest Power Planning Council). 1999. Ocean Conditions and the management of Columbia River salmon: Proceedings of a symposium, July 1, 1999, Portland, Oregon.

OCSRI (Oregon Coastal Salmon Restoration Initiative) Science Team. 1996. Recommendations related to population status. Draft Report Dated 8/21/96. 11p. (Available from Oregon Department of Fish and Wildlife, P.O. Box 59, Portland, Oregon 97207).

ODFW (Oregon Department of Fish and Wildlife). 1995. Oregon coho salmon biological status assessment and staff conclusions for listing under the Oregon Endangered Species Act. Oregon Department of Fish and Wildlife, Portland, Oregon February 22, 1995. 59 p.

ODFW (Oregon Department of Fish and Wildlife). 1995a. Oregon coho salmon biological status assessment and staff conclusions for listing under the Oregon Endangered Species Act. Oregon Department of Fish and Wildlife, Portland, Oregon February 22, 1995. 59 p. (Attachment to II-B-I to the Draft OCSRI Plan dated 8/20/96.

ODFW (Oregon Department of Fish and Wildlife). 1995b. 1995 Biennial Report on the status of wild fish in Oregon. Portland, Oregon.

O'Hanlon, D. 2002a. April 12 letter from Daniel O'Hanlon to the Assistant Regional Administrator, Protected Resources Division, National Marine Fisheries Service, Portland, OR re: Comments Regarding Findings on Petitions to Delist Coho Salmon in the Southern Oregon/Northern California Coast ESU (67 Federal Register 6215, February 11, 2002).

O'Hanlon, D. 2002b. July 24 letter from Daniel O'Hanlon to the Assistant Regional Administrator, Protected Resources Division, National Marine Fisheries Service, Portland, OR re: Findings on Petition to Delist Coho Salmon in the Klamath River Basin; Reopening of Public Comment Period (67 Federal Register 40679, June 13, 2002).

Ollerenshaw, E. 2002. 2000 Oregon Lower Columbia River Coho Spawning Ground Surveys and 2001 Juvenile Survey Results. ODFW.

Oregon Plan. 1997. Oregon Plan for Salmon and Watersheds (consisting of the Oregon Coastal Salmon Restoration Initiative, March 10, 1997 and as amended with the steelhead Supplement, December 1997). Governor's Natural Resources Office, State of Oregon, Salem.

Oregon Trout, Native Fish Society, Oregon Council of Trout Unlimited. 2000. Petition to list lower Columbia River coho salmon (*Oncorhynchus kisutch*) as endangered pursuant to the Endangered Species Act of 1973 as amended. Petition to Secretary of Commerce, Washington D.C., July 2000, 22 p.

PFMC (Pacific Fishery Management Council). 1997. Preseason report III. Analysis of Council adopted management measures for 1997 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon 97201.

PFMC (Pacific Fishery Management Council). 1998. Preseason report III. Analysis of Council adopted management measures for 1998 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland Oregon 97201.

PFMC (Pacific Fishery Management Council). 1999. Preseason report III. Analysis of Council adopted management measures for 1999 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland Oregon 97201.

PFMC (Pacific Fishery Management Council). 2000. Preseason report III. Analysis of Council adopted management measures for 2000 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland Oregon 97201.

PFMC (Pacific Fishery Management Council). 2001. Preseason report III. Analysis of Council adopted management measures for 2001 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland Oregon 97201.

PFMC (Pacific Fishery Management Council). 2002a. Preseason report III. Analysis of Council adopted management measures for 2002 ocean salmon fisheries. Prepared by the Salmon Technical Team and Staff Economist, Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland Oregon 97201.

PFMC (Pacific Fishery Management Council). 2002b. Review of 2001 ocean salmon fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7790 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384.

PFMC (Pacific Fishery Management Council). 2003. Preseason report III. Analysis of Council adopted management measures for 2003 ocean salmon fisheries. Prepared by the Salmon Technical Team and Council Staff, Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland Oregon 97220.

Pritchard, A. L. 1940. Studies on the age of the coho salmon (*Oncorhynchus kisutch*) and the spring salmon (*Oncorhynchus tschawytscha*) in British Columbia. Trans. R. Soc. Can., Serv. 3, 34(V):99-120.

Quinones, A. R. 1994? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1993-1994. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Quinones, A. R. 1995? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1994-1995. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Quinones, A. R. 1996? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1995-1996. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Quinones, A. R. 1997? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1996-1997. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Quinones, A. R. 1998? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1997-1998. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Quinones, A. R. 1999? Annual report: Warm Springs Salmon and Steelhead Hatchery, 1998-1999. Central Coast Region, Wildlife and Inland Fisheries Division Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Ramsden, G. R. 1993. Annual report: Trinity River Salmon and Steelhead Hatchery, 1991-1992. Region 1, Inland Fisheries Administrative Report No. 93-3. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

Ramsden, G. R. 1994. Annual report: Trinity River Salmon and Steelhead Hatchery, 1992-1993. Region 1, Inland Fisheries Administrative Report No. 94-4. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

Ramsden, G. R. 1995. Annual report: Trinity River Salmon and Steelhead Hatchery, 1993-1994. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

Ramsden, G. R. 1996. Annual report: Trinity River Salmon and Steelhead Hatchery, 1994-1995. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

Ramsden, G. R. 1997?. Annual report: Trinity River Salmon and Steelhead Hatchery, 1995-1996. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Ramsden, G. R. 1998?. Annual report: Trinity River Salmon and Steelhead Hatchery, 1996-1997. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Ramsden, G. R. 1999?. Annual report: Trinity River Salmon and Steelhead Hatchery, 1997-1998. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Ramsden, G. R. 2001?. Annual report: Trinity River Salmon and Steelhead Hatchery, 1999-2000. Fisheries Programs Branch, North Coast, Northern California Region, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Ramsden, G. R. 2002. Annual report: Trinity River Salmon and Steelhead Hatchery, 2000-2001. Fisheries Programs Branch, North Coast, Northern California Region, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Reeves, G. H., F. H. Everest, and T. E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. U.S. Dep. Agric. Forest Serv., Pac. Northwest. Res. Stn., Portland, Oregon, 18 p.

Rodgers, J. D. 2002. Abundance monitoring of juvenile salmonids in Oregon coastal streams, 2001. Oregon Plan for Salmon and Watersheds, Monitoring Report No. OPSW-ODFW-2002-1. Oregon Dept. Fish and Wildlife, Portland, Oregon. 51 pp.

Rushton, K. W. 1997? Annual report: Iron Gate Salmon and Steelhead Hatchery, 1995-1996. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Rushton, K. W. 1998? Annual report: Iron Gate Salmon and Steelhead Hatchery, 1996-1997. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Rushton, K. W. 1999? Annual report: Iron Gate Salmon and Steelhead Hatchery, 1997-1998. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Rushton, K. W. 2000? Annual report: Iron Gate Salmon and Steelhead Hatchery, 1998-1999. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Rushton, K. W. 2001? Annual report: Iron Gate Salmon and Steelhead Hatchery, 1999-2000. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Rushton, K. W. 2002? Annual report: Iron Gate Salmon and Steelhead Hatchery, 2000-2001. Region 1, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft)

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). *In* C. Groot and L. Margolis (editors), Pacific salmon life histories, p. 396-445. Univ. British Columbia Press, Vancouver.

Sheehan, J. 1991. Snags and twists abound in managing sport fish. Outdoor California. May-June 1991: 17-25.

Sinnen, W. 2002. Annual report: Trinity River basin salmon and steelhead monitoring project, 2001-2002 season. Task 3: Survival and spawner escapements made by coho salmon produced at the Trinity River Hatchery. 11 p.

Siskiyou County Farm Bureau. 2002. February 21, 2002 letter from Marcia Armstrong to the Assistant Regional Administrator, Protected Resources Division, National Marine Fisheries Service, Portland, OR re: Federal Register Feb. 11 Vol. 67, No. 28, Proposed Rules, Page 6215-6220.

Siskiyou Project. 2002. April 11, 2002 letter from Barbara Ullian to the Assistant Regional Administrator, Protected Resources Division, National Marine Fisheries Service, Portland, OR re: Request for information and comments on the status of the Southern Oregon/Northern California Coho – Federal Register/Vol 67, No. 28/Monday, February 11, 2002/6215. 2 p. + report by C. D. Williams, Review of the status of Southern Oregon/Northern California coho with thoughts on recovery planning targets. Report to the Siskiyou Regional Education Project for submission to the National Marine Fisheries Service on the status review update for Southern Oregon/Northern California coho salmon. 34 p. + appendices.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott creeks in 2001. Unpublished report available from Dr. Jerry Smith, Department of Biological Sciences, San Jose State University. 9 p. + appendices.

Sollazi , M. F. and S. L. Johnson. 1996. Development and evaluation of techniques to rehabilitate Oregon's wild salmonids. Oregon Department of Fish and Wildlife, Fish Division, Progress reports. 10 p.

SSHAG (Salmon Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum Salmon, Coho Salmon, Chinook Salmon, and Steelhead within Listed and ESUs. Technical review draft. NMFS Northwest and Southwest Fisheries Science Centers.

Steel, E. A. and M. B. Sheer. 2002. Broad-scale habitat analyses to estimate fish densities for viability criteria. Appendix C *in* Willamette/Lower Columbia Pacific salmonid viability criteria. Willamette/Lower Columbia Technical Recovery Team Report. December 2002.

Trout Unlimited. 2002. Petition to List the Oregon Coast Coho Salmon (*Oncorhynchus kisutch*) as a Threatened Species Under the Federal Endangered Species Act. April 25, 2002. 67p.

Wahle, R. J. and R. E. Pearson. 1987. A listing of Pacific Coast spawning streams and hatcheries producing chinook and coho salmon with estimates on numbers of spawners and data on hatchery releases. NOAA Technical Memorandum NMFS F/NWC-122. 109 p.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. 258 p.

White, E., B. Morgan, and J. Fulop. 1999. 1998 Oregon Lower Columbia River Coho spawning Ground Surveys and 1999 Coho Juvenile Survey Results. ODFW.

Williams, G. 1993. Annual report: Warm Springs Salmon and Steelhead Hatchery, 1992-1993. Region 3, Inland Fisheries Administrative Report, California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. (Draft).

Yurok Tribal Fisheries Program. 2002. Data submitted April 12, 2002, by Dave Hellemeier, Yurok Fisheries Program Manager to the National Marine Fisheries Service. 3 p. + electronic data files.

Zhou, S. and M. Chilcote. 2003. Stock assessment and population viability of Clackamas River coho salmon. Oregon Department of Fish and Wildlife Fish Division Information Report; Portland, OR. 35 p.

C.5 APPENDICES

Appendix C.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of the four coho salmon ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

	Stock	Run	Basin	SSHAG Category
Oregon Coast	NF Nehalem	(# 32)	Nehalem	2c
	Fishhawk Lake	(# 99)	Nehalem	2a or 3a
	Trask River	(# 34)	Trask	2c or 3c
	Siletz	(# 33)	Siletz	2a or 3a
	Umpqua	(# 55)	Umpqua	2a
	Cow Creek	(# 18)	Umpqua	2a
	Woahink		Siltcoos	1a
	Coos	(# 37)	Coos	2a
	Coquille	(# 44)	Coquille	2a
S. Oregon/N. California Coasts	Rogue River	(# 52)	Rogue River	2a
	Iron Gate		Klamath	2c
	Trinity River		Trinity	2b
	Mad River		Mad River	4
Central California	Noyo River		Noyo River	2a
	Don Clausen		Russian	1a
	Monterey Bay		Scott Creek	1a
Lower Columbia River	Big Creek		Big Creek	2a
	Klaskanine		Klaskanine	4
	Tanner Creek		Lower Gorge	2b
	Sandy River	late	Sandy	2a
	Eagle Creek		Clackamas	2c
	Little White Salmon		Upper Gorge	3c
	Toutle	Type S	Cowlitz	2a
	Type S Complex	Type S	various	2c or 3c

	Cowlitz	Type N	Cowlitz	2a
	Type N Complex	Type N	various	2b o 2c

Appendix C.5.2. Coho Salmon Time Series Data Sources

Oregon Coast coho salmon ESU

Population	Oregon Coast
Years of Data, Length of Series	1970-2002, 33 years
Abundance Type	Fish
Abundance References	Jacobs et al., 2000, Jacobs et al. 2001, Jacobs et al. 2002, PFMC 2002a, PFMC 2003.
Abundance Notes	Rivers: 1970-1989 index live spawner surveys expanded by stream miles. 1990-2002 stratified random sample (SRS) survey design. Pre-1990 calibrated to SRS estimates. Lakes: index surveys expanded by historical mark-recapture data.

Southern Oregon/Northern California Coasts coho salmon ESU

Population	Rogue River
Years of Data, Length of Series	[see figure captions]
Abundance Type	Adult Fish
Abundance References	[See figure captions]
Abundance Notes	Abundance estimates based on expansion of beach seine abundance index based on hatchery fraction and returns of hatchery fish to Cole Rivers hatchery.
Populations	Hollow Tree Creek (Mendocino Co.)
Years of Data; Length of Series	1986-2002 (1983 included for one site; 1992 excluded from one site); 16-18 years
Abundance Type	Juvenile density estimates (index reaches)
Data Sources	Electronic files provided Scott Harris, CDFG, based on data collected by Scott Harris and Wendy Jones (CDFG retired)
Abundance Notes	Juvenile density estimates are derived based on multiple-pass depletion estimates at index reaches established by CDFG.
Populations	South Fork Eel River basin (5 sites) (Mendocino Co.)
Years of Data; Length of Series	1994-2002 for one site, 1995-2002 for all others; 8-9 years
Abundance Type	Juvenile density estimates (index reaches)
Data Sources	Electronic files provided David Wright and Stephen Levesque, Campbell Timberland Management, Fort Bragg, CA.

Abundance Notes	Juvenile density estimates are derived based on multiple-pass depletion estimates at index reaches established by Campbell Timberland Management. Most index reaches range from approximately 30 to 60 m in length.
Populations	Numerous throughout SONCC ESU
Years of Data; Length of Series	Variable, extending back to 1987.
Data Type	Presence-absence observations
Data Sources	Electronic database developed by NMFS SWFSC augmented with data provided by Bill Jong and Larry Preston, CDFG.
Data Notes	Database contains information on coho salmon occurrence in streams throughout the SONCC ESU. Original sources include a variety of surveys, reports, and other documents produced by CDFG, NMFS, tribes, private landowners, academic institutions, and others doing research or monitoring of coho salmon or other salmonids in streams believed to have historically supported coho salmon. Original sources are documented in databases housed at the NMFS SWFSC.

Central California Coast coho salmon ESU

Populations	Caspar Creek and Little River (Mendocino Co.)
Years of Data, Length of Series	1987-2002; 16 years
Abundance Type	Smolt counts (partial)
Data Source	Electronic files provided Scott Harris, CDFG, based on data collected by Scott Harris and Wendy Jones (CDFG retired)
Abundance Notes	Smolt counts are partial counts made at downstream migrant traps and are not corrected for trap efficiency; numbers should be viewed as indices of abundance rather than population estimates
Population	Noyo River Egg Collecting Station (Mendocino Co.)
Years of Data, Length of Series	1962-2001; 40 years
Abundance Type	Adult counts (partial)
Data Source	Grass 2002
Abundance Notes	Counts of adult coho salmon are partial counts made at the Noyo Egg Collecting Station on the South Fork of the Noyo River. In most years, the trap was not operated continuously during the spawning season. Furthermore, trapping usually ceased when egg take goals were met. Thus, counts should be viewed as indices of abundance rather than population estimates
Populations	Pudding Creek, Caspar Creek, and Little River (Mendocino Co.)
Years of Data; Length of Series	Pudding Creek: 1983-2002 (except 1990); 19 years

	Caspar Creek (2 sites): 1986-2002; 17 years Little River (2 sites): 1986-2002 (except 2000); 16 years
Abundance Type	Juvenile density estimates (index reaches)
Data Sources	Electronic files provided Scott Harris, CDFG, based on data collected by Scott Harris and Wendy Jones (CDFG retired)
Abundance Notes	Juvenile density estimates are derived based on multiple-pass depletion estimates at index reaches established by CDFG. Pudding Creek site has been sampled in recent years by Campbell Timberland Management.
Populations	Noyo River, Big River, and Big Salmon Creek (Mendocino Co.)
Years of Data; Length of Series	Noyo River (8 sites): generally 1993-2002 (variable among sites); 6-10 years Big River (2 sites): 1993-2002; 10 years Big Salmon Creek (5 sites): generally 1993-2002 (variable among sites); 7-10 years
Abundance Type	Juvenile density estimates (index reaches)
Data Sources	Electronic files provided David Wright and Stephen Levesque, Campbell Timberland Management, Fort Bragg, CA.
Abundance Notes	Juvenile density estimates are derived based on multiple-pass depletion estimates at index reaches established by Campbell Timberland Management. Most index reaches range from approximately 30 to 60 m in length.
Populations	Lagunitas Creek (Marin Co.)
Years of Data; Length of Series	1995-2001; 7 years
Abundance Type	Juvenile population estimates (expanded from index reaches)
Data Sources	Electronic files provided Eric Ettlinger, Marin Municipal Water District.
Abundance Notes	Juvenile density estimates for different habitat unit types are derived based on multiple-pass depletion estimates at index reaches. Unit-specific density estimates are then used in conjunction with habitat typing for the entire stream reach to obtain an overall population estimate for juveniles within the stream.
Population	Redwood Creek (Marin Co.)
Years of Data; Length of Series	1994-2001 (excluding 1999); 7 years
Abundance Type	Juvenile population index
Data Sources	Smith 1994-2001.

Abundance Notes	Juvenile counts are made annually at multiple index sites in Redwood Creek using single-pass electrofishing. Mean numbers of fish per linear distance of stream were calculated based only on sites that were sampled each year during the period of record (i.e., sites sampled sporadically were not included in the overall estimate).
Populations	Waddell and Scott Creek (Santa Cruz Co.), and Gazos Creek (San Mateo Co.)
Years of Data; Length of Series	Waddell Creek and Scott Creek, 1992-2001; 10 years Gazos Creek, 1993-2001 (excluding 1994); 8 years
Abundance Type	Juvenile population index
Data Sources	Smith 1992-2001.
Abundance Notes	Juvenile counts are made annually at multiple index sites in each creek using single-pass electrofishing. Mean numbers of fish per linear distance of stream were calculated based only on sites that were sampled each year during the period of record (i.e., sites sampled sporadically were not included in the overall estimate).
Populations	Numerous throughout Central California Coast ESU
Years of Data; Length of Series	Variable, extending back to 1987.
Data Type	Presence-absence observations
Data Sources	Electronic database developed by NMFS SWFSC augmented with data from the Russian River basin provided by Bob Coey, CDFG.
Data Notes	Database contains information on coho salmon occurrence in streams throughout the CCC ESU. Original sources include a variety of surveys, reports, and other documents produced by CDFG, NMFS, private landowners, water districts, academic institutions, and others doing research or monitoring of coho salmon or other salmonids in streams believed to have historically supported coho salmon. Original sources are documented in databases housed at the NMFS SWFSC.

Lower Columbia River coho salmon ESU

Population	Clatskanie River
Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish per mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J. 1999; Ollerenshaw, E. 2002.
Abundance Notes	Data from Streamnet
Population	Scappoose Creek

Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish per mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J. 1999; Ollerenshaw, E. 2002
Abundance Notes	Data from Streamnet
Population	Big Creek
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish per mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J. 1998; White, E., Morgan, B. and Fulop, J. 1999; Ollerenshaw, E. 2002.
Abundance Notes	Data from Streamnet
Population	Clackamas River
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish per mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, E. 2002
Abundance Notes	Data from Streamnet
Population	Youngs Bay
Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish per mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, E. 2002
Abundance Notes	Data from Streamnet
Population	Sandy River (Marmot Dam)
Years of Data, Length of Series	1977 - 2001, 25 years
Abundance Type	Dam count
Abundance References	Cramer 2002
Population	Clackamas River (North Fork Dam)
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Dam count
Abundance References	Cramer 2002

D. SOCKEYE SALMON

D.1 BACKGROUND AND HISTORY OF LISTINGS

Primary contributor: Richard G. Gustafson
(Northwest Fisheries Science Center)

Sockeye salmon, *Oncorhynchus nerka* spawn in North America from the Columbia River in Oregon north to the Noatak River in Alaska, and in Asia from Hokkaido, Japan north to the Anadyr River in Russia (Atkinson et al. 1967, Burgner 1991). The vast majority of sockeye salmon spawn in inlet or outlet streams of lakes or in lakes themselves. The juveniles of these "lake-type" sockeye salmon rear in lake environments for 1 to 3 years, migrate to sea, and return to natal lake systems to spawn after 1 to 4 years in the ocean. However, some sockeye salmon populations spawn in rivers without juvenile lake rearing habitat. Their juveniles rear in slow-velocity sections of rivers for 1 or 2 years ("river-type") or migrate to sea as underyearlings and thus rear primarily in saltwater ("sea-type") (Wood 1995). As with lake-type sockeye salmon, river/sea-type sockeye salmon return to natal spawning habitat after 1 to 4 years in the ocean.

Certain self-perpetuating, nonanadromous populations of *O. nerka* that become resident in lake environments over long periods of time are called kokanee in North America. Genetic differentiation among sockeye salmon and kokanee populations indicates that kokanee are polyphyletic, having arisen from sockeye salmon on multiple independent occasions, and that kokanee may occur sympatrically or allopatrically with sockeye salmon. Numerous studies (reviewed in Gustafson et al. 1997) indicate that sockeye salmon and kokanee exhibit a suite of heritable differences in morphology, early development rate, seawater adaptability, growth and maturation that appear to be divergent adaptations that have arisen from different selective regimes associated with anadromous vs. nonanadromous life histories. These studies also provide evidence that sympatric populations of sockeye salmon and kokanee can be both genetically distinct and reproductively isolated (see citations in Gustafson et al. 1997). Occasionally, a proportion of juveniles in an anadromous sockeye population will remain in the rearing lake environment throughout life and will be observed on the spawning grounds together with their anadromous siblings. Ricker (1938) first used the terms "residual sockeye" and "residuals" to refer to these resident, non-migratory progeny of anadromous sockeye salmon.

In April 1990, NMFS initiated a status review of sockeye salmon in the Salmon River Basin and received a petition from the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation to list Snake River sockeye salmon as endangered under the ESA (NMFS 1990, 1991a). The NMFS Biological Review Team conducted a status review and unanimously agreed that there was insufficient information available to determine with reasonable degree of certainty the origin of the current sockeye salmon gene pool in Redfish Lake (Waples et al. 1991). After some discussion, the BRT reached a strong consensus that, in this instance, obligations as resource stewards required them to proceed under the assumption that recent sockeye salmon in Redfish Lake were descended from the original sockeye salmon gene pool. Therefore, as stipulated in the Species Definition Paper (Waples 1991), the anadromous component of *O. nerka* was considered separately from the non-anadromous (kokanee) component in determining whether an ESA listing was warranted. The decision to treat Redfish Lake sockeye salmon as

distinct from kokanee led the BRT to conclude that the Redfish Lake sockeye salmon were in danger of extinction (Waples et al. 1991). Subsequently, a proposed rule to list Snake River sockeye salmon as endangered was published (NMFS 1991a). After consideration of 183 written comments and testimony from public hearings, NMFS published its final listing determination (NMFS 1991b) that designated Snake River sockeye salmon as an endangered species.

In September 1994, in response to a petition seeking protection for Baker Lake, WA sockeye salmon under the ESA and more general concerns about the status of West Coast salmon and steelhead, NMFS initiated a coastwide status review of sockeye salmon in Washington, Oregon, and California, and formed a Biological Review Team (BRT) to conduct the review. After considering available information on genetics, phylogeny and life history, freshwater ichthyo-geography, and environmental features that may affect sockeye salmon, the BRT identified six ESUs (Ozette Lake, Okanogan River, Lake Wenatchee, Quinault Lake, Baker River, and Lake Pleasant) and one provisional ESU (Big Bear Creek). The BRT reviewed population abundance data and other risk factors for these ESUs and concluded that one (Ozette Lake) was likely to become endangered in the foreseeable future, and that the remaining ESUs were not in significant danger of becoming extinct or endangered, although there were substantial conservation concerns for some of these (Gustafson et al. 1998). In March 1998, NMFS published a proposed rule to list the Ozette Lake ESU as threatened under the ESA, and to place the Baker River ESU on the candidate list. Due to the lack of natural spawning habitat and the vulnerability of the entire population to problems in artificial habitats, NMFS proposed to add the Baker River ESU to the list of candidate species (NMFS 1998). Subsequently, based on the updated NMFS status review (WCSSBRT 1999) and other information received, NMFS published its final listing determination (NMFS 1999) that designated the Ozette Lake sockeye salmon ESU as threatened and removed the Baker River ESU from the candidate list.

In considering the ESU status of resident forms of *O. nerka*, the key issue is evaluating the strength and duration of reproductive isolation between resident and anadromous forms. Many kokanee populations appear to have been strongly isolated from sympatric sockeye populations for long periods of time. Since the two forms experience very different selective regimes over their life cycle, reproductive isolation provides an opportunity for adaptive divergence in sympatry. Kokanee populations that fall in this category will generally not be considered part of sockeye ESUs. On the other hand, resident fish appear to be much more closely integrated into some sockeye populations. For example, in some situations, anadromous fish may give rise to progeny that mature in freshwater (as is the case with residual sockeye), and some resident fish may have anadromous offspring. In these cases, where there is presumably some regular, or at least episodic, genetic exchange between resident and anadromous forms, they should be considered part of the same ESU. The sockeye salmon BRT[1] met in January, March and April 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original BRTs. This report summarizes

[1] The Biological Review Team (BRT) for the updated status review for West Coast Sockeye Salmon included Thomas Cooney, Dr. Richard Gustafson, Dr. Robert Iwamoto, Gene Matthews, Dr. Paul McElhany, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, Dr. John Williams, and Dr. Gary Winans, from NMFS Northwest Fisheries Science Center (NWFSC); Dr. Peter Adams and Dr. Eric Bjorkstedt, from NMFS Southwest Fisheries Science Center (SWFSC); and Dr. Reginald Reisenbichler from the Northwest Biological Science Center, USGS Biological Resources Division, Seattle.

new information and the preliminary BRT conclusions on the following ESUs: Snake River in Idaho and Ozette Lake in Washington.

D.2.1 SNAKE RIVER SOCKEYE

Primary contributor: Robin S. Waples
(Northwest Fisheries Science Center)

D.2.1.1 Summary of Previous BRT Conclusions

The first formal ESA status review for salmon in the Pacific Northwest was conducted in response to a 1990 petition to list sockeye salmon from Redfish Lake in Idaho as an endangered species. The distinctiveness of this population became apparent early in the process: it spawns at a higher elevation (2,000m), and has a longer freshwater migration (1,500 km) than any other sockeye salmon population in the world (Waples et al. 1991). Nor was the precarious nature of the anadromous run in doubt: in the fall of 1990, during the course of the status review, no adults were observed at Lower Granite Dam or entering the lake, and only one fish was observed in each of the two previous years. However, a population of kokanee also existed in Redfish Lake, and the relationship between the sockeye and kokanee was not well understood. This issue was complicated by uncertainty regarding the effects of Sunbeam Dam, which stood for over 2 decades about 20 miles downstream of Redfish Lake. By all accounts, the dam was a serious impediment to anadromous fish, but opinions differed as to whether it was an absolute barrier. Some argued that the original sockeye population in Redfish Lake was extirpated as a result of Sunbeam Dam, and that adult returns in recent decades were simply the result of sporadic seaward drift of kokanee (Chapman et al. 1990). According to this hypothesis, the original sockeye gene pool was extinct and the remaining kokanee population was not at risk because of its reasonably large size (ca. 5,000-10,000 spawners per year). An alternative hypothesis held that the original sockeye salmon population managed to persist in spite of Sunbeam Dam, either by intermittent passage of adults or recolonization from holding areas downstream of the dam. The fact that the kokanee population spawns in the inlet stream (Fishhook Creek) in August-September and all the recent observations of sockeye spawning have been on the lake shore in October-November was cited as evidence that the sockeye and kokanee represent separate populations. According to this hypothesis, the sockeye population was critically endangered, and perhaps, on the brink of extinction.

At the time of the status review, the BRT unanimously agreed that there was not enough information to determine which of the above hypotheses were true (Waples 1991). Although the kokanee population had been genetically characterized and determined to be quite distinctive compared to other *O. nerka* populations in the Pacific Northwest, no adult sockeye were available for sampling, so the BRT could not evaluate whether the two forms shared a common gene pool. When pressed to make a decision regarding the ESU status of Redfish Lake *O. nerka*, the BRT concluded that, because they could not determine with any certainty that the original sockeye gene pool was extinct, they should assume that it did persist and was separate from the kokanee gene pool. This conclusion was strongly influenced by consideration of the irreversible consequences of making an error in the other direction (*i.e.*, if the species was not listed based on the assumption that kokanee and sockeye populations were a single gene pool and this later proved not to be the case, the species could easily go extinct before the error was detected).

The status review of Redfish Lake sockeye salmon is the only instance in which the BRT has been asked to apply the precautionary principle in its deliberations. In subsequent evaluations, when the "best available scientific information" was insufficient to distinguish with any certainty among competing hypotheses regarding key ESA questions, the BRT has simply reported this result and tried to characterize the degree of uncertainty in the team's conclusions. Decisions about how best to apply the precautionary principle in the face of uncertainty in making listing determinations have been left to the NMFS management/policy arm.

Based on results of the status review, NMFS proposed a listing of Redfish Lake sockeye as endangered in April 1991. When finalized in late 1991, this represented the first ESA listing of a Pacific salmon population in the Pacific Northwest. At the time of the listing, the only population that the BRT and NMFS were confident belonged in this ESU was the beach spawning population of sockeye from Redfish Lake. Historical records indicated that sockeye once occurred in several other lakes in the Stanley Basin, but no adults had been observed in these lakes for many decades and their relationship to the Redfish Lake ESU was uncertain.

D.2.1.2 New Data and Updated Analyses

Four adult sockeye returned to Redfish Lake in 1991; these were captured and taken into captivity to join several hundred smolts collected in spring 1991 as they outmigrated from Redfish Lake. The adults were spawned, and their progeny reared to adulthood along with the outmigrants as part of a captive broodstock program, whose major goal was to perpetuate the gene pool for a short period of time (one or two generations) to give managers a chance to identify and address the most pressing threats to the population. As a result of this program and related research, a great deal of new information has been gained about the biology of Redfish Lake *O. nerka* and limnology of the lakes in the Stanley Basin. Genetic data collected from the returning adults and the outmigrants showed that they were genetically similar but distinct from the Fishhook Creek kokanee. However, otolith microchemistry data (Rieman et al. 1994) indicated that many of the outmigrants had a resident female parent. These results inspired a search of the lake for another population of resident fish that was genetically similar to the sockeye. These efforts led to discovery of a relatively small number (perhaps a few hundred) kokanee-sized fish that spawn at approximately the same time and place as the sockeye. These fish, termed "residual" sockeye salmon, are considered to be part of the listed ESU.

Subsequent genetic analysis (Winans et al. 1996, Waples et al. 1997) has established the following relationships between extant populations of *O. nerka* from the Stanley Basin and other populations in the Pacific Northwest: 1) native populations of *O. nerka* from the Stanley Basin (including Redfish Lake sockeye and kokanee and Alturas Lake kokanee) are genetically quite divergent from all other North American *O. nerka* populations that have been examined; 2) within this group, Redfish Lake sockeye and kokanee are genetically distinct, and Alturas Lake kokanee are most similar to Redfish Lake kokanee; 3) two gene pools of *O. nerka* have been identified in Stanley Lake—one may be the remnant of a native gene pool that survived rotenone treatments in the lake, while the other can be traced to introductions from Wizard Falls Hatchery in Oregon; 4) no trace of the original gene pool of *O. nerka* has been found in Pettit Lake. The population that has spawned in Pettit Lake in recent decades can be traced to introductions of

kokanee from northern Idaho, and those populations in turn can be traced to stock transfers of Lake Whatcom (Washington) kokanee early in the last century.

Between 1991 and 1998, 16 naturally-produced adult sockeye returned to the weir at Redfish Lake (Table D.2.1.1) and were incorporated into the captive broodstock program.

Table D.2.1.1. Adult anadromous sockeye salmon returns to the Redfish Lake Creek weir 1954-1968 (Bjornn et al. 1968) and the Redfish Lake Creek trap and Sawtooth Fish Hatchery weir (1991-2002) (L. Hebdon, IDFG, pers. comm.). No data are available for 1967-1984.

Year	Adults	Year	Adults
1954	998	1979	
1955	4,361	1980	
1956	1,381	1981	
1957	523	1982	
1958	55	1983	
1959	290	1984	
1960	75	1985	11
1961	11	1986	29
1962	39	1987	16
1963	395	1988	1
1964	335	1989	1
1965	17	1990	0
1966	61	1991	4
1967		1992	1
1968		1993	8
1969		1994	1
1970		1995	0
1971		1996	1
1972		1997	0
1973		1998	1
1974		1999	7[1]
1975		2000	257[1]
1976		2001	26[1]
1977		2002	22[1]
1978			

[1] Progeny of captive broodstock program

This program, overseen by the Stanley Basin Sockeye Technical Oversight Committee, has produced groundbreaking research in captive broodstock technology (Hebdon et al. 1999, Kline and Willard 2001, Frost et al. 2002) and limnology (Kohler et al. 2002). The program has utilized three different rearing sites to minimize chances of catastrophic failure and has produced several hundred thousand eggs and juveniles, as well as several hundred adults, for release into the wild (Table D.2.1.2). A milestone was reached in 2000, when > 200 adults from the program returned to Redfish Lake. Currently, the captive broodstock program is being maintained as a short-term safety net, pending decisions about longer-term approaches to recovery of the ESU.

Table D.2.1.2. Summary of releases of progeny from the Redfish Lake captive broodstock program into Redfish, Alturas, and Pettit Lakes (L. Hebdon, IDFG, pers. comm.). Release numbers are in thousands for eggs, presmolts and smolts.

Redfish Lake				
	Eggs	**Presmolts**	**Smolts**	**Adults**
1993				20
1994		14		65
1995		82	4	
1996	105	2	12	120
1997	85	152		80
1998		95	38	
1999		24	5	21
2000		48		120
2001		43	14	69
2002		107	39	190
Alturas Lake				
	Eggs	**Presmolts**	**Smolts**	**Adults**
1995				
1996				
1997	20	100		20
1998		39		
1999		13		
2000		12		77
2001		12		
2002		6		
Pettit Lake				
	Eggs	**Presmolts**	**Smolts**	**Adults**
1995		9		
1996				
1997		9		
1998		7		
1999	20	3		
2000	65	6		
2001		11		
2002	31	28		

The Snake River Salmon Recovery Team (Bevan et al. 1994; NMFS 1995) suggested that to be considered recovered under the ESA, this ESU should have viable populations in three different lakes, with at least 1,000 naturally produced spawners per year in Redfish Lake and at least 500 in each of two other Stanley Basin lakes. As a step toward addressing this recommendation, releases of progeny from the Redfish Lake captive broodstock program have been made in Pettit Lake and Alturas Lake as well. In 1991, about 100 outmigrants from Alturas Lake were collected at the same time as the Redfish Lake outmigrants and reared to maturity as a separate population in captivity. However, because of funding and space limitations and uncertainties about priorities for propagating this population, the resulting adults were released into the lake rather than being kept for spawning and another generation of captive rearing. Because the Alturas Lake kokanee spawn earlier than Redfish lake sockeye and in the inlet stream, it is hoped that the introduction of Redfish Lake sockeye into Alturas Lake will not adversely affect this native gene pool.

D.2.2 OZETTE LAKE SOCKEYE SALMON

Primary contributor: Mary H. Ruckelshaus
(Northwest Fisheries Science Center)

D.2.2.1 Summary of Previous BRT Conclusions

Status and trends

The 5-year average (geometric mean) estimated abundance of Ozette Lake sockeye for the period 1994-1998 was 580, slightly below the average of 700 (for the years 1992-1996) reported by Gustafson et al. (1997). This decrease is largely because the earlier average included two dominant brood-cycle years, while the recent average includes only one. The 1998 count of 984 was substantially above the count of 498 that was observed 4 years (one generation) earlier. This may result primarily from a change in counting methods; a video camera was installed in 1998 and the operation period of the weir was expanded (7 May-14 August), resulting in a more complete count of all fish passing the weir (M. Crewson, Makah Indian Tribe, pers. comm., 21 August 1998). It is likely that counts for previous years underestimated total spawner abundance, but the magnitude of this bias is unknown.

Analyses of trends using data through 1998 indicates that the short-term (10-year) trend improved from a decline of 9.9% per year in Gustafson et al. (1997) to a relatively low 2% annual increase. How much this was influenced by the change in counting methods in 1998 is not known. The long-term trend remained slightly downward (-2%).

Threats

A variety of threats to the continued existence of the sockeye populations in Ozette Lake were identified, including siltation of beach spawning habitat, and potential genetic effects of past interbreeding with genetically dissimilar kokanee. The BRT received an analysis of logging history in the Ozette Basin from Rayonier Northwest Forest Resources (Meier 1998). This analysis indicated that most logging in the basin occurred since the mid-1950s: in 1953, only 8.7% of the basin had been logged, while 60% had been logged by 1981. Thus, logging occurred largely after the substantial decline in sockeye salmon catch in the early 1950s.

Previous BRT conclusions

The BRT last reviewed the Ozette Lake sockeye ESU status in November 1998. Their conclusion was that the ESU was likely to become endangered in the foreseeable future. Main uncertainties arose from questions about the reliability of abundance estimates and the historical presence of inlet-spawning sockeye salmon in the basin. Perceived risks were focused on low current abundance and trends and variability in abundance. At the time of the last status assessment, escapements averaging below 1,000 adults per year implied a moderate degree of risk from small-population genetic and demographic variability, with little room for further declines before abundances reach critically low levels. Other concerns included siltation of

beach spawning habitat, very low abundance now compared to harvests in the 1950s, and potential genetic effects of past interbreeding with genetically dissimilar kokanee.

Listing status—Threatened

D.2.2.2 New Data and Updated Analyses

ESU status at a glance

Historical peak abundance	3,000-18,000
Historical populations	1+
Extant populations	1
5-year geometric mean escapement	2,267

ESU structure

The Puget Sound TRT considers the Ozette Lake sockeye ESU to be comprised of one historical population, with substantial substructuring of individuals into multiple spawning aggregations. The primary existing spawning aggregations occur in two beach locations—Allen's and Olsen's beaches, and in two tributaries, Umbrella Creek and Big River (both of the tributary spawning groups were initiated through a hatchery introduction program). Recently, mature adults have been located at other beach locations within the lake (e.g., Umbrella beach, Ericson's Bay, Baby Island, and Boot Bay), but whether spawning occurred in those locations is not known (Makah Fisheries 2000). Similarly, occasional spawners are found sporadically in other tributaries to the lake, but not in as high numbers or as consistently as in Umbrella Creek. The Umbrella Creek spawning aggregation was started through collections of lake-spawning adults as initial broodstock, and in recent years, all broodstock has been collected from returning adults to Umbrella Creek (Makah Fisheries 2000). The extent to which sockeye spawned historically in tributaries to the lake is controversial (Gustafson et al. 1997), but it is clear that multiple beach-spawning aggregations of sockeye occurred historically, and that genetically distinct kokanee currently spawn in large numbers in all surveyed lake tributaries (except Umbrella Creek and Big River). The two remaining beach-spawning aggregations are probably fewer than the number of aggregations that occurred historically, but there is insufficient evidence to determine how many subpopulations occurred in the ESU historically.

Much of the existing spawning in recent years occurs in the spawning aggregation created via fry releases into Umbrella Creek. The status of the historically well-documented spawning aggregations at Allen's and Olsen's beaches is not well understood because of the difficulties in observing spawners and sampling carcasses in the tannin-rich lake.

Updated status information

Because of the concerns about the status of Ozette Lake sockeye, the Lake Ozette Steering Committee was established (comprised of the Makah tribe, Olympic National Park, WDFW, and citizen groups) to organize recovery activities for sockeye. Makah Fisheries initiated a hatchery program designed to supplement existing beach spawners in 1983 (beach

spawner supplementation ceased with the 1995 broodyear) and later to introduce sockeye to lake tributaries (intentional releases to tributaries began in broodyear 1992) (see *Updated Threats Information*). Therefore, all of the abundance information presented contains an unknown fraction of hatchery fish.

Information on abundance of Ozette Lake sockeye comes from visual counts at a weir across the lake outlet, therefore the counts presented represent total run size. The estimates of total run size have been revised upwards since the time of the last status review in 1997, due to resampling of data using new video camera counting technology (Figure D.2.2.1).

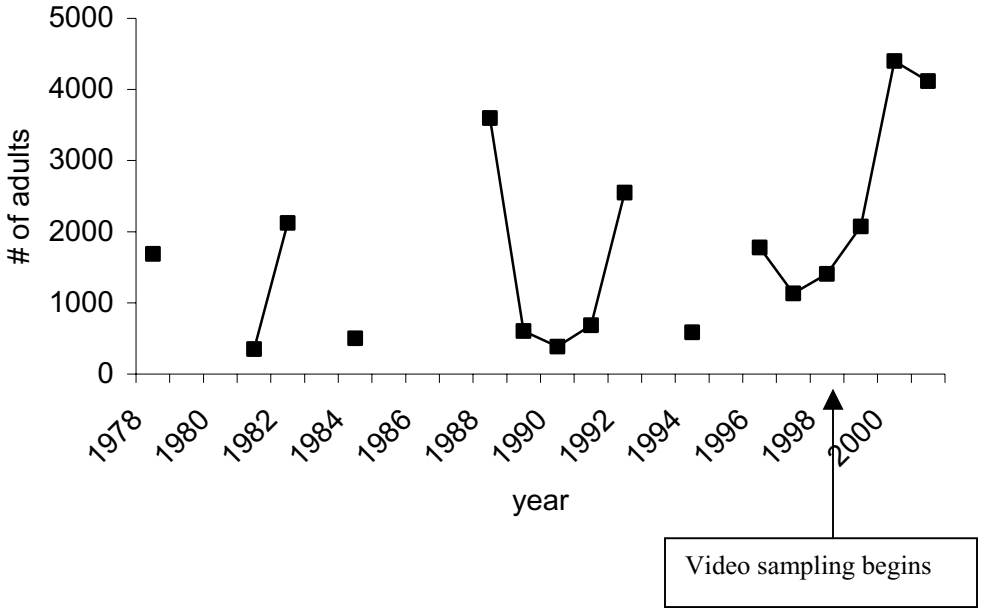


Figure D.2.2.1. Estimated numbers of adult sockeye entering Lake Ozette from 1978 to 2001. (Source: Mike Crewson, Makah Fisheries, unpublished data).

The Makah Fisheries biologists estimate that previous counts of adult sockeye returning to the lake have been underestimates, and they have attempted to correct run-size estimates based on their assessments of human error and variations in inter-annual run-timing (Makah Fisheries 2000; Table D.2.2.1). The run-size estimates are very uncertain—an estimate of the 95% confidence interval around the 2001 count is N = 3,717 (2,815 – 5,416) (J. Fieberg memo to A. Ritchie and M. Crewson, September, 2002). The most recent 5-year geometric mean of sockeye returning to Ozette Lake is 2,267 adults. Since run-size estimates before 1998 are likely to be even more unreliable than recent counts, and the new counting technology has resulted in an increase in estimated run sizes, no statistical estimation of trends is reported. The current trends in abundance are unknown for the beach spawning aggregations. Although overall abundance appears to have declined from historical levels, it is not known whether this resulted in fewer spawning aggregations, lower abundances at each aggregation, or both.

The adults remain in the lake for an extended period of time (return April-August; spawn late October-February) before spawning on beaches or in the tributaries, and the pre-spawning

mortality is not known. Therefore, it is not clear what the escapement levels to the spawning aggregations might be.

Table D.2.2.1. Estimated run size, natural-origin recruits (NOR) to Lake Ozette and to Umbrella Creek (UC), and the fraction of fish returning to Umbrella Creek that are of hatchery origin in Lake Ozette sockeye salmon from 1978-2001 (Makah Fisheries 2000, M. Crewson, Makah Fisheries, unpublished data).

Year	Total Run Size	Lake NOR	UC NOR	UC Hatchery Origin
1978	1,690	nd	nd	nd
1979	nd	nd	nd	nd
1980	nd	nd	nd	nd
1981	350	nd	nd	nd
1982	2,123	nd	nd	nd
1983	nd	nd	nd	nd
1984	502	nd	nd	nd
1985	nd	nd	nd	nd
1986	nd	nd	nd	nd
1987	nd	nd	nd	nd
1988	3,599	nd	nd	nd
1989	603	nd	nd	nd
1990	385	nd	nd	nd
1991	684	nd	nd	nd
1992	2,548	nd	nd	nd
1993	nd	nd	nd	nd
1994	585	nd	nd	nd
1995	nd	nd	nd	44
1996	1,778	1,699	79	0
1997	1,133	998	nd	135
1998	1,406	1,310	nd	96
1999	2,076	1,676	149	251
2000	4,399	1,293		3,106
2001	4,116	591	3,525	

The sockeye salmon returning to Umbrella Creek have averaged more than 10% of the total run size to Lake Ozette from 1995 to 1999, and possibly this fraction has been higher in the last 2 years (Makah Fisheries 2000, Mike Crewson, Makah Fisheries, pers. comm.). A portion of the Umbrella creek hatchery sockeye were marked as juveniles beginning in the late 1980s, and results of monitoring of these marks on returning adults indicates that natural-origin spawners in Umbrella Creek in 1999 ranged from 21.4%-52.9% (Makah Fisheries 2000).

Age data from otolith samples in 2000 and 2001 in Umbrella Creek, Allen's and Olsen's beaches suggest that a small fraction of 5-year old fish do occur in Umbrella Creek and Olsen's beach subpopulations (Table D.2.2.2). Previous estimates of returns from different broodyears will be affected by these age data, since early analyses assumed 100% 4-year old sockeye.

Based on examination of carcasses retrieved from Allen's and Olsen's beaches for otolith marks applied to hatchery fish, straying of hatchery fish from the Umbrella Creek program appears to be very low (Makah Fisheries 2000).

Table D.2.2.2. Percentages of 5-year old fish sampled from otoliths in carcasses in sockeye salmon subpopulations in Lake Ozette (Source: M. Crewson, Makah Fisheries, pers. comm.).

	% 5-year olds	
Sub-population	**2000 (n samples)**	**2001 (n samples)**
Olsen's beach	2.1% (47)	1.2% (81)
Allen's beach	0% (51)	0% (7)
Umbrella creek	3.8% (183)	18.5% (195)*

*One out of 195 fish sampled from Umbrella Creek was a 6-year old

Updated threats information

The Makah Fisheries staff has been working with the Lake Ozette steering committee to identify factors for decline in Ozette Lake sockeye salmon. Thus far, primary sources of threats to VSP parameters include: 1) loss of adequate quality and quantity of spawning and rearing habitat, 2) predation and disruption of natural predator-prey relationships, 3) introduction of non-native fish and plant species, 4) past over-exploitation, 5) poor ocean conditions, and 6) interactions among those factors. There has been no directed harvest on Ozette Lake sockeye salmon since 1982, and commercial fisheries stopped in 1974 (Gustafson et al. 1997, Makah Fisheries 2000).

Previous releases of hatchery fish in Ozette Lake have been relatively low magnitude, but some of the releases were from sockeye salmon stocks outside the ESU or were from Ozette kokanee-sockeye hybrids (Gustafson et al. 1997). The latest artificial propagation program in Ozette Lake has focused on sockeye salmon introductions into Big River and Umbrella Creek tributaries; chosen because of their apparent suitable spawning habitat and relatively low numbers of naturally spawning kokanee. The Umbrella Creek hatchery has been in place since 1982. The first egg source was from the Quinault River, and progeny were hatched at Umbrella Creek, reared in a net pen in Ozette Lake, and released in June of 1983. From 1983 to 1999, all eggs were collected from Olsen's or Allen's beach spawners. Beginning in 2000, the source for future broodstock for tributary releases will be from returns to tributaries, primarily Umbrella Creek. The SSHAG group (2003) determined that the Umbrella Creek hatchery stock would have a category score of 1 or 2 (see Appendix D.1).

The Makah Tribe and the NMFS Marine Mammal Lab have monitored predation on Ozette Lake sockeye salmon by harbor seals and river otters, and biologists believe that pre-spawning predation rates could be significant. Predation by both otters and seals has been observed in the lake and in the outlet river, especially in the vicinity of the counting weir (Makah Fisheries 2000). In addition, predation scars (ranging from scratches to bite marks to lack of heads) on carcasses sampled and adults counted are noted.

The majority of Ozette Lake and the Ozette River lie within the boundaries of Olympic National Park, but the majority of the land in the Ozette Lake watershed is owned by private

timber companies (Makah Fisheries 2000). Recent accelerated timber harvest, road-building activity, and forest practice and water quality violations are reported in a recent analysis by the Makah Tribe (Makah Fisheries 2000). New activities related to mitigating and improving degraded habitat quality could include the Forest and Fish Agreement (if implemented).

D.3. SOCKEYE SALMON BRT CONCLUSIONS

Snake River sockeye salmon ESU

The BRT was unanimous in their assessment of the status of this ESU: 100% of the likelihood votes were in the "danger of extinction" category (Table D.3.1). Mean risk matrix scores were extremely high (4.9-5.0) for every VSP element (Table D.3.2). On the positive side, the captive broodstock program initiated as an emergency measure in 1991 has at least temporarily rescued this ESU from the brink of extinction, and associated research has provided a great deal of information about the biology of this species and its environment. The return of over 200 adults from the hatchery program in 2000 is considered encouraging, but the status of the natural population remains extremely precarious. Only 16 naturally produced adults have returned since the listing in 1991, and all have been taken into the captive program.

Ozette Lake sockeye salmon ESU

A majority (70%) of the BRT votes for this ESU were cast in the "likely to become endangered" category, with the remainder about equally split between the "danger of extinction" and "not likely to become endangered" categories (Table D.3.1). Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.0 for diversity to 3.8 for spatial structure (Table D.3.2). Risk assessment for this ESU continues to be hampered by very incomplete data. Although significant efforts to improve this situation have been taken recently, the process of perfecting the new techniques and adjusting for biases in previous data is still in progress. Recent evaluations have cast even more doubt on the usefulness of population data prior to about 1997, which further complicates the assessment of an ESU for which data are already very limited.

It appears that overall abundance is low for a population that represents an entire ESU and may be substantially below historical levels. The BRT was concerned about reports that habitat degradation in the lake has resulted in loss of numerous sites suitable for beach spawners, but accurately assessing the situation is difficult because of poor visibility in the lake. The number of returning adults in the last few years has increased, but a substantial (but uncertain) fraction of these appear to be of hatchery origin, leading again to uncertainty regarding growth rate and productivity of the natural component of the ESU. Another uncertainty noted by the BRT related to reports that pre-spawning predation by harbor seals and river otters may be significant, but how large a factor this is and how it compares with historical patterns is not known.

Table D.3.1. Tally of FEMAT vote distribution regarding the status of 2 sockeye salmon ESUs reviewed. Each of 13 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River	130	0	0
Lake Ozette	21	91	18

Table D.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 2 sockeye salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River	5.0 (5-5)	5.0 (5-5)	4.9 (4-5)	5.0 (5-5)
Lake Ozette	3.7 (3-4)	3.5 (3-4)	3.8 (3-5)	3.0 (2-4)

D.4 REFERENCES

Abbe, T., A. Ritchie, S. Fisher, and M. McBride. In preparation. The effect of Ozette River logjams on Lake Ozette: Assessing historical conditions and the potential for restoring logjams. Prepared for the Makah Tribe by Philip Williams and Associates, LTD. April 2002, 32 pp.

Atkinson, C. E., J. H. Rose, and O. T. Duncan. 1967. Salmon of the North Pacific Ocean--Part IV. Spawning populations of North Pacific salmon. 4. Pacific salmon in the United States. Int. North Pac. Fish. Comm. Bull. 23:43-223.

Bevan, D., J. Harville, P. Bergman, T. Bjornn, J. Crutchfield, P. Klingeman, and J. Litchfield. 1994. Snake Salmon Recovery Team: final recommendations to the National Marine Fisheries Service. May 1994. Rob Jones, Recovery Plan Coordinator. National Marine Fisheries Service, Portland, Oregon.

Bjornn, T. C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, *Oncorhynchus nerka*. Trans. Am. Fish. Soc. 97(4): 360-373.

Bortleson, G. C. and N. P. Dion. 1979. Preferred and observed conditions for salmon in Ozette Lake and its tributaries, Clallam County, Washington. U.S. Geological Survey Water Resources Investigations. 78-64.

Burgner, R. L. 1991. Life history of sockeye salmon *Oncorhynchus nerka*. *In* C. Groot and L. Margolis (editors), Pacific salmon life histories, p. 3-117. Univ. British Columbia Press, Vancouver, B.C., Canada

Chapman, D. W., W. S. Platts, D. Park, and M. Hill. 1990. Status of Snake River sockeye salmon. Final report, 90 p. (Available from Pacific Northwest Utilities Conference Committee, 101 SW Main Street, Suite 810, Portland, OR 97204.)

Dlugokenski, C. E., W. H. Bradshaw, and S. R. Hager. 1981. An investigation of the limiting factors to Lake Ozette sockeye salmon production and a plan for their restoration. U. S. Fish and Wildl. Serv., Fish. Assist. Office, Olympia, WA 52 pp. + appendices.

Frost, D. A., W. C. McAuley, D. J. Maynard, and T. A. Flagg. 2002. Redfish Lake sockeye salmon captive broodstock rearing and research, 2001, Annual Report. Report to Bonneville Power Administration, Contract No. 00004464, Project No. 199204000, 27 electronic pages (BPA Report DOE/BP-00004464-1). (Available online at: http://www.efw.bpa.gov/Environment/EW/EWP/DOCS/REPORTS/ HATCHERY/ A00004464-1.pdf)

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-33, 282 p.

Hebdon, J. L., M. Elmer, and P. Kline 1999. Snake River sockeye salmon captive broodstock program research element. Annual Progress Report January 1, 1999–December 31, 1999. Report to Bonneville Power Administration, Contract No. 00000167-00001, Project No. 199107200, 56 electronic pages (BPA Report DOE/BP-00000167-1). (Available online at: http://www.efw.bpa.gov/ Environment/EW/EWP/DOCS/REPORTS/HATCHERY/ A00000167-1.pdf)

Kline, P. A., and C. Willard. 2001. Snake River sockeye salmon captive broodstock program hatchery element. Annual Progress Report January 1, 2000 - December 31, 2000. Report to Bonneville Power Administration, Contract No. 00000167, Project No. 199107200, 42 electronic pages. (BPA Report DOE/BP-00000167-2) (Available online at:http://www.efw. bpa.gov/Environment/EW/EWP/DOCS/ REPORTS/HATCHERY/A00000167-2.pdf)

Kohler, A., R. Griswold, and D. Taki, Snake River sockeye salmon habitat and limnological research. Project No. 9107-100, 97 electronic pages, (BPA Report DOE/BP-00004343-3). (Available online at: http://www.efw.bpa.gov/ Environment/EW/EWP/DOCS/REPORTS/ HABITAT/H00004343-3.pdf)

Kramer, R. 1953. Completion report by stream clearance unit on Ozette and Big Rivers, April 1953. Unpublished report by Robert Kramer, Supervisor, Stream Clearance Projects, Stream Clearance Division, Washington Dept. of Fisheries. 12 p.

Makah Fisheries Management. 2000. Lake Ozette sockeye hatchery and genetic management plan. Biological Assessment Section 7 consultation. Prepared by Makah Fisheries Management for Bureau of Indian Affairs. October 23, 2000.

Meier, R. 1998. Letter from R. Meier (Rayonier Northwest Forest Resources) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 22 June 1998, re. "Comments on 'Endangered and threatened species: proposed threatened status and designated critical habitat for Ozette Lake, Washington sockeye salmon.'" 9 pp. + attachments.

NMFS (National Marine Fisheries Service). 1990. STATUS REVIEW: Listing Endangered and Threatened Species; Notice of Status Review for Sockeye Salmon (*Oncorhynchus nerka*). Federal Register [April 9, 1990] 55(68):13181-13182.

NMFS (National Marine Fisheries Service). 1991a. PROPOSED RULE: Endangered and Threatened Species; Proposed Endangered Status for Snake River Sockeye Salmon. Federal Register [Docket 910379-107, April 5, 1991] 56(66):14055-14067.

NMFS (National Marine Fisheries Service). 1991b. FINAL RULE: Endangered and Threatened Species; Endangered Status for Snake River Sockeye Salmon. Federal Register [Docket 910379-1256, November 20, 1991] 56(224):58619-58624.

NMFS (National Marine Fisheries Service). 1995. Federal Register Vol. 60, No. 74, [I.D. 040795A] Endangered and Threatened Wildlife and Plants; Notice of Availability of a

Proposed Recovery Plan for Review and Comment; Public Hearings. April 18, 1995. p. 19388.

NMFS (National Marine Fisheries Service). 1998. PROPOSED RULE: Endangered and threatened species: Proposed threatened status and designated critical habitat for Ozette Lake, Washington sockeye salmon. Federal Register [Docket 980219043-8043-01, March 10, 1998] 63(46):11750-11771.

NMFS (National Marine Fisheries Service). 1999. FINAL RULE: Endangered and Threatened Species; Threatened Status for Ozette Lake Sockeye Salmon in Washington. Federal Register [Docket 980219043–9068–02, March 25, 1999] 64(57):14528-14536.

Ricker, W. E. 1938. "Residual" and kokanee salmon in Cultus Lake. J. Fish. Res. Board Can. 4(3):192-218.

Rieman, B. E., D. L. Myers, and R. L. Nielsen. 1994. Use of otolith microchemistry to discriminate *Oncorhynchus nerka* of resident and anadromous origin. Can. J. Fish. Aquat. Sci. 51:68-77.

SSHAG (Salmon Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum Salmon, Coho Salmon, Chinook Salmon, and Steelhead within Listed and ESUs. Technical review draft. NMFS Northwest and Southwest Fisheries Science Centers.

Waples, R. S. 1991a. Pacific salmon, Oncorhynchus spp., and the definition of "species" under the Endangered Species Act. Mar. Fish. Rev. 53(3):11-22.

Waples, R. S., O. W. Johnson, and R. P. Jones, Jr. 1991. Status review for Snake River sockeye salmon. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-195, 23 p.

Waples, R. S., P. B. Aebersold, and G. A. Winans. 1997. Population genetic structure and life history variability in *Oncorhynchus nerka* from the Snake River Basin. Final Report of Research, Bonneville Power Administration, Portland, OR, 104 p.

NMFS (National Marine Fisheries Service). 1999. Status review update for sockeye salmon from Ozette Lake and Baker River, Washington. Memo from Memorandum thru U. Varanasi (Northwest Fisheries Science Center, NMFS), to W. Stelle (NWFSC, NMFS), and W. Hogarth (Southwest Fisheries Science Center, NMFS) from M. H. Schiewe (Northwest Fisheries Science Center, NMFS), 17 December 1998. 40 p. + cover letter.

Winans, G. A., P. B. Aebersold, and R. S. Waples. 1996. Allozyme variability of *Oncorhynchus nerka* in the Pacific Northwest, with special consideration to populations of Redfish Lake, Idaho. Trans. Am. Fish. Soc. 125:645-663.

Wood, C. C. 1995. Life history variation and population structure in sockeye salmon. *In* J. L. Nielsen (editor), Evolution and the aquatic ecosystem: defining unique units in population conservation. Am. Fish. Soc. Symp. 17:195-216.

D.5. APPENDICES

Appendix D.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of the Ozette Lake sockeye ESU. See "Artificial Propagation" in General Introduction for explanation of the categories.

ESU	Stock	Run	Basin	SSHAG Category
Ozette Lake	Umbrella Creek		Ozette	1a or 2a, or 1b or 2b

E. CHUM SALMON

E.1 BACKGROUND AND HISTORY OF LISTINGS

Primary contributor: Orlay W. Johnson
(Northwest Fisheries Science Center)

Chum salmon (*Oncorhynchus keta)* are semelparous, spawn primarily in freshwater, and apparently exhibit obligatory anadromy, as there are no recorded landlocked or naturalized freshwater populations (Randall et al. 1987). The species is known for the enormous canine-like fangs and striking body color (a calico pattern, with the anterior two thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) of spawning males. Females are less flamboyantly colored and lack the extreme dentition of the males.

The species has the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its range extends further along the shores of the Arctic Ocean than other salmonids. Chum salmon have been documented to spawn from Korea and the Japanese island of Honshu, east, around the rim of the North Pacific Ocean, to Monterey Bay in California. Presently, major spawning populations are found only as far south as Tillamook Bay on the Northern Oregon coast. The species' range in the Arctic Ocean extends from the Laptev Sea in Russia to the Mackenzie River in Canada. Chum salmon may historically have been the most abundant of all salmonids: Neave (1961) estimated that prior to the 1940s, chum salmon contributed almost 50% of the total biomass of all salmonids in the Pacific Ocean. Chum salmon also grow to be among the largest of Pacific salmon, second only to chinook salmon in adult size, with individual chum salmon reported up to 108.9 cm in length and 20.8 kg in weight (Pacific Fisherman 1928). Average size for the species is around 3.6 to 6.8 kg (Salo 1991).

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum salmon, like pink salmon, usually spawn in coastal areas, and juveniles out migrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

In December 1997 the first ESA status review of west coast chum salmon (Johnson et al. 1997) was published which identified four ESU: 1) Puget Sound/Strait of Georgia ESU, which includes all chum salmon populations from Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca up to and including the Elwha River, with the exception of summer-run chum salmon from Hood Canal; 2) Hood Canal summer-run ESU, which includes summer-run populations from Hood Canal and Discovery and Sequim Bays on the Strait of Juan de Fuca; 3) Pacific coast ESU, which includes all natural populations from the Pacific coasts of California,

Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca; and 4) Columbia River ESU.

In March 1998, NMFS published a federal register notice describing the four ESUs and proposed a rule to list two--Hood Canal summer-run and Columbia River ESUs--as threatened under the ESA (NMFS 1998). In March 1999, the two ESUs were listed as proposed, with the exception that the Hood Canal summer-run ESU was extended westward to include summer-run fish recently documented in the Dungeness River (NMFS 1999a).

The NMFS convened a BRT to update the status of listed chum salmon ESUs coastwide. The chum salmon BRT[1] met in January, March and April 2003 in Seattle, Washington to review updated information on each of the ESUs under consideration.

[1] The Biological Review Team (BRT) for the updated chum salmon status review included, from the NMFS Northwest Fisheries Science Center: Tom Cooney, Dr. Robert Iwamoto, Dr. Robert Kope, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from the NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Steve Lindley; from the NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer; and from the USGS Biological Resource Division: Dr. Reginald Reisenbichler.

E.2.1. HOOD CANAL SUMMER-RUN CHUM SALMON

Primary contributors: Mary Ruckelshaus and Norma Jean Sands
(Northwest Fisheries Science Center)

E.2.1.1. Summary of Previous BRT Conclusions

The status of Hood canal summer-run chum salmon was formally assessed during a coastwide status review (Johnson et al. 1997). In November 1998, a BRT was convened to update the status of the ESU by summarizing information received since that review and comments on the 1997 status review, summarize, and present BRT conclusions concerning ESU delineation and risk assessment for chum salmon in Washington, Oregon, and California (NMFS 1999b).

Status and trends

In 1994, petitioners identified 12 streams in Hood Canal as recently supporting spawning populations of summer-run chum salmon. At the time of the petition, summer-run chum salmon runs in five of these streams may already have been extinct, and those in six of the remaining seven showed strong downward trends. Similarly, summer-run chum salmon in Discovery and Sequim Bays were also at low levels of abundance. Spawner surveys in 1995 and 1996 revealed substantial increases in the number of summer-run chum salmon returning to some streams in Hood Canal and the Strait of Juan de Fuca. However, serious concerns remained (Johnson et al. 1997). First, the population increases in 1995 and 1996 were limited to streams on the western side of Hood Canal, especially the Quilcene River system, while streams on the southern and eastern sides of Hood Canal continued to have few or no returning spawners. Second, a hatchery program initiated in 1992 was at least partially responsible for adult returns to the Quilcene River system. Third, the strong returns to the west side streams were the result of a single, strong year class, while declines in most of these streams have been severe and have spanned two decades. Last, greatly reduced incidental harvest rates in recent years probably contributed to the increased abundance of summer-run chum salmon in this ESU. Spawning escapement to the ESU was estimated to be 10,013 fish in 1997 and 5,290 fish in 1998. Of these totals, 8,734 spawners in 1997 and 3,959 spawners in 1998 returned to streams with supplementation programs.

Previously reported threats

A variety of threats to the continued existence of the summer-run chum salmon populations in Hood Canal were identified in the status review (Johnson et al. 1997), including degradation of spawning habitat, low river flows, possible competition among hatchery fall chum salmon juveniles and naturally produced summer-run chum salmon juveniles in Hood Canal, and high levels of incidental harvest in salmon fisheries in Hood Canal and the Strait of Juan de Fuca.

Previous BRT conclusions

The status of the Hood Canal summer-run chum salmon ESU was last reviewed in November 1998, where they concluded that the ESU was likely to become endangered in the

foreseeable future. The primary concerns of the BRT relating to ESU status were low current abundance relative to historical, extirpation of historical populations on the eastern part of Hood Canal, declining trends, and low productivity. Other concerns included the increasing urbanization of the Kitsap Peninsula, recent increases in pinniped populations in Hood Canal, and the fact that recent increases in spawning escapement have been associated primarily with hatchery supplementation programs. Concerns were mitigated to some extent by recent reforms in hatchery practices for fall chum salmon and measures taken by the state and tribes to reduce harvest impacts on summer-run chum salmon.

Listing status—Threatened

E.2.1.2 New Data and Updated Analyses

ESU status at a glance

Historical peak abundance	N/A
Historical populations	16
Extant populations	8
1999-2002 geometric mean escapement per extant population	10 – 4,500
1999-2002 arithmetic mean escapement per extant population	52 – 4,700
recent (1990-2002) trend per extant population	0.82 – 1.62 (median = 1.17)
long-term trend per extant population	0.88 – 1.08 (median = 0.94)

ESU structure

The Hood Canal summer-run chum salmon ESU is comprised of 16 historically independent populations, eight of which are presumed to be extant currently (Table E.2.1.1). Most of the extirpated populations occur on the eastern side of Hood Canal, and some of the seven putatively extinct stocks are the focus of extensive supplementation programs underway in the ESU (WDFW and PNPTT 2000 and 2001).

Table E.2.1.1. Historical populations of summer-run chum salmon in the Hood Canal ESU (WDFW and PNPTT 2001).

Stock	Status
Union River	Extant
Lilliwaup Creek	Extant
Hamma Hamma River	Extant
Duckabush River	Extant
Dosewallips River	Extant
Big/Little Quilcene River	Extant
Snow/Salmon Creeks	Extant
Jimmycomelately Creek	Extant
Dungeness River	Unknown
Big Beef Creek	Extinct
Anderson Creek	Extinct
Dewatto Creek	Extinct
Tahuya River	Extinct
Skokomish River	Extinct
Finch Creek	Extinct
Chimacum Creek	Extinct

The Hood Canal summer-run chum salmon are part of an extensive rebuilding program developed and implemented since 1992 by the state and tribal co-managers (WDFW and PNPTT 2000 and 2001.) The Summer-run Chum Salmon Conservation Initiative involves six supplementation and two reintroduction projects. The largest supplementation program occurs at the Big Quilcene River fish hatchery, and beginning with the 1997 brood year, all fry from the Quilcene facility have been adipose-fin-clipped. Summer-run chum salmon hatchery fish in Salmon Creek have been thermally marked since 1992, and other supplementation programs in Hood Canal recently have instigated thermal mass-marking of otoliths for distinguishing hatchery- from natural-origin spawners. Reintroduction programs have been initiated in Big Beef and Chimacum creeks. Small numbers of marked fish collected in streams (i.e., $\leq$ 3 per stream) over the 1999-2000 season indicate that some straying of summer-run chum salmon from the Big Quilcene River supplementation program is occurring into other Hood Canal streams (WDFW and PNPTT 2001).

The methods for summary statistics reported below are described in the Methods section of this report. We report summary statistics only for the 8 extant populations of summer-run chum salmon in Hood Canal—where information is available, a few additional populations experiencing hatchery reintroductions or natural recolonization are included in some tables for completeness. More detailed information on the sources, data years and nature of the information reported below is summarized for each population in Appendix A.5.2.

Abundance of natural spawners

Recent 4-year (1999-2002) geometric mean abundance of summer-run chum salmon in Hood Canal streams containing extant populations ranges from 10 to just over 4,500 spawners (median = 576, mean = 1,064) (Table E.2.1.2; Figure E.2.1.1). Estimates for the fraction of hatchery fish in the combined Quilcene and Salmon/Snow populations are as high as 28 - 51%,

indicating that the supplementation program is resulting in spawners in streams (Table E.2.1.2). In addition to the supplementation programs, reintroduction of hatchery fish to previously occupied streams is occurring in Big Beef and Chimacum creeks. Recent geometric mean escapements from those programs are 17 and 198 adults respectively (over 800 adults in a single year returned to each stream), suggesting that hatchery juveniles released several years ago are successfully returning as adults to spawn.

The 8 extant summer-run chum salmon stocks in Hood Canal are spawning in 13 streams that occur primarily on the western side of Hood Canal. The spatial distribution of the summer-run chum salmon populations in Hood Canal is being extended through reintroduction programs in Big Beef and Chimacum creeks, and through an apparent natural re-colonization in the Dewatto River (J. Ames, WDFW, pers. comm.).

Table E.2.1.2. Abundance and estimated fraction of hatchery fish in natural escapements of Hood Canal summer-run chum salmon spawning populations. (Data are from WDFW and PNPTT 2000, 2001, 2003; Puget Sound TRT, unpublished data).

Population	**Current status**	**Recent 4-year geometric mean escapement (min- max) (1999-2002)**	**Recent 4-year arithmetic mean escapement (1999-2002)**	**% hatchery in natural escapement (1995-2001)**
Jimmycomelately[4]	Extant	10 (1-192)	52	NA
Salmon[1]/Snow	Extant	1,521 (463-5,921)	2,441	0-69
Combined Quilcene	Extant	4,512 (3,065-6,067)	4,665	5-51
Lilliwaup[1]	Extant	13 (1-775)	202	NA
Hamma Hamma[3]	Extant	558 (173-2260)	783	NA
Duckabush	Extant	382 (92-942)	507	NA
Dosewallips	Extant	919 (351-1,627)	1,057	NA
Union[5]	Extant	594 (159-1,426)	769	NA
Chimacum	Extinct, reintroduction	198 (0-903)	464	100 (>1999)
Big Beef[2]	Extinct, reintroduction	17 (0-826)	376	100 (>1999)
Dewatto	Extinct, natural recolonization	9 (2-32)	14	NA

[1]supplementation program began in 1992; recent low spawner numbers in Lilliwaup due in part to large fraction of return used for broodstock (J. Ames, WDFW, pers. comm.)
[2]reintroduction program began in 1996
[3]supplementation program began in 1997
[4]supplementation program began in 1999; recent low spawner numbers due in part to large fraction of return used for broodstock (J. Ames, WDFW, pers. comm.)
[5]supplementation program began in 2000

Trends in natural spawners

Long-term trends in abundance for extant naturally spawning populations of summer-run chum salmon in Hood Canal both indicate that only two populations (combined Quilcene and Union rivers) are increasing in abundance over the length of available time series (Table E.2.1.3). The median long-term trend over all populations is 0.94, indicating that most

populations are declining at a rate of 6% per year. The range in long-term trend across the extant populations in Hood Canal is from 0.88 in the Jimmycomelately and Lilliwaup populations to 1.08 in the Union population. The Quilcene population's positive growth rate is almost surely due to the supplementation program that has been active on that stream.

In contrast to long-term trends, most of the naturally spawning populations of Hood Canal summer-run chum salmon exhibit increasing abundance over the short term—7 of 8 extant populations in the ESU have been increasing in abundance from 1990-2002 (Table E.2.1.3). These recent increases in abundance likely are a reflection of the supplementation programs in some streams and possibly recent improvements in ocean conditions. Short-term median population growth rates (λ) were calculated under two assumptions about the reproductive success of naturally spawning hatchery fish: the reproductive success was 0 (i.e., HO), or the reproductive success was equal to that of wild fish (i.e., H1). Differing assumptions about the reproductive success of hatchery fish only affected calculations of short-term λ for 2 populations because of the dearth of information on the fraction of hatchery fish in time series (Table E.2.1.3). The median short-term λ (1.18) and short-term trend (1.17) over all populations are very similar. The most impressive short-term increase in natural spawner abundance has occurred in the Quilcene population (trend = 1.62, λ = 1.39), where the supplementation program appears to be succeeding in returning natural spawners to the Big and Little Quilcene rivers. The only population with a declining short-term trend and growth rate is the Lilliwaup, where many of the returning spawners have been collected for broodstock in the supplementation program.

Table E.2.1.3. Estimates of long- and short-term trend, short-term median population growth rate ( ), and their 95% confidence intervals for natural spawners in extant Hood Canal summer-run chum salmon populations (data are from the WDFW and PNPTC, unpublished data). Short-term is calculated assuming the reproductive success of hatchery-origin spawners is equivalent to that of wild-origin spawners (in cases where information on hatchery fish is available).

Population	**Data years**	**LT Trend (CI)**	**ST Trend (CI) (1990-2002)**	**ST λ ($\pm$ lnSE) (1990-2002)** [1]
Combined Quilcene	1974 - 2002	1.05 (0.96-1.16)	1.62 (1.31-2.01)	1.39 (0.22)
Dosewallips	1972 - 2002	0.96 (0.90-1.04)	1.25 (0.94-1.63)	1.17 (0.24)
Duckabush	1968 - 2002	0.91 (0.87-0.96)	1.14 (0.96-1.36)	1.1 (0.17)
Hamma Hamma	1968 - 2002	0.90 (0.86-0.94)	1.20 (1.04-1.40)	1.3 (0.19)
Jimmycomelately	1974 - 2002	0.88 (0.84-0.93)	0.82 (0.64-1.03)	0.85 (0.16)
Lilliwaup	1971 - 2002	0.88 (0.83-0.92)	1.00 (0.74-1.37)	1.19 (0.44)
Salmon/Snow	1974 - 2002	0.99 (0.94-1.03)	1.24 (1.12-1.37)	1.23 (0.10)
Union	1974 - 2002	1.08 (1.05-1.12)	1.10 (1.00-1.22)	1.15 (0.10)

[1]Estimates of the fraction of hatchery fish are available only for the combined Quilcene and Salmon/Snow populations for the years 1995-2000.

Updated information on potential threats

The Puget Sound TRT (unpublished data) has estimated annual fishery exploitation rates for each summer-run chum salmon population in the ESU (Table E.2.1.4). Exploitation rates are calculated as the percentage of the total return that is caught in fisheries (i.e., total return = catch

+ broodstock take + escapement). The estimated numbers of adults harvested (i.e., catch) from Washington and Canadian fisheries are supplied by the co-managers (Nick Lampsakis, PNPTT, pers. comm.). Catch data are available for Hood Canal summer-run chum salmon from 1974 to present.

Table E.2.1.4 Average annual exploitation rates on populations of Hood Canal summer-run chum salmon during three time periods within the period 1974 – 2002. (data source: Puget Sound TRT and WDFW and PNPTT co-managers, N. Lampsakis, pers. comm.).

Population	**1974-1978 mean exploitation rate (%)**	**1979-1997 mean exploitation rate (%)**	**1998-2002 mean exploitation rate (%)**
Combined Quilcene	28	64	13
Lilliwaup	55	43	3
Dosewallips	15	34	3
Duckabush	15	34	3
Hamma Hamma	15	34	3
Jimmycomelately	8	17	1
Union	56	43	5
Salmon/Snow	11	18	1
Mean	25	36	4
Median	15	34	3
Anderson	13	34	extinct
Big Beef	15	10	extinct
Dewatto	55	37	extinct
Tahuya	56	39	extinct
Mean	35	30	
Median	35	36	

Exploitation rates on the eight extant Hood Canal summer-run chum salmon populations averaged 25% (median = 15%; range 8%-56%) in the earliest 5 years of data availability (1974-1978). The annual exploitation rates increased in the 1980s as a result of increased coho fisheries in the area, and they have since dropped to an average of 4% (median = 3%; range 1%-13%) in the most recent 5-year period, 1998-2002 (Table E.2.1.4). The most intensive harvest occurred on Hood Canal summer-run chum salmon during the period 1979-1991, when the total exploitation rate on the aggregate of Hood Canal summer-run stocks reached up to 81% in 1989 (WDFW and most recent run reconstruction from N. Lampsakis, PNPTT). During the high harvest years (1979-1991), exploitation rates on the eight extant individual summer-run chum salmon populations averaged 47% (median = 44%; range 21%–86%).

Estimates of hatchery strays to Hood Canal tributaries have been made only recently, coinciding with the instigation of hatchery programs to supplement summer-run chum salmon spawning on some streams. Releases of hatchery fish in the tributaries began in 1992 for the Big Quilcene and Salmon Rivers, so estimates of returning adult hatchery fish presently are available only for those streams (Table E.2.1.5). The marking of hatchery-origin fish has begun recently

in a number of streams (fin clips began in Quilcene in 1997, otolith marks: 1992 in Salmon Creek, 1997 in Lilliwaup, Hamma Hamma; 1998 in Big Beef Creek; 1999 in Chimacum and Jimmycomelately creeks; 2000 in Union River). Therefore, distinguishing hatchery-produced from naturally-born summer-run chum salmon will not be possible in most Hood Canal streams until 2001 at the earliest.

Table E.2.1.5. Average estimated annual returns of hatchery summer-run chum salmon to the spawning grounds of extant populations of summer-run chum salmon in Hood Canal (WDFW and PNPTT 2000 & 2001; Puget Sound TRT, unpublished data).

Population	**Year that supplementation program started with broodstock takes**	**Average annual hatchery return to stream (min-max)** [1]	**Hatchery return years**
Combined Quilcene	1992	941 (241 – 1619)	1995 - 2002
Dosewallips	None	NA	
Duckabush	None	NA	
Hamma Hamma	1998	NA	
Jimmycomelately	1999	NA	
Lilliwaup	1992	NA	
Salmon/Snow	1992	78 (2 – 319) [2]	1995 - 2002
Union	2000	NA	

[1] Estimated for Salmon River only.

Information on recent releases of hatchery juvenile summer-run chum salmon into Hood Canal streams is reported in Table E.2.1.6. Average annual juvenile summer-run chum salmon releases in streams receiving hatchery fish ranged from 15,000 – 320,000 (average = 92,000) juveniles per year between 1993 and 2001. The SSHAG group identified all hatchery stocks of Hood Canal summer-run chum salmon as category “1a” or “1b” (Appendix E.5.1).

Table E.2.1.6. Numbers of hatchery-origin juvenile summer-run chum salmon released into Hood Canal streams from 1993-2001. (B. Waknitz, unpublished data)

Watershed	Dates	Hatchery	Stock	Release Site	Total	Annual Mean
Salmon Creek	1995-2001	Salmon Creek	Salmon Creek	SalmonCreek	366,743	52,391
Jimmycomelately Creek	2000-2001	Jimmycomelately Creek	Jimmycomelately Creek	Jimmycomelately Creek	29,780	14,890
Chimacum Creek	1999-2001	Chimacum Creek	Salmon River	Chimacum Creek	248,148	82,716
Big Quilcene River	1993-2001	Quilcene NFH	Big Quilcene River	Big Quilcene River	2,918,878	324,319
Hamma Hamma River	1998-2001	Hood Canal	Hamma Hamma	John Creek	121,000	30,250
Lilliwaup Creek	1995-1997	Long Live the Kings Lilliwaup	Lilliwaup Creek	Lilliwaup Creek	93,600	31,200
Big Beef Creek	1997-2001	Big Beef Creek	Big Quilcene River	Big Beef Creek	621,332	124,266
Union River	2001	Hood Canal	Union River	Union River	75,876	75,876

Additional potential threats to Hood Canal summer-run chum salmon include negative interactions with hatchery fish (fall chinook, coho, pink, and fall chum salmon) through predation, competition and behavior modification, or disease transfer. The Hood Canal Summer-run Chum Salmon Conservation Initiative reports annually on the predicted risks associated with each of the hatchery species on summer-run chum salmon (WDFW and PNPTT 2000 and 2001). In the original report, the co-managers summarized what they considered to be the most important historical factors for decline for Hood Canal summer-run chum salmon (Table E.2.1.7). Specific mitigation measures have been identified for those hatchery programs deemed to pose a risk to summer-run chum salmon, and most of the mitigation measures had been implemented by 2000. In addition, some programs have been discontinued.

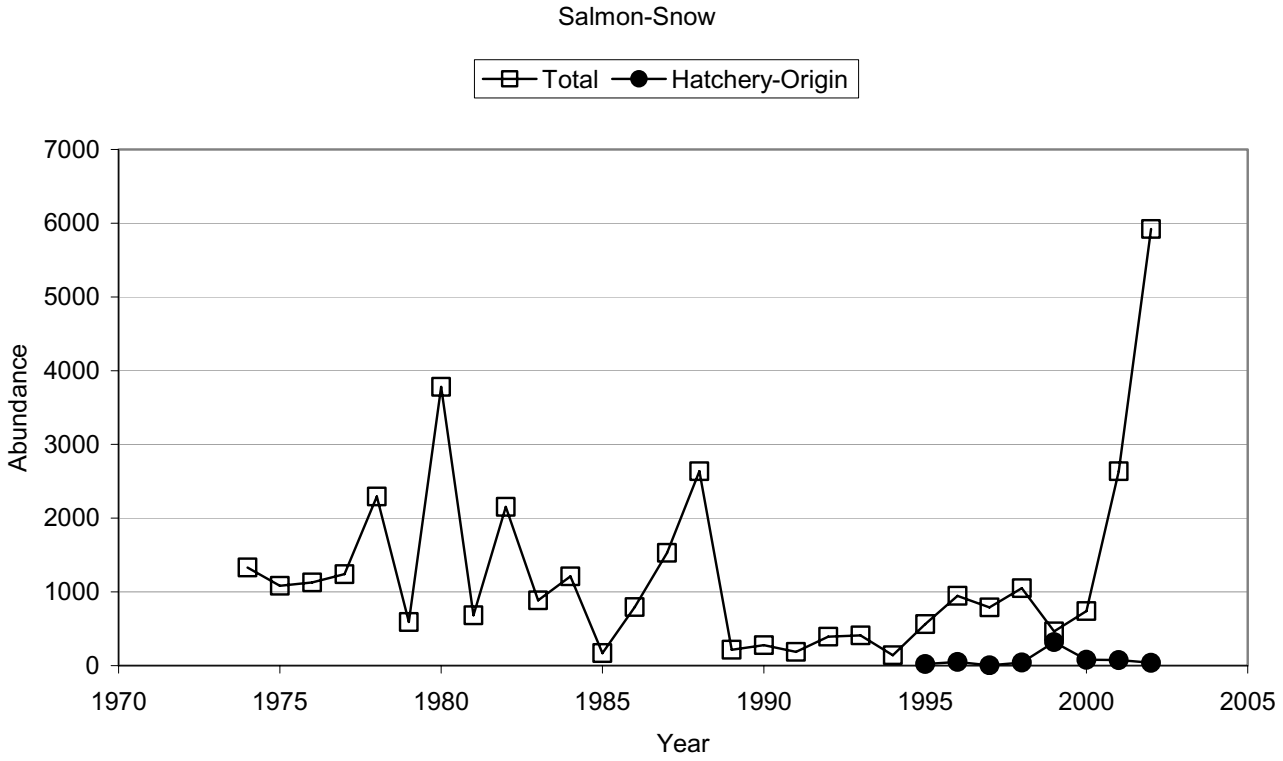
Predation on summer-run chum salmon by marine mammals in Hood Canal has been monitored by WDFW since 1998. The most recent results from these studies estimate that a few harbor seals are killing hundreds of summer-run chum salmon each year (WDFW and PNPTT 2001). Estimates of seal predation ranged from 2% to 29% of the summer-run chum salmon returning to each river annually.

New activities related to mitigating and improving degraded habitat quality in Hood Canal are reported in the Supplemental Report No. 3 under the co-managers' Summer-run Chum salmon Conservation Initiative (WDFW and PNPTT 2001). Such activities include new shoreline management rules issued by Washington Department of Ecology (but no resulting change in shoreline master programs yet), Jefferson County improved some development codes under the Growth Management Act, Clallam County provided limited improvements in upgrading its Critical Areas Ordinance in 1999, and several habitat improvement projects have been funded by the Washington State Salmon Recovery Funding Board. The BRT did not attempt to estimate the collective impacts of these projects on the status of Hood Canal summer-run chum salmon.

Table E.2.1.7. Ratings of region-wide historical factors for decline of summer-run chum salmon in Hood Canal and Strait of Juan de Fuca streams. Impact ratings: +++ Major, ++Moderate, +Low or not likely, and **?** Undetermined (ratings from WDFW and PNPTT 2000).

Factor		**Hood Canal**	**Strait of Juan de Fuca**
Climate	Ocean conditions	**?**	**?**
	Estuarine conditions	**?**	**?**
	Freshwater conditions	++	+++
Ecological Interactions	Wild fall chum salmon	+	+
	Hatchery fall chum salmon	+**?**	+
	Other salmonids (including hatchery)	++	+
	Marine fish	+	+
	Birds	+	+
	Marine mammals	+	+
Habitat	Cumulative impacts	+++	+++
Harvest	Canadian pre-terminal catch	+	++
	U.S. pre-terminal catch	+	+
	Terminal catch	+++	+

Figure E.2.1.1. Hood Canal summer-run chum annual salmon spawner abundance vs. year by population



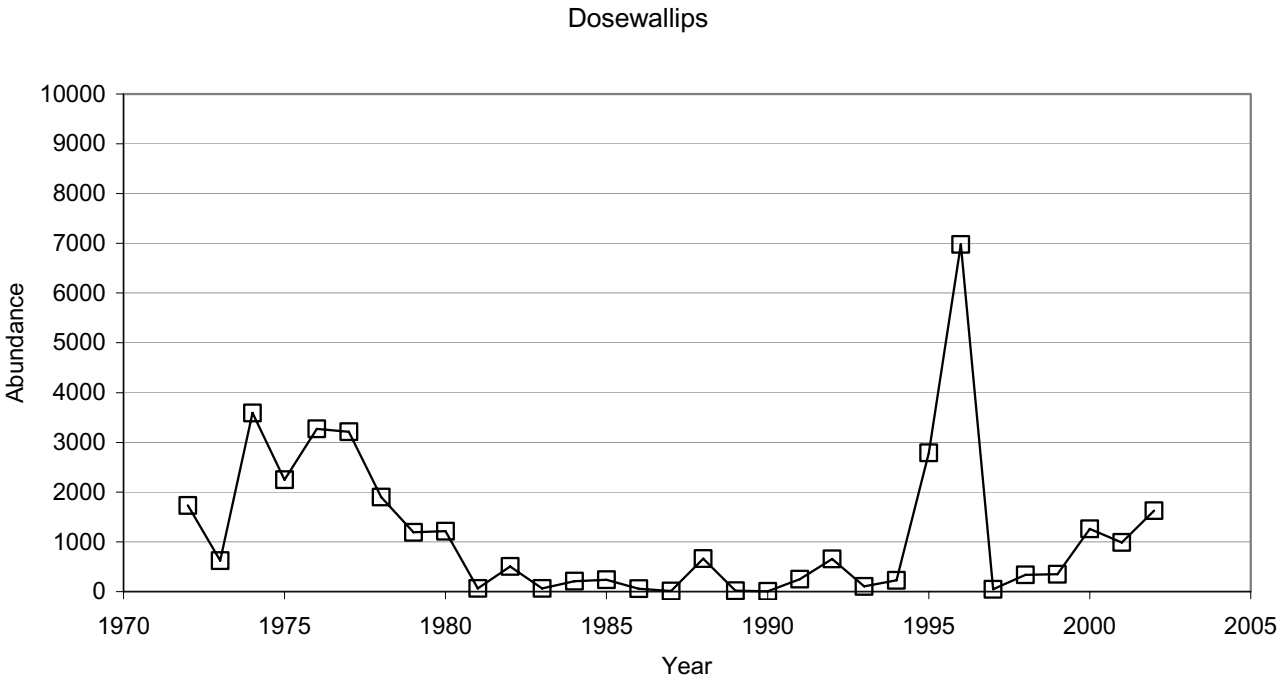
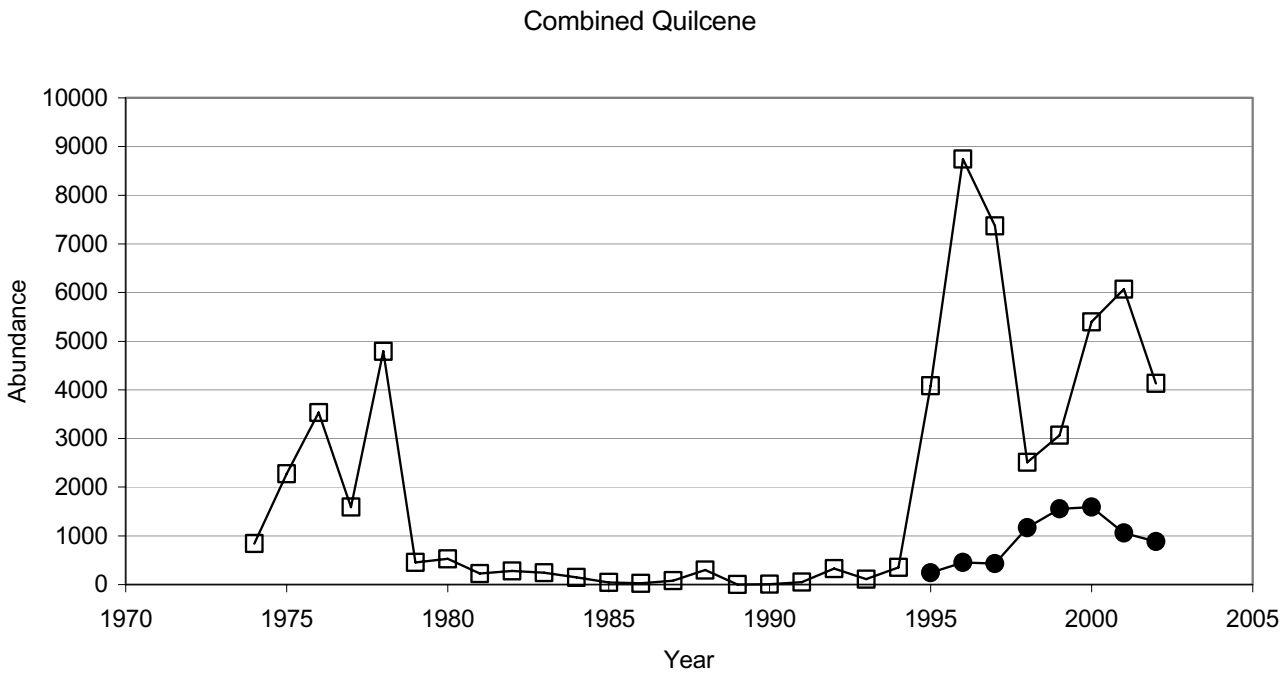


Figure E.2.1.1. (cont.)



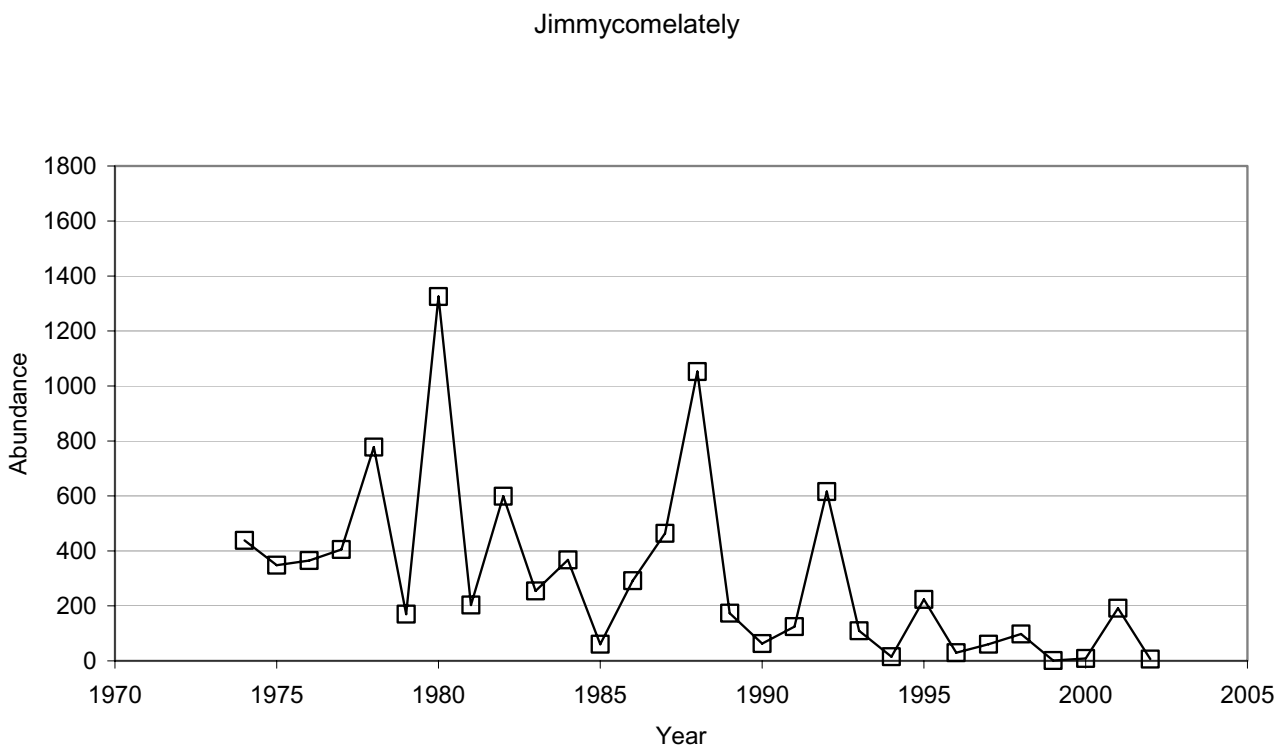
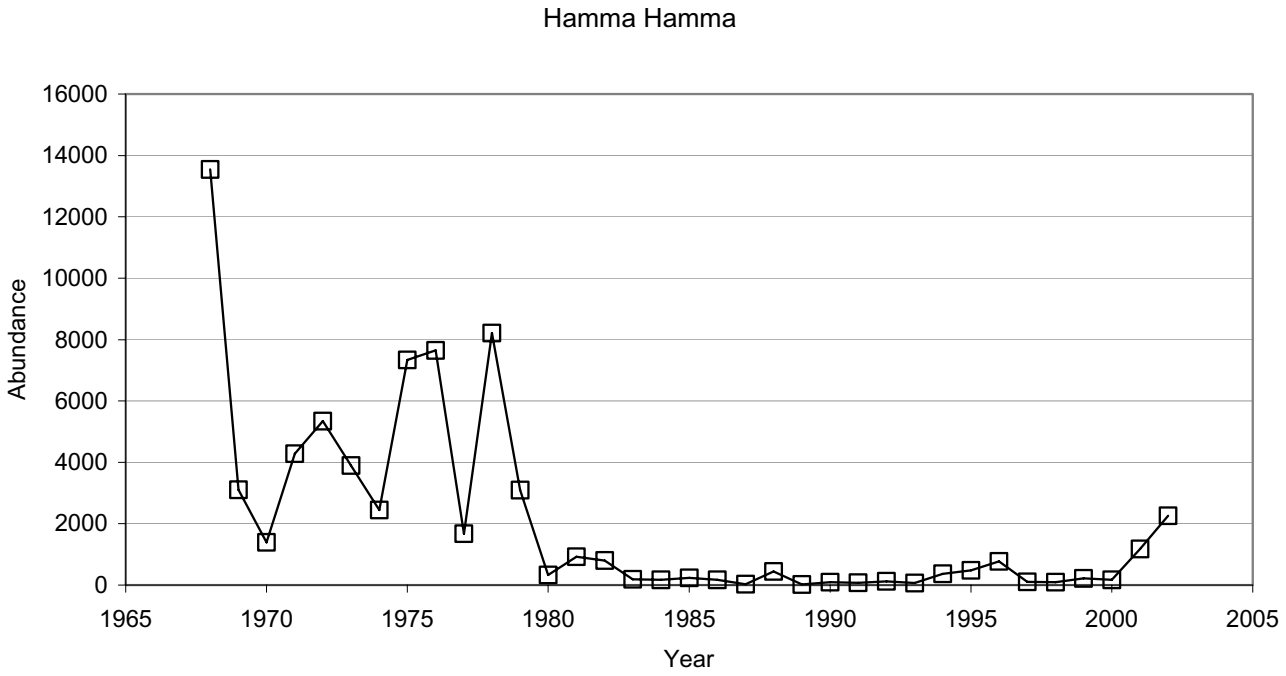


Figure E.2.1.1. (cont.)



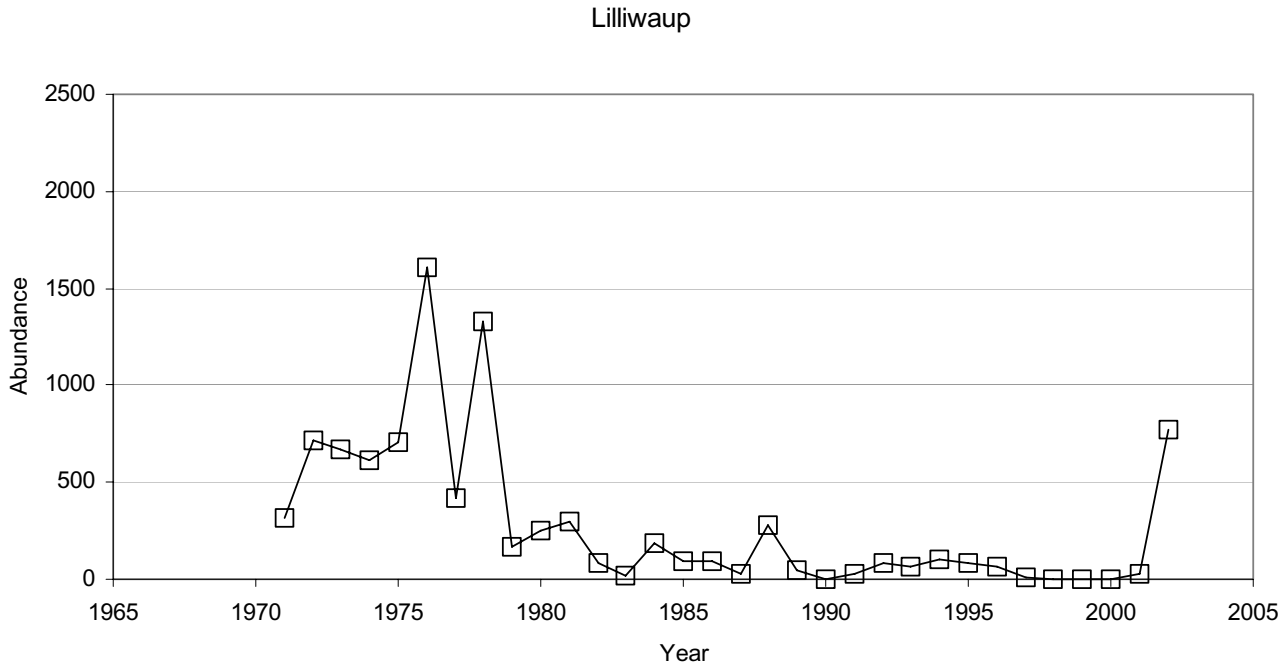


Figure E.2.1.1. (cont.)

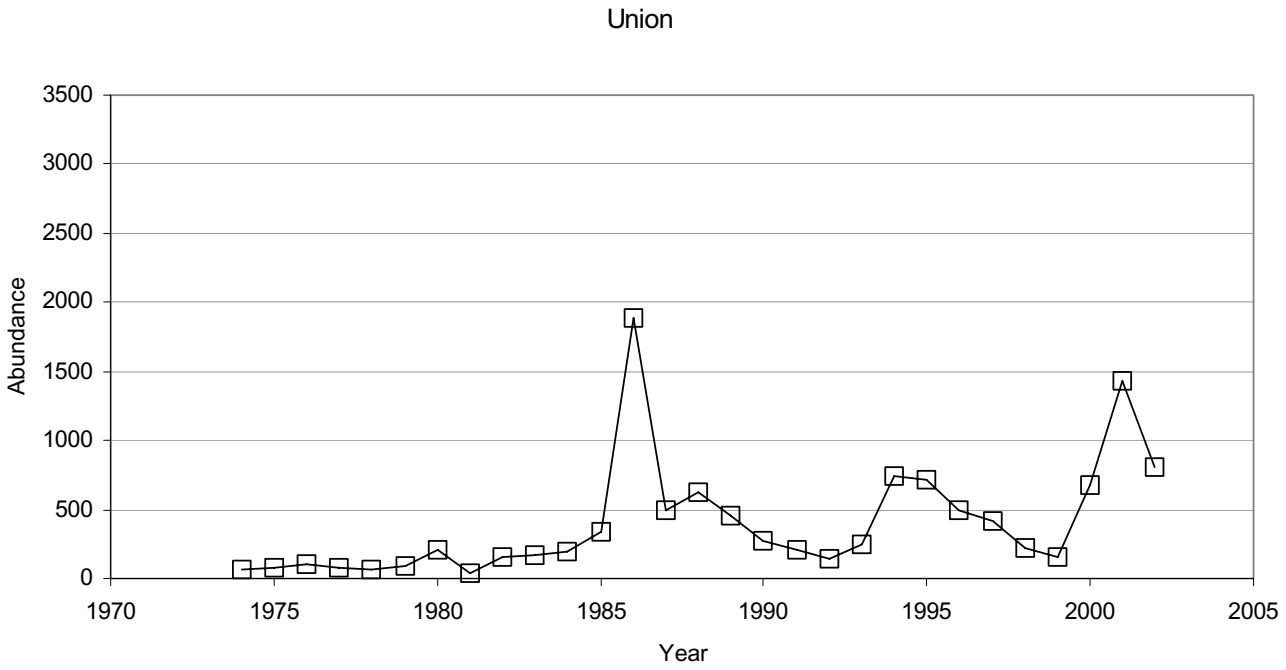
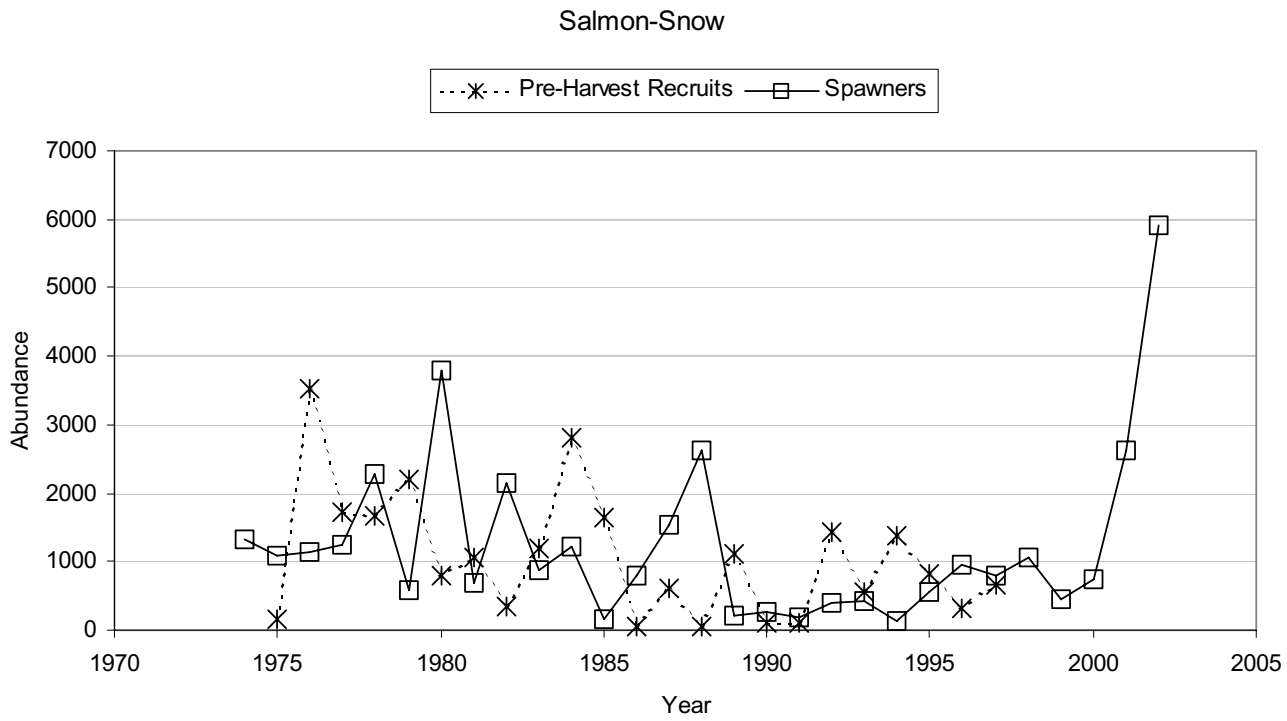


Figure E.2.1.2. Hood Canal summer-run chum recruit and spawner abundance vs. year by population



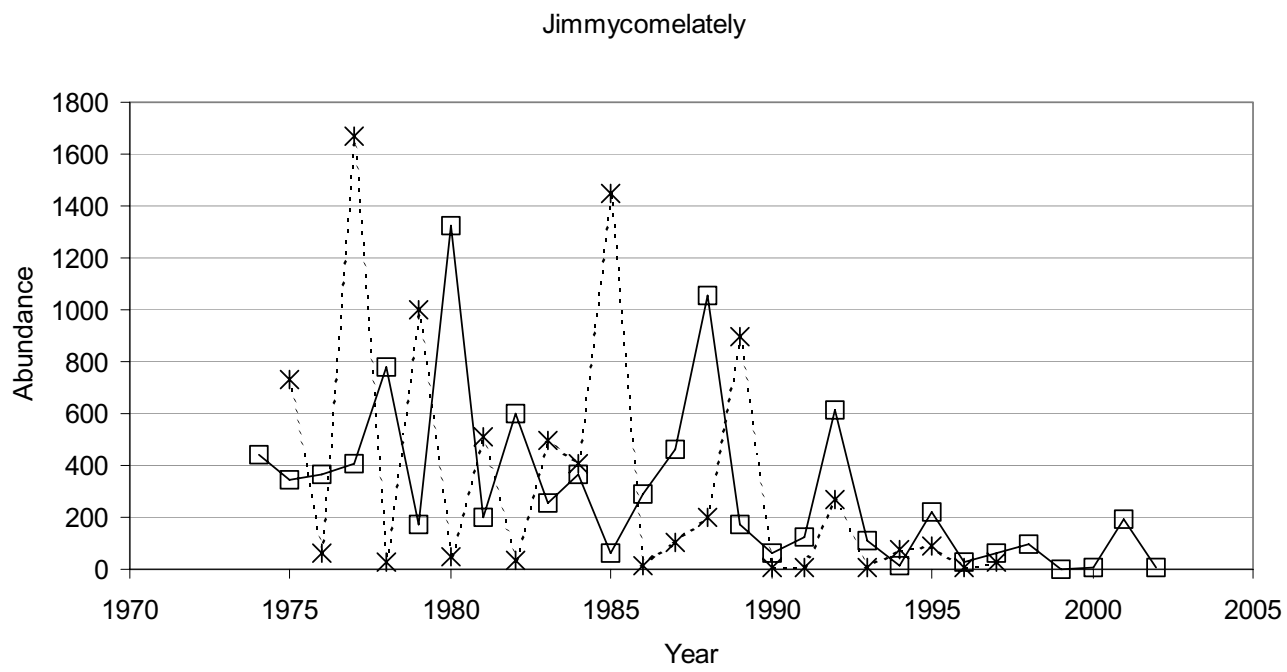
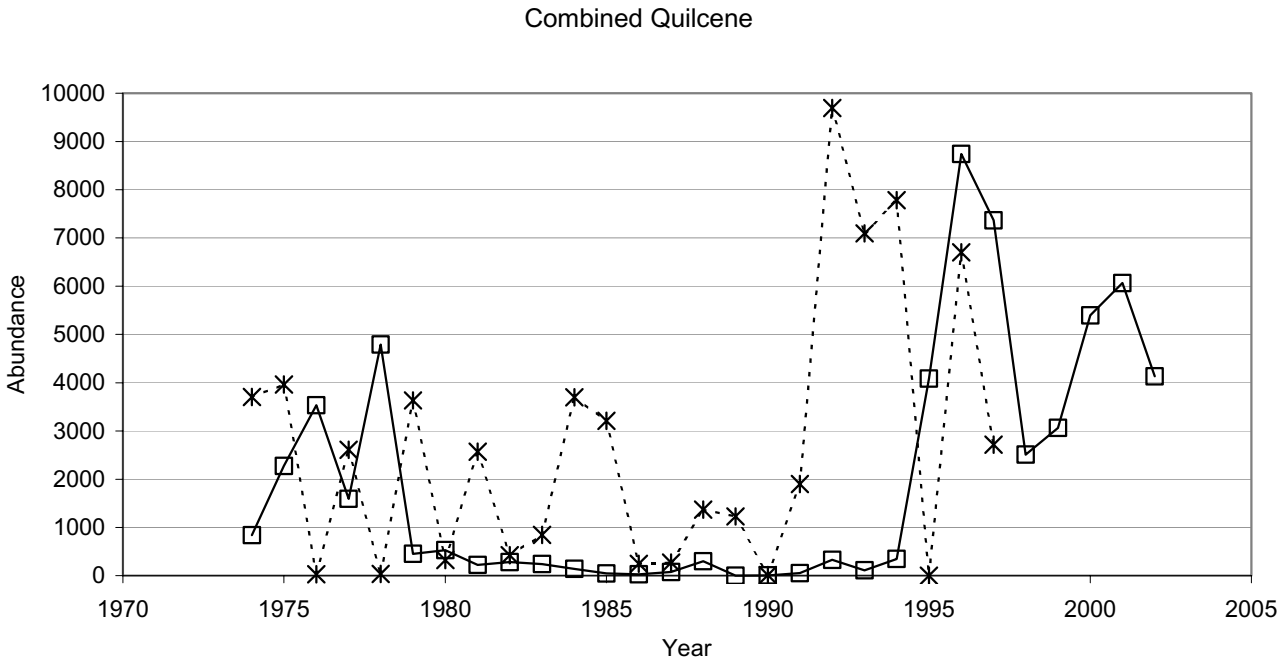


Figure E.2.1.2. (cont.)



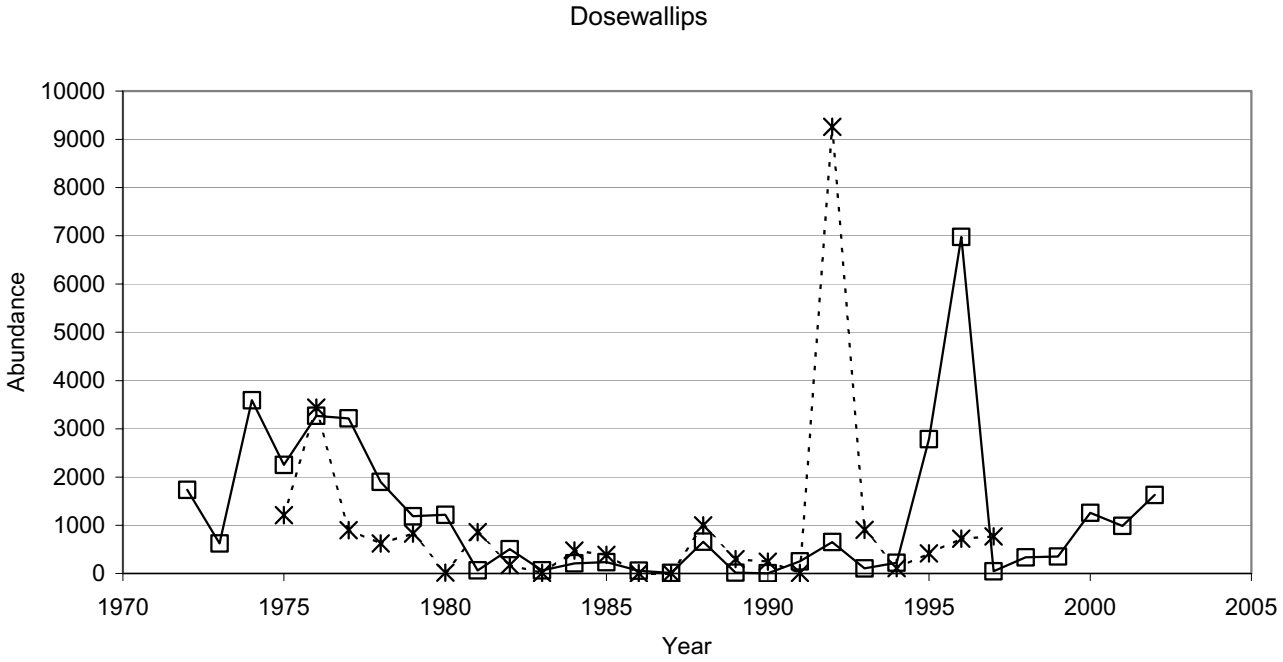
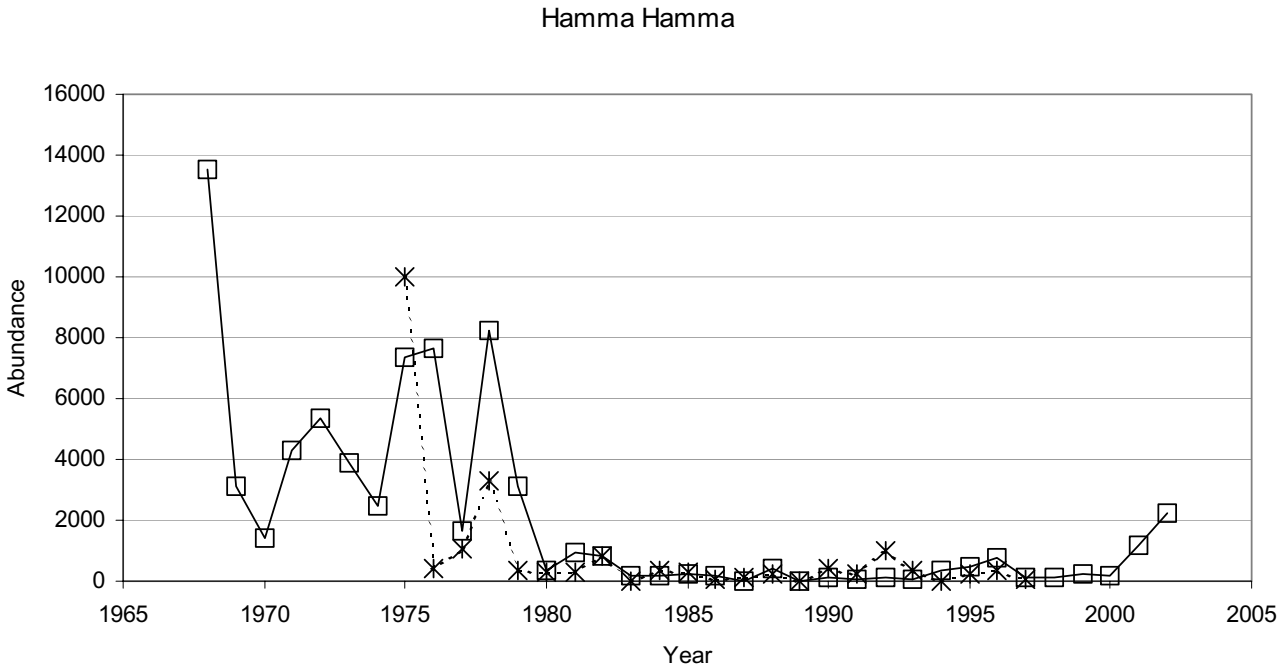


Figure E.2.1.2. (cont.)



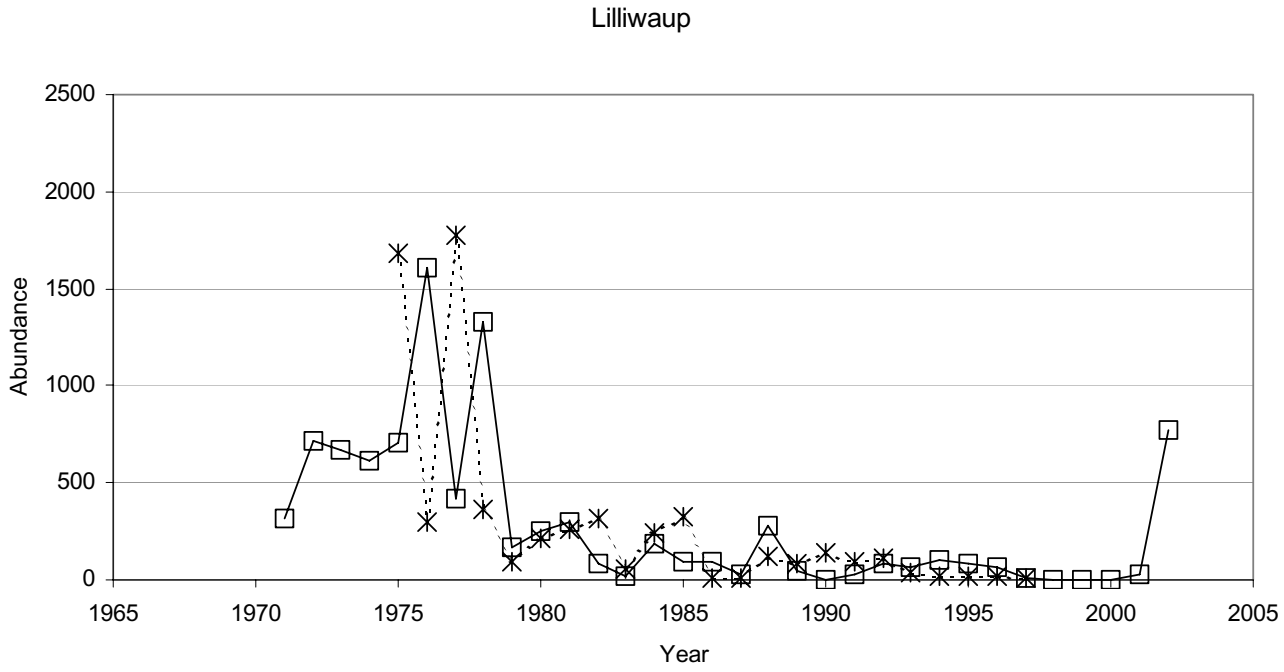
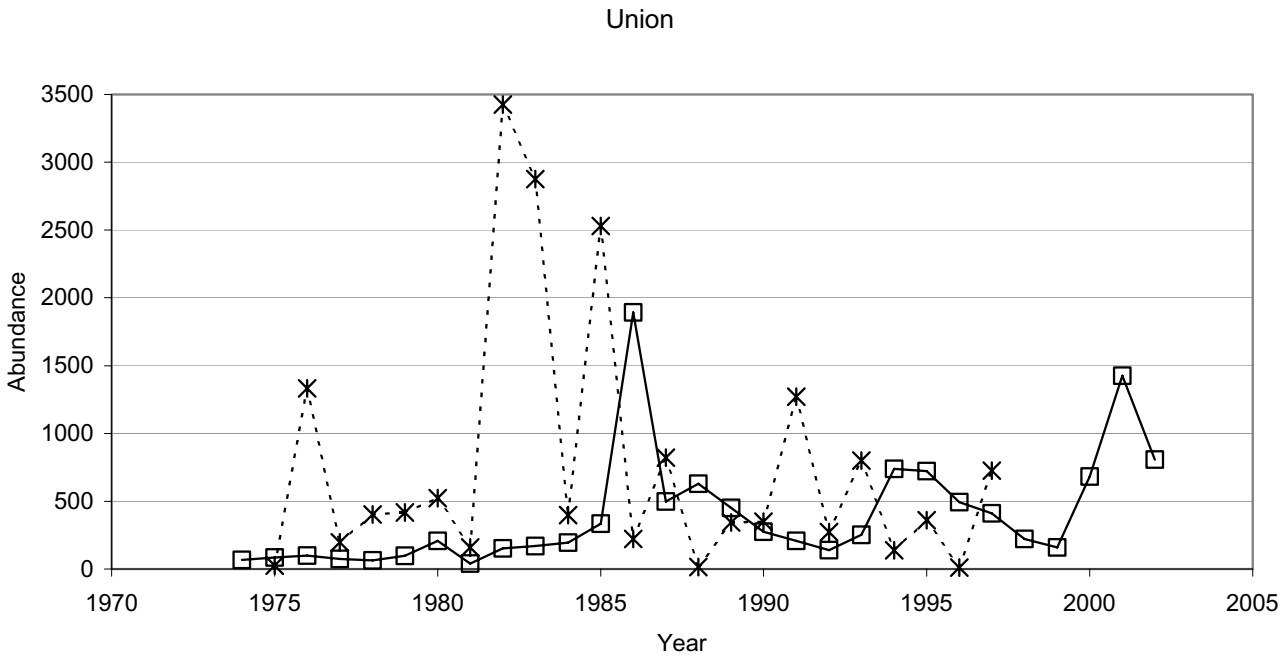


Figure E.2.1.2. (cont.)



E.2.2 LOWER COLUMBIA RIVER CHUM SALMON

Primary contributor: Paul McElhany
(Northwest Fisheries Science Center)

E.2.2.1 Summary of Previous BRT Conclusions

The NMFS last provided an updated status report on Columbia River chum in 1999 (NMFS 1999). As documented in the 1999 report, the previous BRT was concerned about the dramatic declines in abundance and contraction in distribution from historical levels. The previous BRT was also concerned about the low productivity of the extant populations, as evidenced by flat trend lines at low population sizes. A majority of the previous BRT concluded that the Columbia River chum salmon ESU was likely to become endangered in the foreseeable future and a minority concluded that the ESU was currently in danger of extinction.

Current Listing Status—Threatened

E.2.2.2 New Data and Updated Analyses

New data include spawner abundance through 2000, with preliminary estimate of 2002, new information on the hatchery program, and new genetic data describing the current relationship of spawning groups. New analyses include designation of relatively demographically independent populations, recalculation of previous BRT metrics with additional years data, estimates of median annual growth rate (λ), and estimates of current and historically available kilometers of stream.

Results of new analyses

Historical population structure—As part of its effort to develop viability criteria for Columbia River chum salmon, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Myers et al. (2002) hypothesized that the ESU historically consisted of 16 populations (Figure E.2.2.1). The populations identified in Myers et al. (2002) are used as the units for the new analyses in this report.

The WLC-TRT partitioned Columbia River chum salmon populations into a number of "strata" based on ecological zones (McElhany et al. 2002). The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in each of these strata. The strata and associated populations for coho are identified in Table E.2.2.1.

Table E.2.2.1. Historical population structure of Columbia River chum populations. The populations are portioned into ecological zones which are based on ecological community and hydro dynamic patterns. The EDT estimate of historical abundance is based on analysis by WDFW of equilibrium abundance under historical habitat conditions (Busack and Rawding 2003). "ND" indicates no data.

Ecological Zone	Population	EDT Estimate of Historical Abundance
Coastal	Youngs Bay	ND
	Grays River	7,511
	Big Creek	ND
	Elochoman River	ND
	Clatskanie River	ND
	Mill, Abernathy, Germany	ND
	Scappoose Creek	ND
Cascade	Cowlitz River	141,582
	Kalama River	9,953
	Lewis River	89,671
	Salmon Creek	ND
	Clackamas River	ND
	Sandy River	ND
	Washougal river	15,140
Gorge	Lower Gorge Tributaries	>3,141
	Upper Gorge Tributaries	>8,912
	Total	**>283,421**

Abundance, distribution and trends

Chum salmon in the Columbia River once numbered in the hundreds of thousands of adults and, at times, approached a million per year (Figure E.2.2.2). The total number of chum salmon returning to the Columbia River in the last 50 years has averaged perhaps a few thousand per year, returning to a very restricted subset of the historical range (Table E.2.2.2 and Figures E.2.2.2 – E.2.2.3). The status of individual populations is discussed below. References for abundance time series and related data are in Appendix E.5.2. Significant spawning occurs in only two of the 16 historical populations, meaning that 88% of the historical populations are extirpated, or nearly so. The two extant populations are at Grays River and the Lower Gorge (Figure E.2.2.2). The status of individual populations and groups of populations are discussed below.

Grays River—The majority of chum salmon spawning in the Grays River currently occurs in less than 1 mile of the river. Prior to its destruction in a 1998 flood, an artificial spawning channel created by WDFW in 1986, was the location of approximately 50% of the spawning in the Grays River population. Two time series of abundance were available for the Grays River chum salmon population (Table E.2.2.1 and Figures E.2.2.4 -E.2.2.5). One data set by Hymer and others was available on Stream net and covered the years 1944-2000. The other data set covers the years 1967-1998 and was provided by Dan Rawding of WDFW to correct some perceived errors in the expansions used in the Hymer et al. dataset. The Rawding estimates are believed to be more accurate, but both datasets are included in this report because the Hymer et al. series includes estimates both earlier and more recent than the Rawding data set. The Rawding data set shows a small upward trend and λ from 1967-1998 (Table E.2.2.3) and a low probability that the population is declining (Table E.2.2.4). However, the longer Hymer et al. data set indicates both long- and short-term trends are negative over the period 1950-2000, with a high probability that the trend and λ values are less than one. There was insufficient data to estimate the short-term trend (i.e. since 1990) using the Rawding data.

Table E.2.2.2. Recent abundance estimates for subset of Columbia River chum populations. Two different time series estimates are available for the Grays River Population. The majority of Columbia River chum currently spawn as part of either the Grays River or Lower Gorge Populations.

Population		**Years for Recent Means**	**Recent Geometric Mean**	**Recent Arithmetic Mean**
Grays River	Rawding estimate	1994-1998	704	812
	Hymer et al. estimate	1996-2000	331	576
Lower Gorge		1996-2000	425	490

Table E.2.2.3. Trend and growth rate for subset of Columbia chum populations (95% C.I. are in parentheses). The long-term analysis used the entire data set (see Table C.2.4.2 for years). Short-term data sets include data from 1990 to the most recent available year. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. Two different time series estimates are available for the Grays River Population.

Population		**Years of Time Series**	**Long-Term**		**Short-Term**	
			Trend in Abundance	**Median Growth Rate (λ)**	**Trend in Abundance**	**Median Growth Rate (λ)**
Grays River	Rawding estimate	1967-1998	1.058 (1.021-1.096)	1.043 (0.957-1.137)	Not enough data	Not enough data
	Hymer et al estimate	1951-2000	0.990 (0.965-1.016)	0.954 (0.855-1.064)	0.904 (0.661-1.235)	0.807 (0.723-0.900)
Lower Gorge		1950-2000	0.979 (0.961-0.997)	0.984 (0.883-1.096)	1.003 (0.882-1.141)	1.001 (0.899-1.116)

Table E.2.2.4. Probability that the abundance trend or growth rate of Columbia River chum salmon is less than one. The λ calculation is an estimate of what the natural growth rate would have been after accounting for hatchery-origin spawners. Two different time series estimates are available for the Grays River Population.

Population		Years of Time Series	Long-Term		Short-Term	
			Prob. Trend <1	Prob. λ < 1	Prob. Trend <1	Prob. λ < 1
Grays River	Rawding estimate	1967-1998	0.001	0.197	Not enough data	Not enough data
	Hymer et al. estimate	1951-2000	0.776	0.774	0.759	0.934
Lower Gorge		1950-2000	0.987	0.657	0.478	0.494

Final abundance estimates for 2002 are also not available, but preliminary estimates have been received (Rawding, pers. comm.). The preliminary estimates suggest a substantial increase in abundance in 2002 over what has been observed over the last 50 years. Survey crews handled over 7,000 chum salmon carcasses in the Grays River in 2002, but the total population size is in the neighborhood of 10,000 adults (Figure E.2.2.4). However, a new chum salmon hatchery program in the Grays River started in 1999 confounds the abundance estimates as hatchery returns are included in the 10,000 adult estimate. The hatchery fish were otolith marked, so it will be possible to determine the fraction of hatchery-origin spawners once the otoliths are read, but that information is not available at this time. The Chinook River is a sub-population of the Grays River population that had essentially no chum salmon in recent years, prior to 2002 return of hatchery fish. In 2002, a preliminary estimate of 600 chum salmon returned to the Chinook River, suggesting a 1% return of 3-year-olds from the hatchery fish. Potential causes of this increase in 2002 are discussed below. No estimates of 2001 abundance were available from WDFW at the time of this report, though run was described as "…large, though not as large as 2002."

Lower Gorge Population—The Lower Gorge population consists of a number of subpopulations immediately below Bonneville dam. The subpopulations include Hardy Creek, Hamilton Creek, Ives Island, and the Multnomah area. Both the Ives Island and Multnomah area sub-populations spawn in the Columbia mainstem. The time series used for analysis of the Lower Gorge population is based on summing the abundance in the Hardy Creek, Hamilton Creek, and the artificial spawning channel in Hamilton Creek (Tables E.2.2.1- E.2.2.3, Figures E.2.2.6- E.2.2.7). There is some question about whether or not these data provided a representative index of the population, as it does not include the mainstem spawning areas. Chum salmon may alternate between the tributaries and the mainstem, depending on flow conditions, causing counts in only a subset of the population to be poor indicators of the total population abundance in any given year. Base on these data, the population has shown a downward trend since the 1950s and has been at relatively low abundance up to 2000. However, preliminary data indicate that the 2002 abundance has shown a substantial increase estimated at greater than 2,000 chum salmon in the Hamilton and Hardy creeks, plus another 8,000 or more in the mainstem. There have been no hatchery releases in the lower gorge population, so hatcheries are not responsible for this increase in 2002 unless there has been long distance straying from

Grays River (>100 km). Potential causes of the 2002 increase are discussed below. No estimates of 2001 abundance were available from WDFW at the time of this report, though run was described as "…large, though not as large as 2002."

Washougal Population—Chum salmon were recently observed (within the last 3-4 years) to be spawning in the mainstem Columbia River on the Washington side, near the I-205 bridge (at Woods Landing and Rivershore). These spawners would be considered part of the WLC-TRT's Washougal population, as that is the nearest tributary mouth. It is not clear if this is a recently established population or only recently discovered by WDFW. Genetic analysis indicates that the fish currently spawning in this area are more closely related to fish in the lower gorge area than to fish in Grays River (Marshall 2001). In 2000, WDFW estimated 354 spawners at this location (Figure E.2.2.8). As with the two other Columbia chum salmon spawning populations, preliminary data indicate a dramatic increase in 2002. Preliminary estimates put the 2002 abundance of this population in the range of several thousand spawners.

Upper Gorge Population—A large portion of the upper gorge population chum salmon habitat is believed to have been inundated by Bonneville Dam. However, small numbers of chum salmon still pass Bonneville Dam (Figure E.2.2.9). The number of fish passing Bonneville showed some increase in 2002, but not the dramatic increases estimated in the other three populations.

Other Washington populations

In 2000, the Pacific States Marine Fisheries Commission conducted a study to determine the distribution and abundance of chum salmon in on the Washington side of the Columbia River. The results of that survey are shown in Figure E.2.2.8. Very small numbers of chum salmon were observed in several locations, but with the possible exception of the Washougal River mainstem ("I-205) population (discussed above), none of the populations would be considered close to self-sustaining abundances.

Oregon populations

Chum salmon spawn on the Oregon side of the lower gorge population (Multnomah area), but appear to be essentially absent from other populations in the Oregon portion of this ESU. In 2000, ODFW conducted surveys with a similar purpose to the WDFW 2000 surveys (i.e., to determine the abundance and distribution of chum salmon in the Columbia). Out of 30 sites surveyed, only one chum salmon was observed. With the exception of the Lower Gorge population, Columbia chum salmon are considered extirpated, or nearly so, in Oregon.

Reason for 2002 increase in abundance

It is not known why the Columbia chum salmon dramatically increased in abundance in 2002. As of the writing of this draft, the run has just ended and firm abundance estimates are not even available yet. However, several hypotheses have already been floated regarding this increase. These include:

- Improved ocean conditions

- Grays River and Chinook River hatchery program
- Columbia river mainstem flow agreements (the lower gorge population is in the tailrace of Bonneville Dam and subject to hydrosystem induced flow fluctuations)
- Favorable freshwater conditions
- Increased sampling effort (Since the 2000 survey, effort seems to have increased, though this alone certainly does not explain the apparent increase).

These are all possible contributors to the increase, but the reason for the increase is not known, just as it is not known exactly why chum salmon were restricted to low abundance and limited distribution for the last 50 year. It does not appear that chum salmon have expanded their range in 2002 beyond the Grays River, Lower Gorge, and I-205 areas, though not all the data on the 2002 survey has been reported. Since the cause of the 2002 increase is unknown, it is impossible to know if it will continue. The 2002 increase in Columbia River chum parallels a recent increase in Puget Sound chum. It is not known if the reasons for the increase in the two regions are the same.

EDT-based estimates of historical abundance

The Washington Department of Fish and Wildlife (WDFW) has conducted analyses of Columbia River chum salmon populations using the Ecosystem Diagnosis and Treatment (EDT) model, which attempts to predict fish population performance based on input information about reach-specific habitat attributes (http://www.olympus.net/community/dungenesswc/EDT-primer.pdf). WDFW populated this model with estimates of historical habitat condition, which produced the estimates of average historical abundance shown in Table E.2.2.1. There is a great deal of unquantified uncertainty in the EDT historical abundance estimates, which should be taken into consideration when interpreting these data. In addition, the habitat scenarios evaluated as "historical" may not reflect historical distributions, since some areas that were historically accessible but currently blocked by large dams are omitted from the analyses and some areas that were historically inaccessible but recently passable because of human intervention are included. The EDT outputs are provided here to give a sense of the historical abundance of populations relative to each other and an estimate of the historical abundance relative to the current abundance.

Loss of habitat from barriers

An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the Lower Columbia River (Table E.2.2.5). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient). This is likely especially true of chum salmon with seem to prefer particular microhabitats for spawning.

Table E.2.2.5. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0% and 3.5%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0% and 3.5%. The current to historical habitat ratio is the percent of the historical habitat that is currently available. This table does not consider habitat quality.

Population	Potential Current Habitat (%)	Potential Historical Habitat (km)	Current to Historical Habitat Ratio
Youngs Bay	269	287	94
Grays River (Hymer)	229	230	100
Grays River (Rawding)	229	230	100
Big Creek	369	407	91
Elochoman River	242	242	100
Clatskanie River	160	165	97
Mill, Abernathy, Germany	266	306	87
Scappoose Creek	888	1,048	85
Cowlitz River	114	120	95
Kalama River	382	579	66
Lewis River	319	362	88
Salmon Creek	416	471	88
Clackamas River	148	194	76
Sandy River	125	240	52
Washougal river	81	82	99
Lower Gorge Tributaries	55	77	71
Upper Gorge Tributaries			
Total	4,292	5,041	85

E.2.2.3 New ESU Information

Updated information provided in this report, the information contained in previous LCR status reviews, and preliminary analyses by the WLC-TRT suggest that 14 of the 16 historical populations (88%) are extinct or nearly so. The two extant populations have been at low abundance for the last 50 years in the range where stochastic processes could lead to extinction. Encouragingly, there has been a substantial increase in the abundance of these two populations. In addition there are the new (or newly discovered) Washougal River mainstem spawning groups. However, it is not known if the increase will continue and the abundance is still substantially below the historical levels.

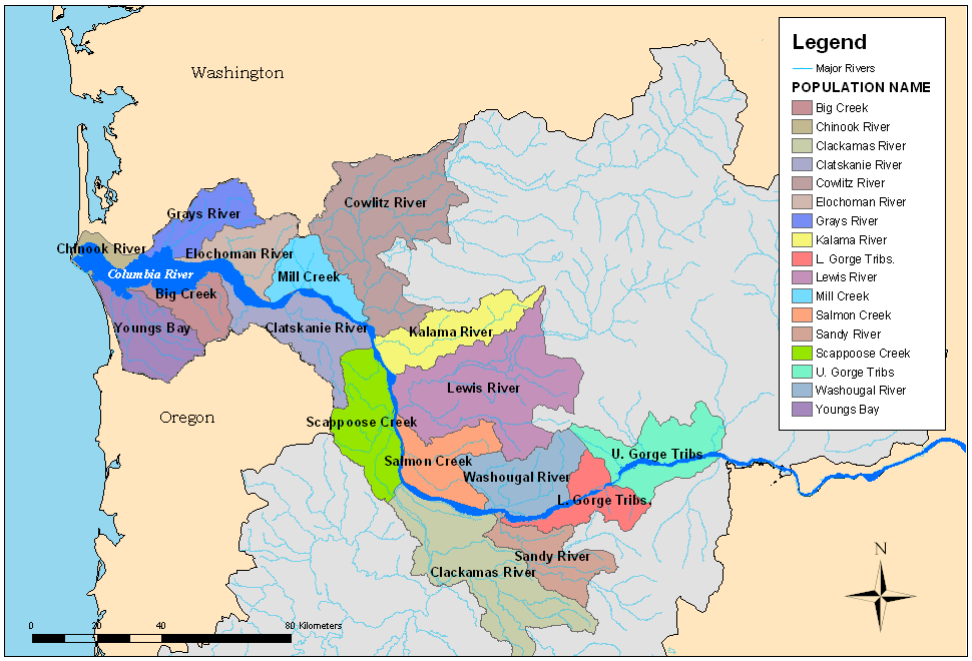


Figure E.2.2.1. Historical chum salmon populations in the Columbia River chum salmon ESU. This map does not reflect the most recent modification of the population designation which merged the Grays River and Chinook River chum salmon into a single population for a total of 16 populations (Myers et al. 2002).

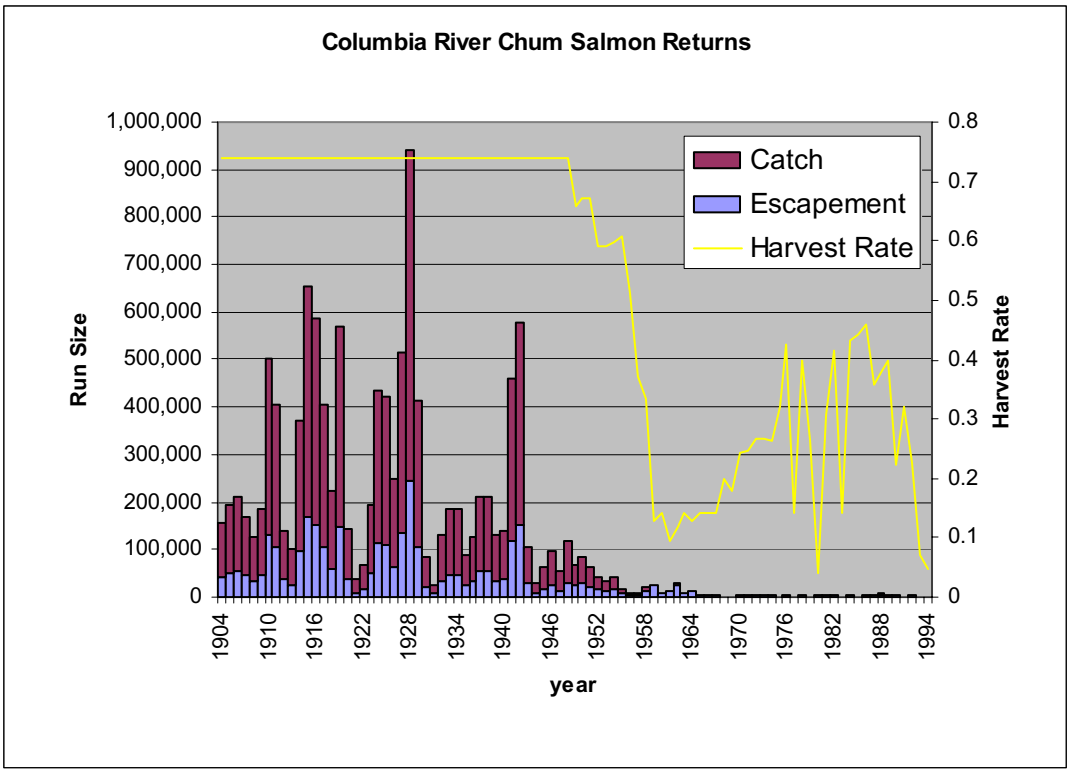


Figure E.2.2.2. Columbia River chum salmon returns.

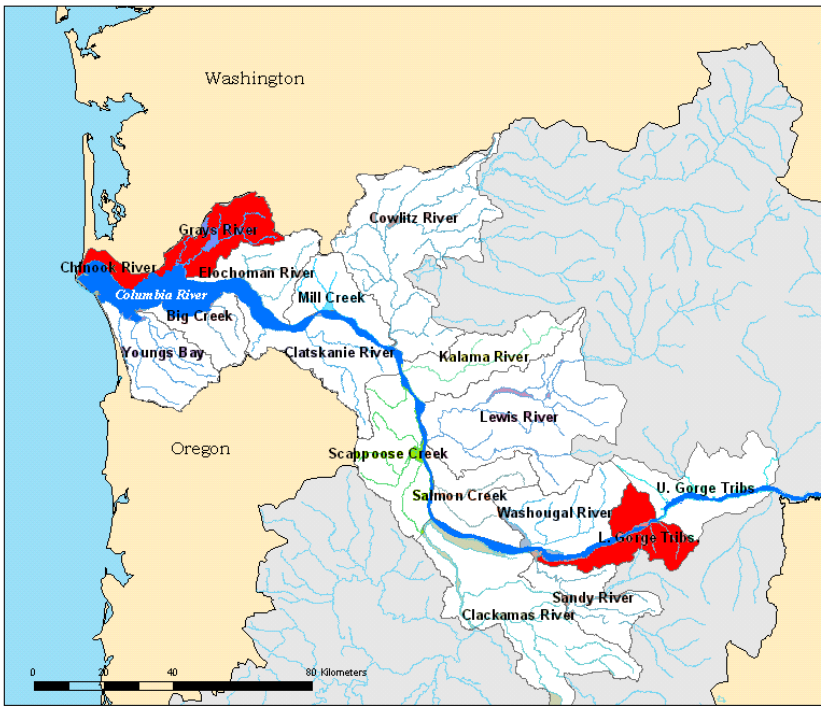


Figure E.2.2.3. Extant Columbia River chum salmon populations.

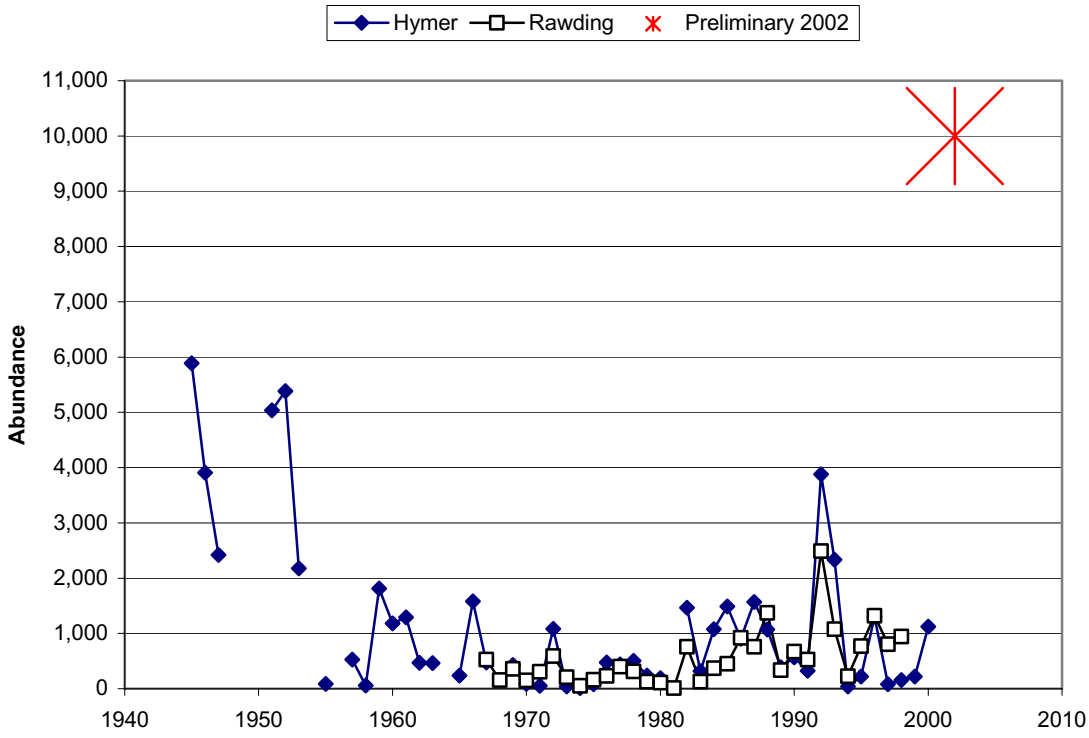


Figure E.2.2.4. Gray's River chum salmon abundance estimate. The two data sets use different information and expansions to estimate the Grays River chum salmon abundance. The 2002 data are preliminary and include an unknown number of hatchery-origin spawners.

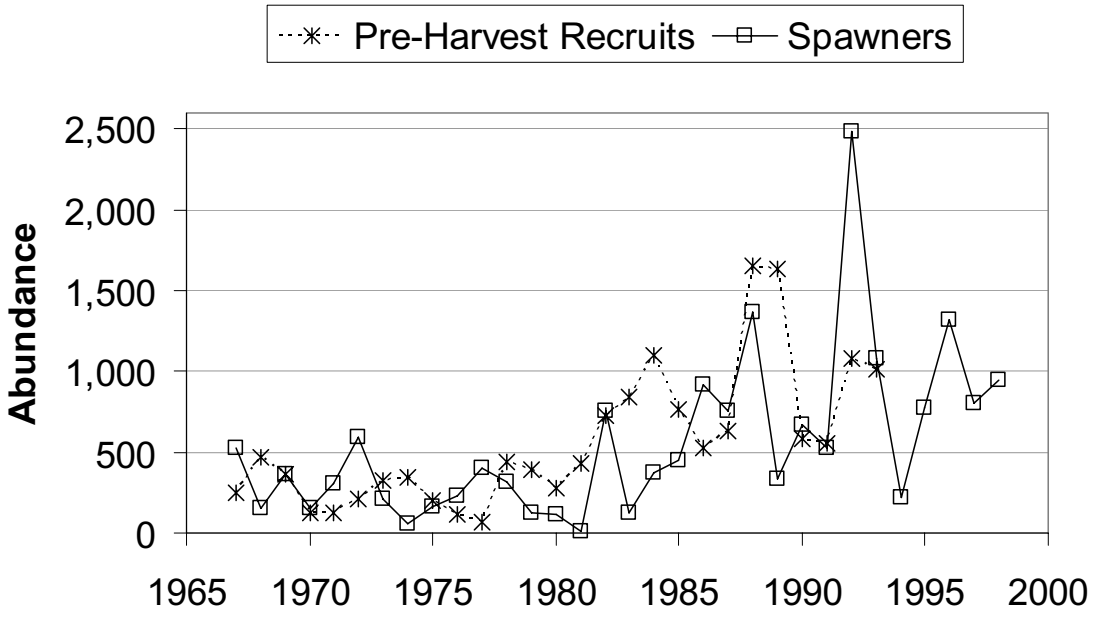


Figure E.2.2.5. Grays River chum salmon recruits and spawners. Based on dataset provided by Rawding (2002; see Appendix E.5.2).

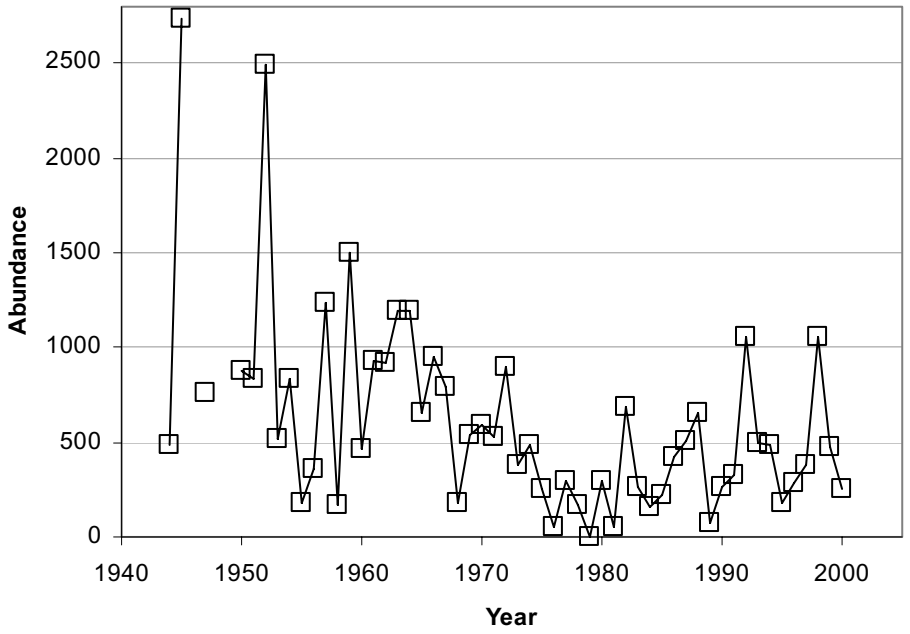


Figure E.2.2.6. Hamilton and Hardy Creek (Lower Gorge population) chum salmon spawner abundance.

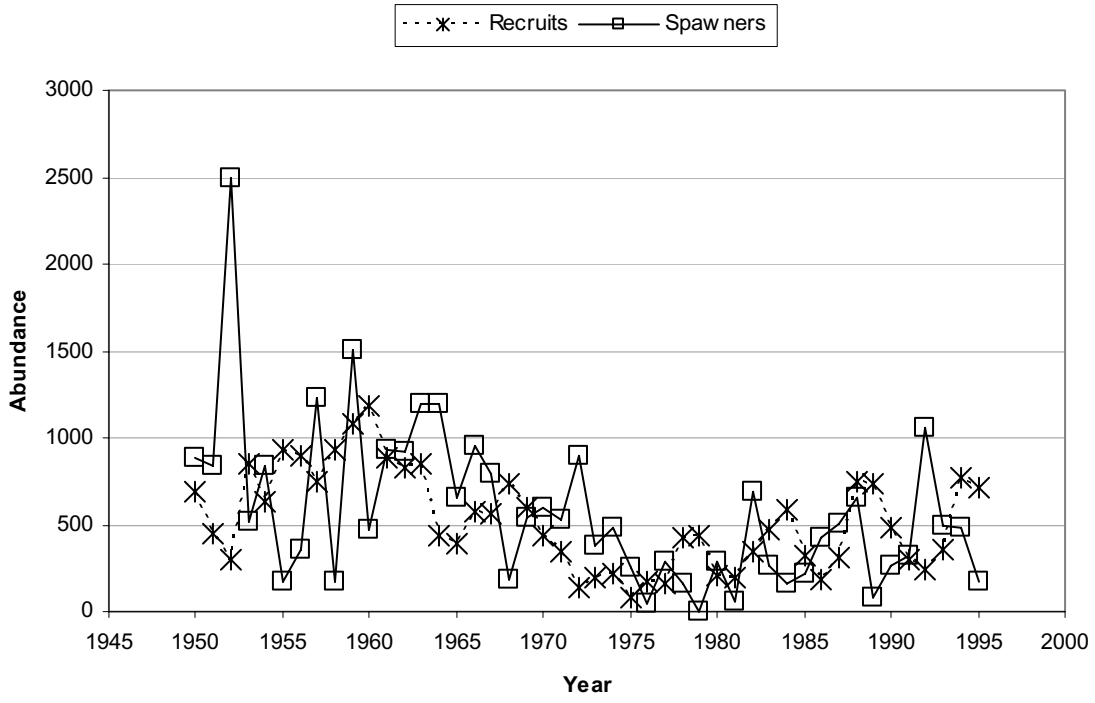


Figure E.2.2.7. Hamilton and Hardy Creek (Lower Gorge population) chum salmon recruits and spawners.

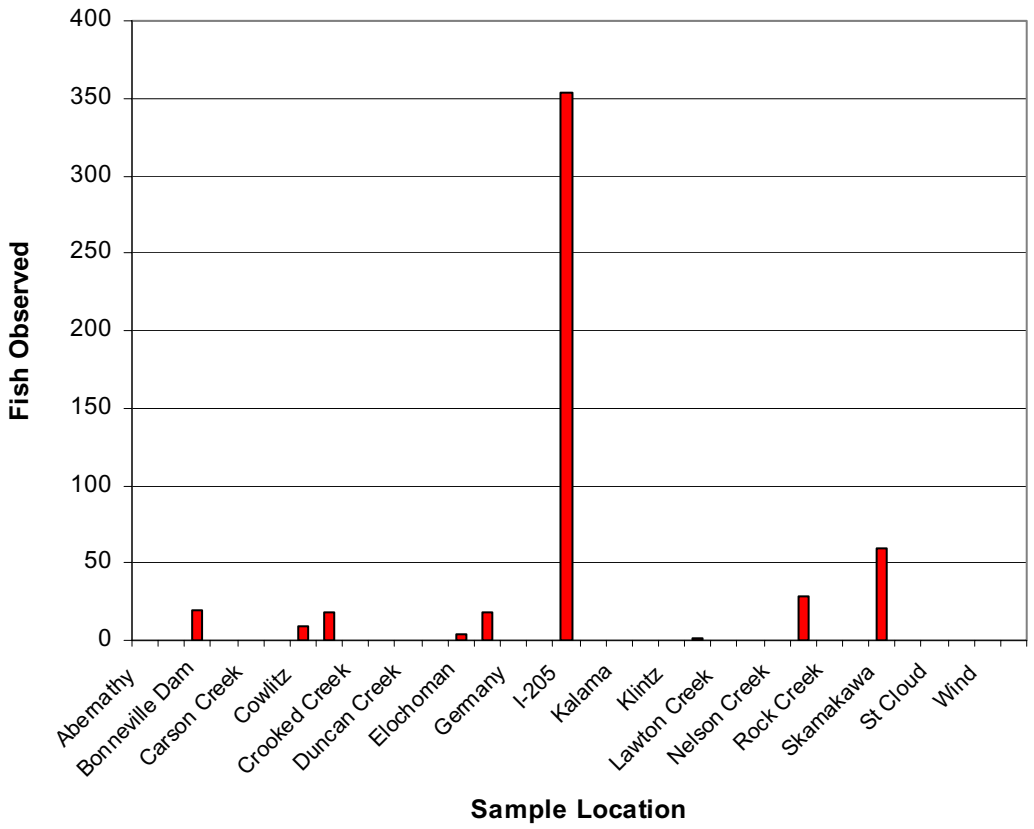


Figure E.2.2.8. Abundance of chum salmon observed in 2000 PSMFC surveys.

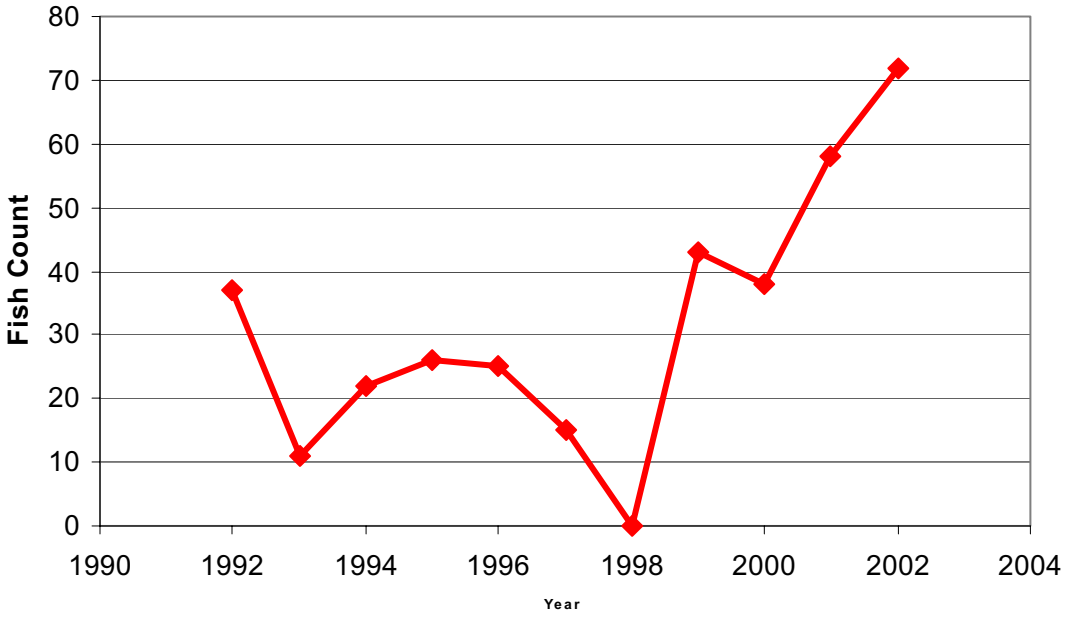


Figure E.2.2.9. Adult chum salmon passing Bonneville Dam.

E.3 CHUM SALMON BRT CONCLUSIONS

Hood Canal summer-run chum salmon ESU

Most of the BRT votes for this ESU fell in the "likely to become endangered" category (74%), with a minority in the "danger of extinction" category (32%) and the balance in the "not likely to become endangered" category (Table E.3.1). Mean risk matrix scores were moderately high (3.4-3.7) for each VSP element (Table E.3.2), reflecting ongoing BRT concerns for the major risks identified in previous assessments. An estimated 7 of 16 historical populations in this ESU have been extirpated, with most of the population losses occurring on the eastern side of Hood Canal. Although many of the remaining populations remain at very depressed levels, adult returns in a number of streams increased in 2000-2002. Harvest rates have been reduced considerably since their peaks in the 1980s, which should help facilitate recovery if other limiting factors are addressed. The BRT felt that the joint state/tribal Summer Chum Salmon Conservation Initiative represented a positive step toward recovery of this ESU. However, although the Initiative includes guidelines for habitat restoration, implementation of habitat actions is largely outside its jurisdiction. In particular, the BRT remains concerned that widespread loss of estuary and lower floodplain habitat is an ongoing risk factor for this ESU. A number of supplementation programs have been initiated in recent years to help boost abundance of local populations. Although these programs may help speed recovery of existing populations and/or reseed vacant habitat, the BRT found it difficult to assess the current effects of these programs because of the inability to distinguish most hatchery and wild fish. More intensive marking programs have been implemented recently, and this should make it easier to monitor natural production of summer chum salmon in the future.

Lower Columbia River chum salmon ESU

Nearly all of the likelihood votes for this ESU fell in the "likely to become endangered" (63%) or "danger of extinction" (34%) categories (Table E.3.1). The BRT had substantial concerns about every VSP element, as indicated by mean risk matrix scores that ranged from 3.5 for growth rate/productivity to 4.4 for spatial structure (Table E.3.2). Most or all of the risk factors identified previously by the BRT remain important concerns. The WLC TRT has estimated that close to 90% of the historical populations in the ESU are extinct or nearly so, resulting in loss of much diversity and connectivity between populations. The populations that remain are small, and overall abundance for the ESU is low. This ESU has showed low productivity for many decades, even though the remaining populations are at low abundance and density dependent compensation might be expected. The BRT was encouraged that unofficial reports for 2002 suggest a large increase in abundance in some (perhaps many) locations. Whether this large increase is due to any recent management actions or simply reflects unusually good conditions in the marine environment is not known at this time, but the result is encouraging, particularly if it were to be sustained for a number of years.

Table E.3.1. Tally of FEMAT vote distribution regarding the status of 2 chum salmon ESUs reviewed by the chum salmon BRT. Each of 13 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Hood Canal summer-run	25	89	6
Lower Columbia River	44	82	4

Table E.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 2 chum salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Hood Canal summer-run	3.7 (3-4)	3.4 (2-4)	3.7 (3-5)	3.5 (2-4)
Lower Columbia River	3.6 (3-4)	3.5 (2-4)	4.4 (4-5)	3.8 (3-5)

E.4 REFERENCES

Busack, C. and D. Rawding. 2003. HPVA results for salmon and steelhead production in Washington Lower Columbia basins. Appendix J in McElhany et al. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific Salmonids. NMFS-NWFSC March 2003.

Hymer, J. 2000. Gray's River Chum Peak Counts. WDFW. Delivered via e-mail from Chris Jordan on May 26, 2000.

Johnson, O.W., W. S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-32, 280 p.

Keller, K. 2001. 1999 Columbia River Chum Return. Columbia River Progress Report 2000-6. WDFW.

Keller, Ken and Richard Bruce. 2001. 2000 Columbia River Chum Return. Columbia River Progress Report 2001-4. WDFW.

Marshall, Anne. 2001. Columbia River mainstem chum genetic samples. Memo to Joe Hymer, WDFW Region 5 dated May 22.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer. NMFS-NWFSC-42.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel and C. Steward. 2003. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific Salmonids. Report from the Willamette/Lower Columbia Technical Recovery Team. NMFS-NWFSC. March 2003.

Miller, R .J. and E. L. Brannon. 1982. The origin and development of life history patterns in Pacific salmonids. Pp. 296-309 in E.L. Brannon and E.O. Salo, eds. Proceedings of the Salmon and Trout Migratory Behavior Symposium. University of Washington, School of Fisheries, Seattle, WA.

Myers, J. M. , C. Busack, D. Rawding, and A. Marshall. 2002. Identifying historical populations of chinook and chum salmon and steelhead within the lower Columbia River and upper Willamette River evolutionary significant units. Draft report to the co-managers from the Willamette/Lower Columbia River Technical Recovery Team (10 May 2002).

NMFS (National Marine Fisheries Service). 1998. Endangered and threatened species: Proposed threatened status and designated critical habitat for Hood Canal summer-run chum salmon and Columbia River chum salmon. Federal Register [Docket 980219043-8043-01, No. 011498B. 10 March 1998] 63(46):11774-11795.NMFS 1998

NMFS (National Marine Fisheries Service). 1999. Endangered and threatened species: Threatened status for two ESUs of chum salmon in Washington and Oregon. [Docket 980219042-9069-02, No. 011498B. 25 March 1999] 64(57):14508-14517.NMFS 1999

Neave, F. 1961. Pacific salmon: Ocean stocks and fishery developments. Proc. 9th Pac. Sci. Congr. 1957(10):59-62.

Pacific Fisherman. 1928. Record chum caught off Quadra. Pac. Fisherman 1928(Oct.):13.

Pitcher, T. J. 1986. Functions of shoaling in teleosts. *In* T.J. Fisher (ed.). The Behavior of Teleost Fishes. Johns Hopkins University Press, Baltimore, Maryland, pp. 294-337.

Randall, R. G., M. C. Healey, and J. B. Dempson. 1987. Variability in length of freshwater residence of salmon, trout, and char. *In* M.J. Dodswell et al. (editors), Common Strategies of Anadromous and Catadromous Fishes. American Fisheries Society Symposia, Bethesda, MD. 1:27-41.

Rawding, Dan (WDFW). 2001c. Hardy Chum data via e-mail.

Salo, E. O. 1991. Life history of chum salmon, *Oncorhynchus keta*. *In* C. Groot and L. Margolis (editors), Pacific salmon life histories, p. 231-309. Univ. B.C. Press, Vancouver, B.C.

SSHAG (Salmon Steelhead Hatchery Assessment Group). 2003. Hatchery Broodstock Summaries and Assessments for Chum Salmon, Coho Salmon, Chinook Salmon, and Steelhead within Listed and ESUs. Technical review draft. NMFS Northwest and Southwest Fisheries Science Centers.

Steel, E. A. and M. B. Sheer. 2002. Broad-scale habitat analyses to estimate fish densities for viability criteria. Appendix C *in* Willamette/Lower Columbia Pacific salmonid viability criteria. Willamette/Lower Columbia Technical Recovery Team Report. December 2002.

WDFW (Washington Department of Fish and Wildlife) and PNPTT (Point no Point Treaty Tribes). 2000. Summer chum salmon conservation initiative. An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca region . 384 pages plus appendices (available at: www.wa.gov/wdfw).

WDFW (Washington Department of Fish and Wildlife) and PNPTT (Point no Point Treaty Tribes). 2001. Summer chum salmon conservation initiative. An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca region. Supplemental Report No. 3. Annual Report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca region. 123 pp. (available at: www.wa.gov/wdfw).

E.5 APPENDICES

Appendix E.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of chum salmon of the two ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

ESU	Stock	Run	Basin	SSHAG Category
Hood Canal summer	Big Quilcene	summer	Quilcene	1a
	Lilliwaup Creek	summer	S. Hood Canal	1a
	Hamma Hamma	summer	S. Hood Canal	1a
	Big Beef Creek	summer	N. Hood Canal	1b
	Salmon Creek	summer	Dungeness	1a
	Chimacum Creek	summer	Dungeness	1b
	Union River	summer	Union	1a
	Jimmycomelately	summer	Dungeness	1a
Lower Columbia River	Sea Resources	fall	Chinook River	1a
	Gorley Creek	fall	Grays	1a
	Hamilton Creek	fall	Gorge	1a
	Washougal/Duncon Creek	fall	Washougal	1a

Appendix A.5.2. Chum Salmon Time Series Data Sources

Hood Canal Chum Salmon ESU

Population	Anderson
Years of Data, Length of Series	1970-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Counts include all ages
Hatchery Reference	
Hatchery Notes	No supplemental hatchery program
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The offshore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Anderson is that from the areas 12B, 12, and 9A.
Age Reference	Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Spawner survey; n=10 fish sampled from 2001-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Big Beef
Years of Data, Length of Series	1968-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap. Includes all ages.
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal communication (Johnson 2003b)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program was started with releases in basin in 1996. No sampling for hatchery marks on escapement grounds, but assume that all returns after 1996 are from hatchery plants since there have been no returns for several years prior.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Big Beef is that from the areas 12B, 12, and 9A.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002

	age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=396 fish sampled from 200-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Big Quilcene
Years of Data, Length of Series	1968-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio) Method - area under the curve, 10 day stream life. Escapement counts include all ages.
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program started in 1992 in the Big Quilcene River. Broodstock is taken from returning fish; eggs are incubated, and fry released into the Big Quilcene.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Big Quilcene is that from areas 82F, 12A, 12B, 12, and 9A.

Age Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	From bay fisheries, spawner surveys; n=3770 fish sampled from 1992-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Chimacum
Years of Data, Length of Series	1999-2002
Abundance Type	?
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal communication (Johnson 2003b)
Abundance Notes	Returns come from recent hatchery plants to system. Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Reintroduction program started in 1996 when eyed eggs were transferred in from Salmon Creek.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to

	spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. There is no terminal catch area for Chimacum.
Age Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=537 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Combined Quilcene
Years of Data, Length of Series	1974-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages.
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	CWT Otolith sampling for hatchery marks
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables

	(Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Quilcene is that from areas 82F, 12A, 12B, 12, and 9A
Age Reference	implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	From bay fisheries, trap, spawner surveys; n=4076 fish sampled from 1992-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dewatto
Years of Data, Length of Series	1968-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	No broodstock take
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point

	Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Dewatto is that from the areas 12C, 12B, 12, and 9A
Age Reference	Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Spawner survey; n=5 fish sampled from 2001-2001. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Dosewallips
Years of Data, Length of Series	1972-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	There are no hatchery releases in basin. There may be some from nearby hatchery summer chum releases, but it is not sampled. Hatchery impact on natural spawners assumed to be zero.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point

	Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Dosewallips is that from the areas 12B, 12, and 9A
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=500 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Duckabush
Years of Data, Length of Series	1968-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	No hatchery releases or broodstock take in the Duckabush
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer

	chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Duckabush is that from fishing areas 12B, 12, 9A.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=326 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Hamma Hamma
Years of Data, Length of Series	1968-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program was started with broodstock takes in 1998; assumed that there was no

	hatchery straying into basin prior to hatchery releases in basin.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The offshore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Hamma Hamma is that from the areas 12B, 12, 9A
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, seine, spawner survey; n=386 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Jimmycomelately
Years of Data, Length of Series	1974-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal communication (Johnson 2003b)
Abundance Notes	Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region

	(WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program started with 1999 broodyear
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The offshore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Jimmycomelately is that from the Sequim area.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=233 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Lilliwaup
Years of Data, Length of Series	1971-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for

	the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program was started with broodstock take in 1992
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The offshore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Lilliwaup is that from the areas 12C, 12B, 12, and 9A
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=233 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Little Quilcene
Years of Data, Length of Series	1968-2002
Abundance Type	Method - area under the curve, 10 day stream life.
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages.

Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program started in 1992 in the Big Quilcene River. Broodstock is taken from Big Quilcene and fry released into the Big Quilcene. Some return to Little Quilcene.
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Little Quilcene is that from the areas 12A, 12B, 12, and 9A.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	From bay fisheries, spawner survey, seine in bay, rack; n=2599 fish sampled from 1992-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Salmon
Years of Data, Length of Series	1971-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal

	communication (Johnson 2003b)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program was started in 1992
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Salmon is that from the Discovery Bay.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=1087 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Salmon/Snow
Years of Data, Length of Series	1974-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan

	de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Salmon and Snow is that from Discovery Bay.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=1227 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Snow
Years of Data, Length of Series	1972-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No.

	3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal communication (Johnson 2003)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	No estimate of hatchery fish contribution to spawners
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Salmon and Snow is that from Discovery Bay.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=140 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Population	Tahuya
Years of Data, Length of Series	1972-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point

	Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, personal communication (Johnson 2003b)
Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	No estimate of hatchery contribution to spawners
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The off shore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Tahuya is that from the areas 12D, 12C, 12B, 12, and 9A.
Age Reference	
Age Notes	No surveys

Population	Union
Years of Data, Length of Series	1974-2002
Abundance Type	Trap count (excluding broodstock take adjustment) plus redd counts downstream of trap
Abundance References	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)

Abundance Notes	Redd count expanded by 2 (assumes 1:1 male female ratio). Escapement counts include all ages
Hatchery Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001)
Hatchery Notes	Supplementation program was started with broodstock take in 2000
Harvest Reference	Summer Chum Salmon Conservation Initiative: An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca Region (WDFW & Point No Point Treaty Tribes 2000); Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Run Reconstruction Tables (Nick Lampkis 2003)
Harvest Notes	The offshore catch includes marine catch from Seattle Area 10, Admiralty Area 9, U.S. Conv. Areas and Canadian Area 20. For summer chum these are assumed to be mature fish returning to spawning grounds. Catches by population/stock are determined from the run reconstruction tables given in the Summer Chum Salmon Conservation Initiative report. The terminal catch for Union is that from the Sequim area.
Age Reference	Summer Chum Salmon Conservation Initiative. Supplemental Report No. 3 Annual report for the 2000 summer chum salmon return to the Hood Canal and Strait of Juan de Fuca Region (WDFW and Point No Point Treaty Tribes 2001); Thom Johnson, unpublished 2001 and 2002 age data, personal communication (Johnson 2003a,b)
Age Notes	Trap, spawner survey; n=317 fish sampled from 1999-2002. Age distribution reconstructed for other years using average cohort distribution weighted by annual abundance of contributing years (Norma Sands)

Columbia River Chum Salmon ESU

Population	Grays River Chum Salmon
Years of Data, Length of Series	1945 - 2000, 34 years
Abundance Type	Live/dead index
Abundance References	Hymer, Joe. 2000; Keller, Ken. 2001; Keller, Ken and Richard Bruce. 2001
Abundance Notes	1999 and 2000 data downloaded from Streamnet; references are Keller and Keller and Bruce
Hatchery Reference	Rawding, Dan (WDFW). 2001c.

Hatchery Notes	There has been no significant contribution of hatchery fish to the Grays River chum salmon population
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum salmon for the duration of the time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E. O. 1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure

Population	Grays River Chum Salmon
Years of Data, Length of Series	1967 - 1998, 34 years
Abundance Type	Live/dead index
Abundance References	Rawding. 2001
Abundance Notes	
Hatchery Reference	Rawding, Dan (WDFW). 2001c.
Hatchery Notes	There has been no significant contribution of hatchery fish to the Grays River chum salmon population
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum salmon for the duration of the time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E. O. 1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure

Population	Lower Gorge Tributary Chum Salmon (Hamilton Cr, Hamilton Sp. & Hardy Cr Chum)
Years of Data, Length of Series	1944 - 2000, 57 years
Abundance Type	Live/dead index
Abundance References	Rawding, Dan (WDFW). 2001c.
Abundance Notes	Rawding provided separate time series for each subpopulation that were combined for analysis
Hatchery Reference	Rawding, Dan (WDFW). 2001c.
Hatchery Notes	There has been no (or extremely little) hatchery impact on Hardy Creek chum salmon.
Harvest Reference	Rawding, Dan (WDFW). 2001c.
Harvest Notes	There has been no significant directed harvest on Columbia chum salmon for the duration of the

	time series. Indirect harvest is believed to be negligible
Age Reference	Salo, E. O. 1991.
Age Notes	LCR_Wil Chinook Chum Steelhead from Holmes and McClure