UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
2725 Montlake Blvd. E.
Seattle, WA 98112-2097

December 23, 1998

MEMORANDUM FOR: F/NW - William Stelle
F/SW - William Hogarth

THRU: F/NWC - Usha Varanasi

FROM: F/NWC3 - Michael H. Schiewe

SUBJECT: 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

The Biological Review Team (BRT) for the updated west coast chinook salmon review met in Seattle on 16-19 November 1998 to discuss new information received regarding status of four evolutionary significant units (ESUs) that earlier this year were proposed for listing under the Endangered Species Act (ESA). The BRT concluded that one ESU (Columbia River spring-run chinook salmon) remains at risk of extinction if present conditions continue, and that the three other ESUs (Puget Sound, Lower Columbia River, and Upper Willamette River ESUs) remain at risk of becoming endangered in the foreseeable future if present conditions exist.

Attached is the BRT report : "Status Review Update for West Coast Chinook Salmon (*Oncorhynchus tshawytscha*) from Puget Sound, Lower Columbia River, Upper Willamette River and Upper Columbia River Spring-Run ESUs." This report presents BRT conclusions concerning ESU delineation and risk assessment for these four. This report also summarizes comments on the 1998 West Coast chinook salmon status review and new scientific information received for the four ESUs considered by the BRT in November. The status of chinook salmon hatchery broodstocks will be dealt with in a subsequent document.

Please contact either Dr. Robin Waples or myself if you have any questions about this report.

Attachment.

cc: F/PR - Hilda Diaz Soltero
F/NWO - Donna Darm
F/SWC - Michael Tillman
F/SWO3 - James Lecky
F/NWO3 - Garth Griffin ✓
GCNW - Michael Bancroft
BRT

Status Review Update for West Coast Chinook Salmon (*Oncorhynchus tshawytscha*) from Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River Spring-Run ESUs

23 December 1998

Prepared by the
West Coast Chinook Salmon Biological Review Team[1]

[1]The Biological Review Team (BRT) for the updated chinook salmon status review included, from NMFS Northwest Fisheries Science Center: Peggy Busby, Dr. Stewart Grant, Dr. Robert Kope, Gene Matthews, Dr. James Myers, Philip Roni, Dr. Mary Ruckelshaus, Dr. Michael Schiewe, David Teel, Dr. Thomas Wainwright, F. William Waknitz, Dr. Robin Waples, and Dr. John Williams; from NMFS Northwest Region: Susan Bishop; from NMFS Southwest Region: Gregory Bryant and Craig Wingert; from NMFS Southwest Region (Tiburon Laboratory): Dr. Steve Lindley, and Dr. Peter Adams; and from NMFS Alaska Fisheries Science Center (Auke Bay Laboratory): Alex Wertheimer.

TABLE OF CONTENTS

SUMMARY

The Biological Review Team (BRT) for the updated west coast chinook salmon status review met in Seattle, 16-19 November 1998, to discuss new information received regarding the status of four evolutionarily significant units (ESUs) under the Endangered Species Act (ESA) and re-evaluate ESU designations and risk determinations.

All four of the ESUs considered were proposed for listings under the U.S. ESA by NMFS (1998a) in early 1998. Three of the ESUs were proposed for threatened listings (Puget Sound, Lower Columbia River, Upper Willamette River), and one of the ESUs was proposed for an endangered listing (Upper Columbia River Spring Run). The final conclusions of the BRT are summarized below.

Species Issues Considered

Puget Sound ESU

This ESU occupies coastal basins of the eastern part of the Strait of Juan de Fuca, Hood Canal and Puget Sound. This includes the Elwha River and extends to the Nooksack River Basin and the U.S.-Canada Border. Spring-, summer-, and fall-run chinook salmon are included in this ESU.

The BRT considered a number of issues regarding the inclusion into the ESU of naturally spawning populations that either were established in areas which historically may not have maintained large self-sustaining populations or supported populations on only an intermittent basis. The existing populations may have been established through direct introductions or by hatchery strays. In general, the BRT considered all naturally spawning populations founded by broodstocks of within-ESU origin to be part of the ESU.

Lower Columbia River ESU

This ESU occupies tributaries to the Columbia River from the mouth of the Columbia River to, but not including, the Klickitat River. This includes natural fall- and spring-run chinook salmon, with the exception of spring-run chinook salmon in the Willamette River Basin above Willamette Falls, spring-run chinook salmon in the Clackamas River, and fall-run chinook salmon which are descended from "upriver bright" or Rogue River fall-run chinook salmon stocks. Similar to its finding for the Puget Sound ESU, the BRT considered naturally spawning populations in this ESU to be part of the ESU despite the influence of introductions from a myriad of hatcheries located within this ESU. The BRT maintained its earlier conclusion that this ESU is distinct, based on genetic data, ocean distribution, age at maturation, and other life history traits.

Upper Willamette River ESU

This ESU occupies the Willamette River Basin above the Willamette Falls. The ESU includes natural spring-run chinook salmon, but excludes fall-run chinook salmon that were introduced above the Willamette Falls. These fish exhibit an ocean-type life history, and are very distinct from adjacent ESUs genetically, in their age structure, and in marine distribution. Additionally, the BRT determined that spring-run chinook salmon in the Clackamas River are part of this ESU.

Upper Columbia River Spring-Run ESU

This ESU occupies tributaries to the Columbia River upstream of the Yakima River to Chief Joseph Dam. It includes spring-run chinook salmon in the Wenatchee, Entiat, and Methow River Basins. These fish all exhibit a stream-type life history. The BRT restated its earlier conclusion that this ESU is ecologically distinct from other ESUs that contain genetically similar populations, and may contain important locally adapted genotypes.

Risk Assessment Conclusions

Puget Sound ESU

Widespread declines and outright losses of the spring- and summer-run chinook populations represent a significant reduction in the life history diversity of the Puget Sound ESU. Additionally, in most streams for which abundance data are available, both long- and short-term trends in abundance are declining. This ESU was proposed threatened in March 1998. The BRT concluded that this ESU remains at risk of endangerment.

Lower Columbia River ESU

Very few naturally self-sustaining populations of native chinook salmon remain in the Lower Columbia River ESU. Long-term trends in abundance of the remaining populations are mixed, but short-term trends in abundance are predominantly downward. The presence of hatchery chinook salmon in this ESU poses an important threat to the persistence of the ESU and also obscures trends in abundance of native fish. This ESU was proposed threatened in March 1998. The BRT concluded that this ESU remains at risk of endangerment.

Upper Willamette River ESU

There are few remaining populations of spring-run chinook salmon in the Upper Willamette River ESU. In addition, it is estimated that two-thirds of the naturally-spawning spring chinook salmon are first generation hatchery fish. This ESU was proposed threatened in March 1998. The BRT concluded that this ESU remains at risk of endangerment.

Upper Columbia River Spring Run ESU

None of the individual populations of spring-run chinook salmon in the Upper Columbia River ESU consist of greater than 100 fish. The severe declines in abundance and the aggressive artificial propagation measures adopted in recent years are further indicators of the significant risks to persistence of this ESU. This ESU was proposed endangered in March 1998. The BRT concluded that this ESU remains at risk of extinction.

INTRODUCTION

On 9 March 1998, the National Marine Fisheries Service (NMFS) published a Federal Register notice describing 11 new evolutionary significant units (ESUs) and 1 modification of an existing ESU for chinook salmon from the states of Washington, Oregon, California, and Idaho (NMFS 1998a). The notice included a proposed rule to list as threatened or endangered seven chinook salmon ESUs under the U.S. Endangered Species Act (ESA). This proposal was based upon the status review conducted by the west coast chinook salmon Biological Review Team (BRT) convened by NMFS (Myers et al. 1998).

The BRT met in November 1998 to discuss comments and new data received in response to the proposed rules and to determine if the new information warranted any modification of the conclusions of the original BRT. This report summarizes the final BRT conclusion on the following ESUs: Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River Spring Run. For the remaining ESUs (Central Valley Fall and Late-Fall Run, Central Valley Spring Run, and Snake River Fall Run), substantial scientific issues and disagreements remain. These issues may be resolved with new information being developed in the next few months and will be discussed in a separate document.

BACKGROUND INFORMATION

On 14 March 1994, the National Marine Fisheries Service (NMFS) was petitioned by the Professional Resources Organization-Salmon (PRO-Salmon) to list spring-run populations of chinook salmon (*Oncorhynchus tshawytscha*) in the North Fork and South Fork Nooksack River, the Dungeness River[2], and the White River as threatened or endangered species under the Endangered Species Act (ESA), either singly or in some combination (PRO-Salmon 1994). At about the same time, NMFS also received petitions to list additional populations of other Pacific salmon species in the Puget Sound area. In response to these petitions and the more general concerns for the status of Pacific salmon throughout the region, NMFS announced on 12 September 1994 that it would initiate ESA status reviews for all species of anadromous salmonids in Washington, Oregon, California, and Idaho (NMFS 1994). Subsequent to this announcement, NMFS was petitioned on 1 February 1995 by the Oregon Natural Resources Council (ONRC) and Richard K. Nawa to list 197 stocks of chinook salmon either separately or in some combination. The results of the status review were published in Myers et al. (1998).

In determining whether a listing under the ESA is warranted, two key questions must be addressed:

1) Is the entity in question a "species" as defined by the ESA?
2) If so, is the "species" threatened or endangered?

The ESA allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. However, the ESA provides no specific guidance for determining what constitutes a distinct population, and the resulting ambiguity has led to the use of a variety of criteria in listing decisions over the past decade. To clarify the issue for Pacific salmon, NMFS

---

[2] The use of the term "spring-run" to describe the chinook salmon returning to the Dungeness River has been discontinued by state, tribal, and federal agencies. It has been replaced with the term "native," but in this report the term "spring-run" has been retained for the purpose of maintaining consistency with older references to the stock.

published a policy document 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). 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 evolutionarily significant unit (ESU) of the biological species. An ESU is defined as a population that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

If it is determined that a listing(s) is warranted, then NMFS is required by law (1973 ESA Sec. 4(a)(1)) to identify one or more of the following factors responsible for the species' threatened or endangered status: 1) destruction or modification of habitat, 2) overutilization by humans, 3) disease or predation, 4) inadequacy of existing regulatory mechanisms, or 5) other natural or human factors. This status review does not formally address factors for decline, except insofar as they provide information about the degree of risk faced by the species in the future if current conditions continue. A separate NMFS document (NMFS 1998b) identifies factors for decline of chinook salmon from Washington, Oregon, California, and Idaho.

Previous Conclusions of the BRT

8) Puget Sound ESU

This ESU occupies coastal basins of the eastern part of the Strait of Juan de Fuca, Hood Canal and Puget Sound. This includes the Elwha River and extends to the Nooksack River Basin and the U.S.-Canada Border. Spring-, summer-, and fall-run chinook salmon are included in this ESU. Puget Sound chinook salmon tend to mature at ages 3 and 4, and are not recovered in Alaskan waters to the same extent as fish from the Washington Coast (ESU 7; Myers et al. 1998). The genetic and life-history characteristics of Puget Sound chinook salmon are very distinct from the adjacent Washington Coast ESU; however, the Elwha River chinook salmon were somewhat genetically intermediate and exhibited intermediate life history traits relative to the two ESUs.

A majority of the BRT concluded that chinook salmon in this ESU are not presently in danger of extinction, but they are likely to become so in the foreseeable future. A minority concluded that this ESU is not presently at significant risk or were uncertain about its status. Overall abundance of chinook salmon in this ESU has declined substantially from historical levels, and many populations are small enough that genetic and demographic risks are likely to be relatively high. Special concern was expressed regarding the status of spring- and summer-run populations. Contributing to these reduced abundances were widespread blockages or degradation of freshwater, especially in upper river reaches. Estuaries, lower tributaries, and mainstem rivers in this ESU have been affected by widespread agriculture and urbanization. Both long- and short-term trends in abundance in this area were predominantly downward, and several populations exhibited severe short-term declines. Spring-run chinook salmon populations throughout this ESU were all depressed, and a number of populations have been extirpated.

Tens of millions of hatchery fish have been released annually throughout the ESU. More than half of the recent total Puget Sound escapement returned to hatcheries. The BRT was concerned that the preponderance of hatchery production throughout the ESU may mask trends in natural populations and makes it difficult to determine whether they are self-sustaining. This difficulty was compounded by the dearth of data on the proportion of naturally spawning fish that are of hatchery origin. There have also been widespread use of a limited number of hatchery stocks (i.e. Green River Hatchery stock), resulting in increased risk of loss of fitness and diversity among populations. There also was concern that harvest rates of natural stocks in mixed-stock fisheries may be excessive, as evidenced by recent declines in most stocks managed for natural escapement despite curtailed terminal fisheries.

9) Lower Columbia River ESU

This ESU occupies tributaries to the Columbia River from the mouth of the Columbia River to, but not including, the Klickitat River. This includes natural fall- and spring-run chinook salmon, with the exception of spring-run chinook salmon in the Willamette River Basin above Willamette Falls, which were considered their own ESU (see ESU 10, Upper Willamette River). Chinook salmon in this ESU were genetically distinct from those in their neighboring ESUs (Washington Coast, Oregon Coast, Upper Willamette River, and Upper Columbia River Summer- and Fall-Run ESUs), and exhibited distinctive life-history traits (age at maturation) and ocean migration distribution.

A majority of the BRT concluded that chinook salmon in this ESU are not presently in danger of extinction but are likely to become so in the foreseeable future. A minority felt that this ESU was not at significant risk or were uncertain as to its status. Estimated overall abundance of chinook salmon in this ESU was not cause for immediate concern. However, apart from the relatively large and apparently healthy fall-run population in the Lewis River, production in this ESU appeared to be predominantly hatchery-driven with few identifiable native, naturally reproducing populations. Long- and short-term trends in abundance of individual populations were mostly negative, some severely so. About half of the populations comprising this ESU were very small, increasing the likelihood that risks due to genetic and demographic processes in small populations are high. Numbers of naturally spawning spring-run chinook salmon were very low, and native populations in the Sandy and Clackamas Rivers have been supplanted by spring-run fish from the Upper Willamette River. There have been at least six documented extinctions of populations in this ESU, and it is possible that extirpation of other native populations has occurred but has been masked by the presence of naturally spawning hatchery fish. The BRT was particularly concerned about the inability to identify any healthy native spring-run populations in this ESU.

The large numbers of hatchery fish in this ESU made it difficult to determine the proportion of naturally produced fish. Despite widespread production of hatchery fish in this ESU, genetic and life history characteristics of populations in this ESU still differ from those in other ESUs. The BRT, however, identified the loss of fitness and diversity within the ESU as an important concern. There was a special concern regarding recent releases of Rogue River fall-run fish at Youngs Bay and their documented straying into many tributaries in the Lower Columbia River.

Freshwater habitat is in poor condition in many basins, with problems related to forestry practices, urbanization, and agriculture. Dam construction on the Cowlitz, Lewis, White Salmon, and Sandy Rivers eliminated access to a substantial portion of the spring-run spawning habitat, with a lesser impact on fall-run habitat.

10) Upper Willamette River ESU

This ESU occupies the Willamette River Basin above Willamette Falls. The ESU includes natural spring-run chinook salmon, but excludes fall-run chinook salmon that were introduced above the Willamette Falls. These fish exhibit an ocean-type life history, and are very distinct from adjacent ESUs genetically, in their age structure, and marine distribution. Furthermore, the geography and ecology of the Willamette Valley is considerably different from surrounding areas. Historically, migratory access above Willamette Falls was only possible during a narrow temporal window, which provided a powerful isolating mechanism for upper Willamette River spring-run stocks.

A majority of the BRT concluded that chinook salmon in this ESU are not presently in danger of extinction but are likely to become so in the foreseeable future. A minority felt that this ESU is not presently at significant risk or were uncertain as to its status, and one member considered this ESU to be at risk of extinction. Total abundance has been relatively stable at approximately 20,000 to 30,000 fish; however, recent natural escapement was less than 5,000 fish and has been declining sharply. Furthermore, it was estimated that about two-thirds of the natural spawners are first-generation hatchery fish, suggesting that the natural population is falling far short of replacing itself. The BRT noted a similarity between these population dynamic parameters and those for the upper Columbia River steelhead ESU, which was recently listed as endangered by NMFS.

The introduction of fall-run chinook salmon into the basin and laddering of Willamette Falls have increased the potential for genetic introgression between wild spring- and hatchery fall-run chinook salmon, but there was no direct evidence of hybridization (other than an overlap in spawning times and spawning location) between these two runs.

The primary sources of risk to chinook salmon in this ESU were habitat blockage of large areas of important spawning and rearing habitat by dam construction. Remaining habitat has been degraded by thermal effects of dams, forestry practices, agriculture, and urbanization. Another concern for this ESU was that commercial and recreational harvest are high relative to the apparent productivity of natural populations.

13) Upper Columbia River Spring-Run ESU

This ESU occupies tributaries to the Columbia River upstream from the Yakima River to Chief Joseph Dam. It includes spring-run chinook salmon in the Wenatchee, Entiat, and Methow River Basins. These fish all exhibit a stream-type life history. Although slight genetic differences exist between this ESU and the other ESUs containing stream-type fish (see ESU 11 and 15), ecological differences in spawning and rearing habitat between these stream-type ESUs were important in establishing the ESU boundaries. Fish in this ESU were also influenced by the Grand Coulee Fish Maintenance Project (1939-43). The result of this project was the mixing of multiple populations into one relatively homogenous genetic group.

The majority of the BRT concluded that chinook salmon in this ESU are in danger of extinction. A minority concluded that this ESU is not presently in danger of extinction, but it is likely to become so in the foreseeable future. Recent total abundance of this ESU was quite low, and escapements in 1994-1996 were the lowest in at least 60 years. At least 6 populations of spring-run chinook salmon in this ESU have become extinct, and almost all remaining naturally spawning populations have fewer than 100 spawners. The BRT expressed concern about the genetic and demographic risks associated with such small populations. In addition to extremely small population sizes, both recent and long-term trends in abundance were downward, some extremely so.

Hydrosystem development has substantially affected this ESU. Grande Coulee Dam blocked access to important spawning and rearing habitat, and downstream dams are an impediment to migration (both juvenile and adult fish from this ESU must navigate past as many as nine mainstem dams). The BRT also had substantial concerns over degradation of the remaining spawning and rearing habitat.

Risks associated with interactions between wild and hatchery chinook salmon were also a concern, as there continues to be substantial production of the composite, non-native Carson National Fish Hatchery (NFH) stock for fishery enhancement and hydropower mitigation. For example, estimates of hatchery contribution to natural spawning escapements were 39% in the Methow River Basin.

TECHNICAL COMMENTS

Comments on the Proposed Listing of Chinook Salmon ESUs

General Comments

A number of comments submitted to the Federal Register are applicable to some or all of the ESUs proposed (NMFS 1998a). In general, these comments either concerned the process of ESU designations or risk determinations. The remaining comments addressed issues pertaining to critical habitat. Critical habitat issues were not considered by the BRT.

Some of the comments received suggested that the ESA does not provide for the creation of ESUs, and the ESUs do not correspond to species, subspecies, or Distinct Population Segments (DPS) that are specifically identified in the ESA (Palmisano and Kaczynski 1998, Strong 1998).

The use of genetic information (allozyme- or DNA-derived) by the BRT to determine ESU boundaries was criticized by several commenters. It was argued that allozyme-based electrophoretic data cannot be used to imply evolutionary significance, nor does it imply local adaptation. Other commenters indicated that the BRT used genetic distances inconsistently in determining the creation of ESUs.

Strong (1998) and Palmisano and Kaczynski (1998) argued that there was insufficient scientific information presented to justify the establishment of the chinook salmon ESUs discussed. Information was lacking concerning a number of "key" criteria for defining ESU. Commenters contended that NMFS did not find any life history, habitat, or phenotypic characteristics that were unique to any of the ESUs discussed. Disagreement within the BRT was also given as a reason for challenging the proposed listing decision.

Some of the comments received suggested that risk determinations were made in an arbitrary manner and that the BRT did not rely of the best science available (Clark et al. 1998, Feldmann 1998, Strong 1998). Other comments identified factors for decline that were either not identified in the Status Review (Myers et al. 1998) or which they believed were not given sufficient weighing in the risk analysis. For example:

> 1) Harvesting of immature fish in non-terminal mixed stock fisheries results in a decrease in the average age of spawning, and causes substantial incidental mortalities. Furthermore, the reliance on hatcheries compounds the problems of mixed stock fisheries (Mathews 1997).
>
> 2) Recent declines in abundance were related to natural factors: avian predation, marine mammal predation, and especially changes in ocean productivity. Until ocean conditions improved, the potential for recovery is extremely limited. Furthermore, commenters contend that NMFS did not show how the present declines were significantly different from natural variability in abundance, nor that

abundances were below the current carrying capacity of the marine environment and freshwater habitat (Feldmann 1998, Palmisano and Kaczynski 1998).

3) A number of anthropogenic factors were not sufficiently addressed in the Status Review or Federal Register. Commenters highlight the fact that much of the remaining freshwater habitat classified as "good to fair" is located in forested lands, while there has been a considerable loss of estuarine and lower river (floodplain) habitat. This environmental modification would most strongly impact coastal ocean-type fish. Competition and predation resulting from the introduction of exotic species may also be reducing salmonid survival and the potential for recovery. Lastly, the modification of the hydraulic characteristics of many rivers in combination with the interruption of fish migration by dams has severely limited the production potential of natural populations (Palmisano and Kaczynski 1998).

Response

General issues relating to ESUs, Distinct Population Segments, and the ESA have been dealt with extensively elsewhere (NMFS 1991, Waples 1991; 1995; 1998;) and are not considered here. As discussed in the status review, genetic data were used primarily to evaluate the criterion regarding reproductive isolation, not evolutionary significance. The ESUs were identified using the best available scientific information. In some cases, there was a considerable degree of confidence in the ESU determinations; in other cases, more uncertainty was associated with this process, as discussed in the status review. Similarly, the risk analysis necessarily involved a mixture of quantitative and qualitative information and scientific judgement. We are always eager to consider specific suggestions for improving that process.

The status review did not attempt to comprehensively identify factors for decline, except insofar as they contributed directly to the risk analysis. Comments on these issues will be considered carefully in the recovery planning process, whether that process takes place inside our outside of the ESA.

ESU-Specific Comments

8) Puget Sound ESU

Some comments expressed a concern that the ESUs are too diverse, and that specific major river basins and life history types should be recognized as distinct ESUs (Kailin 1998). Conversely, Clark et al. (1998) believed that the Puget Sound ESU should include populations in southern British Columbia. Other commenters reiterated their earlier opinion that the Elwha River chinook salmon populations should be kept in the Puget Sound ESU. Additionally, it was suggested that the Status Review should have emphasized the diversity of smolt emigration strategies expressed by Puget Sound stocks (everything from nearly buttoned-up fry to yearling migrants) as a example of the diversity that remains in the ESU.

Several commenters were unsure of the accuracy of historical and present estimates for Puget Sound abundances (Feldmann 1998, Hayman 1998). Furthermore, they argued that the total abundance of Puget Sound chinook salmon was "relatively" high, even with current harvest levels, and although there have been recent declines in escapement, these have been within historical variations in abundance and did not warrant an threatened listing (Clark et al. 1998, Feldmann 1998). It was unclear to the respondents why hatchery-derived fish were not included in the risk determination, especially if the BRT noted that they could not differentiate between hatchery and naturally produced fish. Some comments stressed that the majority of the trends in

Puget Sound were actually stable or upward, and this situation was compared to the Mid-Columbia River Spring-Run ESU (ESU 11), where there were an equal number of upward and downward trends and relatively low abundance, a situation which did not produce a proposed ESA listing by NMFS. Smith (1998) provided further information on the interpretation of fish abundances. Smith (1998) argued that many of the stock abundances and trends listed in the Status Review contain a high proportion of hatchery fish and should not be included. These sites include areas in south Puget Sound and the Kitsap Peninsula. Some abundances for rivers in this area are not based on spawning escapements, but on a proportion of neighboring river escapements. Additionally, Puyallup River estimates are of poor quality and based upon a single peak live and dead count. Smith (1998) expressed the opinion that none of the populations with a large hatchery stray component (e.g. Elwha, Nisqually, and Duwamish/Green Rivers) should be used in the risk analysis. There were several additional comments that existing regulatory mechanisms are insufficient to recover declining stocks or the regulations are inadequately enforced.

Some comments suggested that the Status Review indicated that introductions from outside of the ESU (from Lower Columbia River hatcheries) may have had a considerable impact on the genetic characteristics of Puget Sound fish, and that this may have contaminated the genetics of Puget Sound stocks (Feldmann 1998). Alternatively, Smith (1998) accentuated the genetic diversity that exists in the Puget Sound ESU. Smith (1998) felt that the Status Review was misleading in the way that it emphasized the homogenization effects of hatchery releases and similarities in life history characteristics. WDFW and NWIFC did not disagree with the risk conclusion made by the previous BRT that the Puget Sound ESU was likely to become endangered in the foreseeable future (B. Sanford, WDFW, 600 Capitol Way N, Olympia, WA 98501-1091, and G. Graves, NWIFC, 6730 Martin Way E., Olympia, WA 98506. Pers. commun., November, 1998).

Response--The distribution of positive and negative trends is very uneven in Puget Sound. The increasing trends are associated with populations having high hatchery influence, while downward trends are found in populations supported primarily by natural production. These data and others (e.g., declining recruit/spawner ratios in Skagit River populations) raise serious concerns about the sustainability of natural chinook salmon populations in Puget Sound.

New information on historical and current abundance of Puget Sound chinook salmon is discussed below in the Risk Assessment section of this report.

Since 1991 NMFS has made it clear that although hatchery populations may be part of a salmon ESU, they are not considered a substitute for conservation of natural populations in their native ecosystems. Therefore, risk analysis focuses on the health and sustainability of populations supported by natural production. This is consistent with the approach the USFWS has taken under the ESA for terrestrial and freshwater species and is mandated by the ESA's focus on conserving species in their ecosystems.

9) Lower Columbia River ESU

The Columbia River Inter-tribal Fisheries Commission (Strong 1998) argued that, in light of the NMFS determination that a Lower Columbia River Coho Salmon ESU no longer existed, a similar determination should have been made for Lower Columbia River chinook salmon. However, other commenters concurred with NMFS that the designation of this ESU was valid.

A number of comments suggested that the abundance of some hatchery stocks should be included in the risk determination, especially in light of the fact that many of these hatcheries contain the only representative populations from a number of river systems (which were blocked to migratory passage) (Clark et al. 1998, ODFW 1998). Furthermore, although there is a potential for hatcheries to pose a risk to naturally spawning populations, it was suggested that there was no evidence for this to be the case (Olson 1998). Finally, it was asserted that population abundances in this ESU are well above historical lows, and do not indicate that this ESU is in danger of extinction (Clark et al. 1998, ODFW 1998).

ODFW (1998) recommended that this ESU be given candidate status rather than the proposed threatened listing. Specifically, they disputed the BRT's exclusion of spring-run chinook salmon in the Sandy and Clackamas Rivers. Although these systems have received substantial introductions of fish from the upper Willamette River, ODFW (1998) argued that there is no a priori reason to assume that the genetic resemblance between naturally spawning fish in the Sandy and Clackamas Rivers and hatchery fish from the upper Willamette River is due to these introductions. Additionally, they also consider the several thousand upriver bright fall chinook salmon that are spawning below Bonneville Dam as part of this ESU. This population was apparently founded by strays from the upriver bright (URB) fall-run chinook salmon program at Bonneville Hatchery. These fish are viewed positively by ODFW, as a source of new genetic diversity. ODFW also outlined efforts to reduce the straying of Rogue River fall-run chinook salmon from the Big Creek Hatchery program. New information was provided to document the abundance of naturally spawning populations in Oregon river basins in this ESU. In all, ODFW estimated that there are some 20,000 to 30,000 natural spawners in the entire ESU.

Response--Since at least some demonstrably native, natural populations of chinook salmon remain in the Lower Columbia River, there is no basis for concluding that the ESU does not exist. The pattern of abundance and trends in this ESU depends heavily on which populations are considered. This topic is dealt with extensively in the Risk Assessment section of this report.

10) Upper Willamette River ESU

Commenters agreed with NMFS that an Upper Willamette River ESU should be defined, but argued that the hatchery populations should be included in the ESU and used in consideration of the extinction risk (Clark et al. 1998, ODFW 1998). Given that NMFS had very little genetic or life history data from naturally spawning fish and relied on information obtained from hatchery-produced fish to describe the ESU, commenters argued that hatchery fish should be considered part of the ESU for the determination of risk status. Finally, ODFW (1998) and Olson (1998) argued that hatchery abundances should be considered in the risk determination, because without hatchery operations the ESU might fail to persist. Currently, abundances are well above historical lows. Furthermore, it was suggested that the proposed ODFW Willamette Basin Fish Management Plan would provide additional spawning habitat for naturally spawning fish and modify hatchery operations to minimize hatchery/wild interactions and loss of genetic integrity.

Information provided by ODFW (1998) indicated that the naturally spawning population in the McKenzie River Basin represents the last of five major populations in the ESU. Previously it had been suggested that a population in the North Santiam River existed; however, ODFW contended that the thermal profile of water releases from Detroit Dam significantly lowers the survival of any progeny from naturally spawning fish. ODFW concurred with the previous risk conclusion made by the BRT that the Upper Willamette River ESU is likely to become endangered in the foreseeable future (J. Martin, ODFW, 2501 SW First Avenue, P.O. Box 59, Portland, OR 97207. Pers. commun. November 1998).

Response--If it is true that the ESU would fail to persist without the hatchery populations, that is a strong indication that the natural populations need protection under the ESA.

13) Upper Columbia River Spring-Run ESU

Several respondents agreed with NMFS that chinook salmon stocks in this ESU represent an identifiable group that merits definition as a separate ESU. Clark et al. (1998) believed that there was no scientific basis to exclude spring-run chinook salmon from the Rock Island Fish Hatchery Complex and Methow Fish Hatchery Complex from consideration in the risk assessment. Furthermore, Clark et al. (1998) estimates that the total escapement of naturally spawning fish in this ESU averages around 5,000 fish, and that given the historical importance of these fish and the current "moderate" abundance level, a listing of "threatened" rather than endangered is warranted. The U.S. Dept. of the Interior (Taylor 1998) concurred with the proposed endangered listing. Furthermore, Taylor (1998) suggested that the impact of Carson NFH spring run introductions were much more limited than was indicated in the Status Review. Although there have been strays from the Leavenworth, Entiat, and Winthrop NFHs observed spawning naturally near the hatcheries, there is little evidence that these fish have strayed into the upper portions of the river watersheds or hybridized with the natural populations. Marked strays from other, out-of basin, programs (e.g., Dworshak NFH) have been found on the natural spawning grounds.

NEW INFORMATION

Genetic Information

Lower Columbia River and Upper Willamette River

Scientific disagreement existed on the status of spring-run chinook salmon in the Sandy and Clackamas Rivers. In the Status Review, the BRT concluded that native runs were extirpated or swamped by the introduction of Upper Willamette River hatchery fish introductions.

NMFS recently analyzed new genetic data for Willamette River and Sandy River spring-run chinook salmon. In 1996 and 1997 ODFW collected samples of juvenile salmon from the North Fork Clackamas (n=80), Sandy (n=93), McKenzie (n=100), and North Santiam Rivers (N=99). The new samples were screened for approximately 70 gene loci. An analysis of population structure was done using 31 loci common to all of the genetic samples used in the status review.

The samples are thought to consist of naturally produced fish, taken in areas where hatchery fish are not present. However, the new samples cluster with samples from Clackamas, Marion Forks, McKenzie, and Dexter Hatcheries. In a preliminary analysis, samples from the Clackamas River are genetically most similar to samples taken previously from Willamette River hatcheries. These hatchery populations are all of upper Willamette River origin. Samples in this "Upper Willamette" cluster, including the new samples, are genetically distinct from all other Columbia Basin samples (Figure 1), including a large group of ocean-type populations (which includes lower Columbia River spring and fall runs) and a second large group of stream-type populations from the Columbia and Snake rivers (both spring and summer runs). Although the new samples are genetically similar to samples from Willamette River hatcheries, it is important to note that none of the pairs of samples in this group are genetically "identical". G-tests between all pairs of these samples are significant ($p< 0.05$).

It is noteworthy that the Sandy River spring-run chinook salmon sample did not cluster with the sample of Sandy River fall-run chinook salmon. This result is unusual for lower Columbia River and coastal populations; spring and fall runs within a basin were usually part of the same genetic group (Myers et al. 1998). We looked at genetic distances between individual

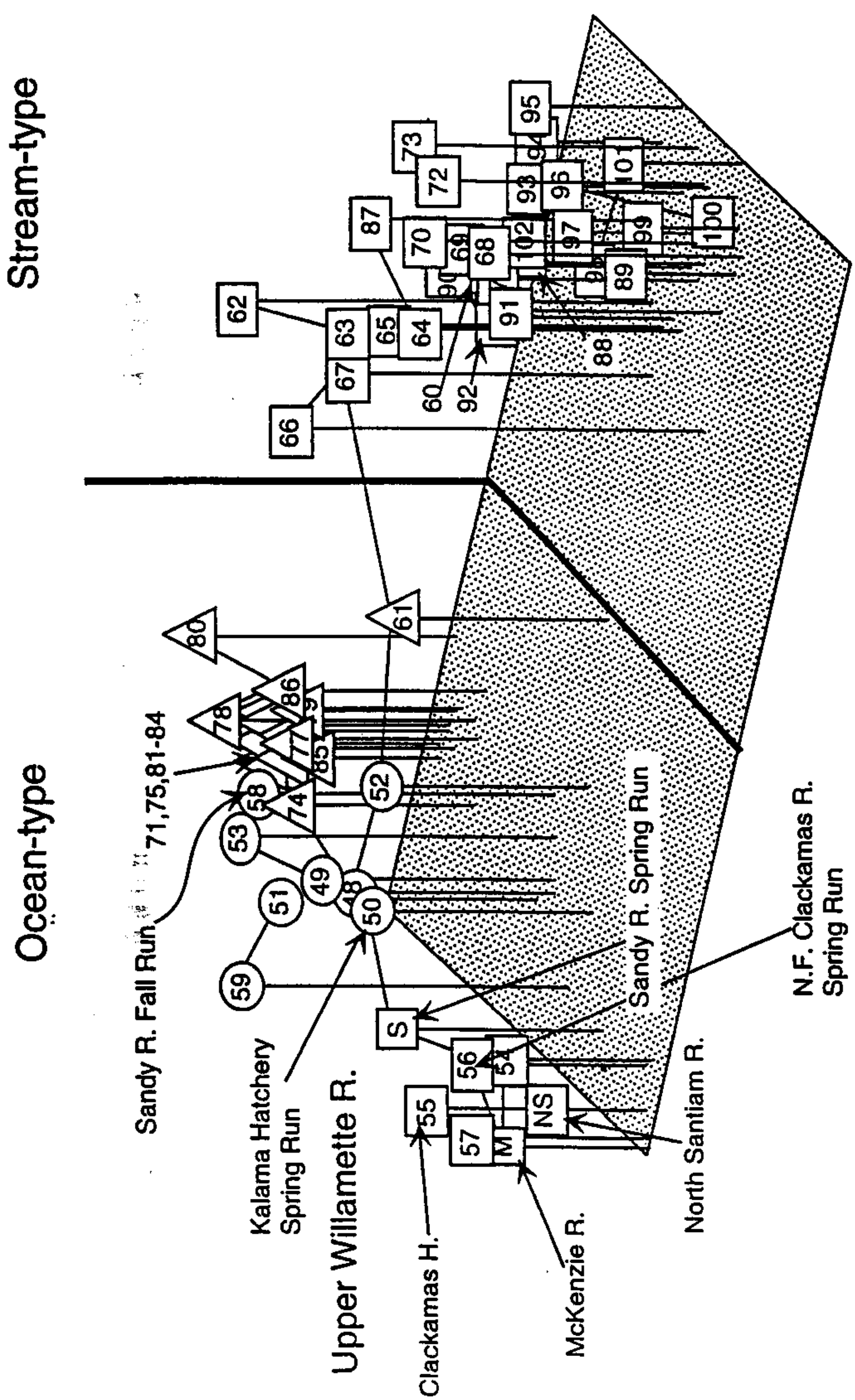

Figure 1. Multidimensional scaling (MDS) of Cavalli-Sforza and Edwards (1967) chord distances based on 31 allozyme loci between 57 composite samples of chinook salmon from Columbia River Basin populations (published and unpublished NMFS and WDFW data). Sample numbers correspond to those in Table 1. Within the ocean-type populations, squares designate populations from the Willamette River Basin, circles - Lower Columbia River, triangles - mid and upper Columbia River and Snake River Basins.

samples and found that the Sandy River spring-run sample was most similar to the samples from the Clackamas, McKenzie and Dexter Hatchery spring-run broodstock, and McKenzie River naturally-produced spring-run fish, in addition to the a sample of Kalama Hatchery spring-run chinook salmon.

Bentzen et al. (1998) used microsatellite DNA analysis to compare four populations of spring-run chinook salmon in the Columbia River Basin: upper Sandy River, Bull Run (Sandy River Basin), Clackamas Hatchery, and Yakima River. A total of 72 fish were analyzed using 16 microsatellite loci. The level of differentiation between the Clackamas Hatchery and Sandy River samples was "low ($F_{ST} = 0.007$) in comparison to what one might expect among river drainages or distinct populations within regions" (Bentzen et al. 1998). Tissue samples from Bull Run spring-run chinook salmon clustered with the Sandy River and Clackamas Hatchery samples. In contrast, there was much greater differentiation between the Sandy River, Bull Run, and Clackamas Hatchery samples and those from the Yakima River ($F_{ST} = 0.072$-0.091). Although the Sandy River and Clackamas Hatchery samples were significantly different, Bentzen et al. (1998) could not rule out the possibility the Sandy River fish were derived from Clackamas Hatchery introductions.

Other Information

Additional life history and artificial propagation information was gathered to assist the BRT in resolving the origin of spring-run populations in a number of river basins. This information was submitted with comments concerning the Proposed Rule or West Coast Chinook Salmon Status Review or was gathered independently by NMFS personnel.

Clackamas River

The Clackamas River historically contained a spring run of chinook salmon, but relatively little information about this run exists. Barin (1886) reported that a run of chinook salmon "commences in March or April, sometimes even in February." Even in 1885 there were apparent declines in salmon abundance: "... the salmon are not so plentiful now as they were, for some years ago the river was literally alive with Chinook salmon..." (Bairn 1886). Abernethy (1886) reported that some 3,500 chinook salmon were caught in the Clackamas River between April 10 and July 10, 1885; however he noted that there was no fishing done in the river in March when the run was apparently very large. There are various accounts of when the spring run adults spawned in the Clackamas River. Bairn (1886) mentioned fish spawning in September, although his observations were in the vicinity of Clear Creek (RKm 13) and he may have observed fall-run fish spawning. The U.S. Fish Commission operated two hatcheries: on the upper Clackamas River, Oak Grove Fork (Rkm 95), and on the lower Clackamas River (RKm 6). Eggs were collected at the upper Clackamas Station beginning 17 July and ending 26 August, with some five million eggs collected (Ravenel 1898a). At the lower Clackamas Station, ripe fish were not collected until 15 September and by 7 November, 1897, only spawned out fish were collected (Ravenel 1898a). ODFW (1990) suggests that fish collected at the lower Clackamas Station were probably fall-run "Tule" chinook salmon. Currently, naturally spawning spring-run chinook salmon spawn from September to October (Olsen et al. 1992).

A number of hatcheries have operated in the Clackamas River Basin. In the late 1890s some 3.5 million spring-run eggs from the Sandy River were transferred to the Clackamas River Station and released into the Clackamas River (Craig and Suomela 1940); however, a large portion of the eggs were lost during incubation, due to an unknown epizootic, and the remaining fry were planted at a very small size (Ravenel 1898b). Additionally, several million eggs from the U.S. Bureau of Fisheries Battle Creek Station (Upper Sacramento River) were transferred to the Clackamas Hatchery; however, the majority were released as fry and a limited number were reared for a short interval and released at 1.5 grams (Ravenel 1898b). The success of these early transfers is doubtful.

The construction of the Cazadero Dam in 1904 (RKm 43) and River Mill Dam in 1911 (RKm 37) limited migratory access to the majority of the historical spawning habitat for the spring run. In 1917, the fish ladder at Cazadero Dam was destroyed by floodwaters, eliminating fish passage to the upper basin (ODFW 1992). Hatchery production of spring-run chinook salmon in the basin continued using broodstock captured at the Cazadero and River Mill Dams (Willis et al. 1995). Transfers of Upper Willamette River hatchery stocks (primarily the McKenzie River Hatchery) began in 1913, and between 1913 and 1959 over 21.3 million eggs (Table 1) were transferred to the Clackamas River Basin (Wallis 1961, 1962, 1963). Furthermore, a large proportion of the transfers occurred during the late 1920s and early 1930s to supplement the failure of the runs in the Clackamas River Basin at that time (Leach 1932). In 1942 spring-run chinook salmon propagation programs in the Clackamas River Basin were discontinued. By 1939, when passage for spring-run chinook salmon was restored over the Clackamas River dams, the spring-run population had declined considerably since the turn of the century. A spawner survey conducted in August 1940 observed 300 adults below Cazadero Dam and more than 500 below River Mill Dam (Parkhurst et al. 1950); however, unspecified conditions did not permit these fish to migrate above the dams. A further 500-700 spring-run chinook salmon were observed spawning in Eagle Creek (where the U.S. Bureau of Fisheries Station was sited) in September and October 1941 (Parkhurst et al. 1950).

Recolonization of the upper Clackamas River was somewhat limited. The average annual dam count (River Mill or North Fork Dam) from 1952-59 was 461 (ODFW 1992). More importantly, 30% of the adult passage counts occurred in September and October. Artificial propagation activities were restarted at the Eagle Creek National Fish Hatchery in 1956 using eggs from a number of upper Willamette River hatchery stocks. The program released approximately 600,000 smolts annually through 1985. In 1976, the ODFW Clackamas Hatchery (located below River Mill Dam) began releasing spring-run chinook salmon (Willamette River hatchery broodstocks were used, since it was believed that the returns from the local population was too small to meet the needs of the hatchery (ODFW 1992)). Increases in adult returns over the North Fork Dam, and increases in redd counts above the North Fork Reservoir corresponded to the initial return of adults to the hatchery in 1980 (ODFW 1992, Willis et al. 1995). Adult counts over North Fork Dam rose from 592 in 1979 to 2,122 in 1980 (ODFW 1992).

Sandy River

The Sandy River historically had a large run of spring-run chinook salmon; run size for the Sandy River Basin may have been in excess of 12,000 fish (Mattson 1955). There is limited information on the life history characteristics for this spring run. Adult run and spawn timing is available from the records of the numerous hatcheries that operated in the basin. In 1896, the U.S. Fish Commission contracted for the construction of a weir across the Salmon River, a tributary to the Sandy River (RKm 56). The first eggs were obtained on 11 August, although natural spawning was observed in late July, and egg collection continued until 12 September 1896 (Ravenel 1898a). The next year, the first eggs were taken 22 July 1897 and the last eggs were taken "during the latter part of August" (Ravenel 1898b). During the first three years of operation approximately 3.5 million spring-run chinook salmon eggs were taken at the Salmon River weir and transferred for release out of the basin (Table 2). Bureau of Fisheries hatchery operations continued intermittently until 1925. Access to the upper Sandy River Basin was severely restricted by the construction of Marmot Dam in 1913 at RKm 43. Water from the Sandy River was diverted at Marmot Dam into the Little Sandy and Bull Run Rivers, and there was little, if any flow, into the Sandy River below Marmot from July to September (Craig and Suomela 1940); furthermore, the diversion was unscreened until 1951, so a high proportion of the progeny of naturally spawning fish above the dam was diverted and killed by the turbines of the Bull Run powerhouse prior to that time (ODFW 1990). In 1922, the Bureau of Fisheries erected a new weir at the base of Marmot Dam; however, they apparently missed the early part of the run and collected 1.6 million eggs from 18 August to 10 September (Leach 1923). Propagation activities were terminated in 1925, due to the low size of the run.

The state of Oregon reactivated artificial propagation activities with the collection of spring-run broodstock at the base of Marmot Dam from 1938 to 1955. Until the 1950s, introductions of Upper Willamette River spring-run chinook salmon were limited and intermittent. A hatchery was established on Cedar Creek, a tributary to the Sandy River, below Marmot Dam. Although releases of spring-run chinook salmon were made from the Cedar River site, there is some evidence that many of the returning "spring-run" fish were actually fall-run chinook salmon (Wallis 1966). Introductions of Upper Willamette River spring-run chinook salmon into the Sandy River Basin increased considerably during the 1960s and 1970s. Recent estimates of spawn timing indicate a shift towards a later period, mid-September to mid-October (ODFW 1990), although surveys of naturally spawning spring-run adults are not conducted. This later spawning time corresponds to the Clackamas River Hatchery spring-run broodstock (an Upper Willamette River derivative).

ESU DEFINITIONS

Conclusions on the Status of Specific Populations

Co-manager comments and additional review identified a number of populations with uncertain ESU affinities. In evaluating the status of these populations the BRT utilized all available life history information (historical and present), historical abundance information, hatchery transfer and release records, and genetic information. This information was used to determine the evolutionary relationships between these populations and chinook salmon ESUs. Discussion of some specific populations follows.

Clackamas River Spring-Run Chinook Salmon

Nicholas (1995) originally argued that spring-run chinook salmon in the Clackamas River should be considered part of the Upper Willamette River ESU. In the status review, the BRT had described these population(s) as out-of-ESU introductions from the Upper Willamette River. ODFW (1998) currently views these population(s) as part of the Lower Columbia River ESU. There is little information available on the historical spring-run population(s) in this basin.

In the late 1800s, the Clackamas River historically contained a large run of spring-run chinook salmon, which spawned from the end of July to the end of August or early September (Barin 1886, Abernethy 1886, Ravenel 1898b). The construction of the Cazadero and River Mill Dams in the early 1900s effectively eliminated access to the historical spring-run spawning habitat. Following the construction of the dams, the spring-run chinook salmon population in the Clackamas River Basin was sustained through limited natural spawning below the dams and through artificial propagation. Although hatcheries in the basin have used locally returning fish as broodstock, they have also heavily relied on transfers of eggs from upper Willamette River hatcheries for production. Following restoration of passage facilities at the Clackamas River dams in 1939, recolonization of the upper Clackamas River was limited. Since 1950, two major hatchery programs have been in operation in the Clackamas River Basin: Eagle Creek National Fish Hatchery (1956-1985) and ODFW Clackamas Hatchery (1976-present). Both of these hatcheries utilized upper Willamette River hatchery stocks. Increases in adult returns over the North Fork Dam and increases in redd counts above the North Fork Reservoir corresponded to the initial return of adults to the hatchery in 1980 (ODFW 1992, Willis et al. 1995). Currently, naturally spawning spring-run chinook salmon spawn from September to October, a time that corresponds more closely with upper Willamette River stocks (Olsen et al. 1992).

Genetic analysis by NMFS of naturally produced fish from the upper Clackamas River indicated that this stock clustered with hatchery stocks from the Upper Willamette River Basin (Myers et al. 1998). This finding agrees with an earlier comparison of naturally produced fish from the Collawash River (a tributary to the upper Clackamas River) and upper Willamette River hatchery stocks (Shreck et al. 1986).

The BRT discussed, at length, several scenarios for the ESU status of naturally spawning spring-run chinook salmon in the Clackamas River. It was generally agreed that introductions of fish from the upper Willamette River have significantly introgressed into, if not overwhelmed, spring-run fish native to the basin. Although there is no genetic baseline for the historical population, the significant changes in spawning time from the 1890s to the present is the pattern that would be expected if the native stock had been displaced. Furthermore, observed adult passage at the dams indicates that this change had occurred by the early 1950s, before the recent large hatchery programs were initiated at the Eagle Creek NFH (1956) and the Clackamas Hatchery (1976). Finally, the fact that increases in spawner abundance in the upper Clackamas River Basin corresponded directly with the first adult returns to the Clackamas Hatchery persuaded most of the BRT that the present naturally spawning population(s) in the Clackamas River are derivatives of upper Willamette River populations.

It was suggested by ODFW (1998) that spring-run fish returning to the upper Willamette River Basin historically may have strayed into the Clackamas River at times when conditions at Willamette Falls prevented upstream passage. If so, the current genetic similarity of Clackamas River and Upper Willamette River fish might reflect an historical/evolutionary affinity rather than a recent artifact of human intervention. The BRT concluded that, regardless of the explanation for the current similarity between the spring runs in the Clackamas and upper Willamette Rivers, the existing naturally spawning population in the Clackamas River is derived from fish from the Upper Willamette River ESU and is not part of the Lower Columbia River ESU.

Sandy River Spring Run Chinook Salmon

There was limited information on the life history characteristics for this spring run. Historical records from hatcheries that operated in the basin indicated that spawning began in late July and ended in late August (Ravenel 1898a, 1898b). Access to the upper Sandy River Basin was severely impacted by the construction of Marmot Dam, and the downstream survival of any smolts produced in the upper basin was severely reduced with the construction of a water diversion/hydropower system at Marmot Dam (Craig and Suomela 1940). There was limited spawning habitat available below Marmot Dam, and broodstock were captured at the base of the dam (1938-1955) for artificial propagation. Additionally, eggs were transferred from upper Willamette River hatcheries to bolster the spring run. Although adequate adult passage facilities were restored in 1939, the water diversion facilities were not screened until 1951. Introductions of Upper Willamette River spring-run chinook salmon increased considerably during the 1960s and

1970s. Currently, spawning is estimated to occur from mid-September to mid-October; this later spawning time corresponds to the Clackamas River Hatchery spring-run broodstock (an Upper Willamette River derivative).

Genetic analysis of allozyme variation in naturally spawning fish from the Sandy River suggested that the Sandy River population was genetically intermediate between Upper Willamette River populations and Lower Columbia River populations. Nicholas et al. (1995) stated that population(s) of spring-run chinook salmon in the Sandy Rivers had been considerably influenced by introductions of chinook salmon from the Upper Willamette River ESU. If so, this would help explain the allozyme data that show little genetic resemblance between spring-run and late fall-run fish in the Sandy River Basin. In other Lower Columbia River and coastal basins, spring- and fall-run populations within a basin generally show a high level of genetic similarity. Microsatellite DNA data indicate that the allele frequencies in the Sandy River spring-run are statistically different from those in the Clackamas Hatchery spring-run broodstock; however, the degree of differentiation is much smaller than that between spring runs in the Sandy and Yakima Rivers. Bentzen et al. (1998) concluded from these data that, although some interbreeding between the Upper Willamette River and Sandy River stocks had presumably occurred, the Sandy River population still retained some of its ancestral genetic characteristics. Therefore, the BRT reiterated its conclusion that the naturally spawning population in the Sandy River is part of the Lower Columbia River ESU.

Lower River Bright Chinook Salmon

ODFW (1998) presented the BRT with information on a population of apparently naturally reproducing fall-run chinook salmon that spawns along several islands in the mainstem Columbia River below Bonneville Dam. Genetic analysis indicates that fish from this population most closely resembled upriver bright (URB) stocks released from a number of hatcheries in the Lower Columbia River: Bonneville Hatchery, Little White Salmon NFH, and Yakima River Fall-Run (which represents a composite of hatchery releases and some natural production) (Marshall 1998). It is not clear when this population was established, but when "discovered" in 1994 it numbered over a thousand spawners (Hymer 1997). There have been a few recoveries of coded wire tags (CWTs) from fish spawning in this area. ODFW (1998) suggested that it was most likely that this population was established by strays from the various URB hatchery programs, but the population has since become self-sustaining. They view this population as an important source for gene diversity in the Lower Columbia River ESU.

The BRT concluded that the genetic and evolutionary affinities of this population lie with the URB populations, and therefore it should be considered part of the Upper Columbia River Summer- and Fall-Run ESU.

Select Area Brights

As part of a fisheries enhancement program, fall-run chinook salmon the Rogue River's Cole River hatchery were released from facilities at Big Creek (beginning in 1984) and Young's Bay (beginning in 1989). Because of the large number of straying adults observed in tributaries to the lower Columbia River, the release of fish from the Big Creek Hatchery has been terminated (ODFW 1998). Although attempts have been made to limit impacts of this program to natural populations in the Lower columbia River, some natural spawning has occurred (Marshall 1997)

Any naturally spawning fish (or their descendants) derived from this program are not considered part of the Lower Columbia River ESU.

ESU-Specific Conclusions

Puget Sound ESU

Few comments were received regarding the geographic boundaries of the Puget Sound ESU. The BRT reviewed, and reiterated, its previous conclusions that chinook salmon in the Elwha, North Fork Nooksack, and South Fork Nooksack Rivers are part of the Puget Sound ESU while chinook salmon populations from Southern British Columbia are not.

The BRT had considerable discussion on the inclusion of naturally spawning chinook populations founded by hatchery populations which originated from within the ESU, but may not be representative of the historical local stock or which may represent a mixture of within-ESU stocks. The BRT concluded that, unless there is evidence that they resulted from out-of-ESU introductions, naturally spawning populations within the geographic boundaries of the Puget Sound ESU generally should be considered part of the biological ESU. What role individual populations might play in recovery will be determined during the recovery process, taking into consideration the origin and status of the current population.

The BRT also considered some areas that may not have historically supported large or persistent chinook salmon populations. For example, the small, shallow, lowland streams in southern Puget Sound (west of the Nisqually River) are subject to seasonal flooding and drought events and represent marginal chinook salmon habitat (Williams et al. 1975). It is doubtful that most of these systems were historically self-sustaining, and much of the current abundance appears to be the result of extensive outplantings of stocks from other areas in the ESU and strays from nearby hatchery programs (WDF et al. 1993). Nevertheless, the current natural production appears to result from fish within this ESU.

The BRT also discussed the status of chinook salmon spawning in the Deschutes River. Historically, access to the river was blocked at Tumwater Falls and chinook salmon did not exist above the falls. The construction of a fish ladder at Tumwater Falls in 1954 provided access to suitable spawning and rearing habitat for chinook salmon (Williams et al. 1975). Planting records for this river and surrounding areas indicate that this population was probably derived primarily from Green River hatchery plants. Genetic analysis indicated that Deschutes River chinook salmon cluster with fish from other Green River derived stocks (Myers et al. 1998). Based on this information the BRT concluded that any naturally spawning populations that were established above the barrier should be included in the ESU.

Lower Columbia River ESU

As described above, the BRT discussed at length the status of several chinook salmon populations in the Lower Columbia River. The BRT concluded that, although fish introduced from the Upper Willamette River ESU have probably interbred with indigenous spring run in the Sandy River, this population still retained some genetic characteristics from the native population. In light of the extirpation of the majority of the spring run populations in this ESU and despite the history of introductions from outside of the ESU, this population may be an important genetic resource and was considered part of the Lower Columbia River ESU. In contrast, naturally spawning Clackamas River spring-run chinook salmon are considered to be part of the Upper Willamette River ESU, and the fall-run fish that spawn in the mainstem Columbia River below Bonneville Dam (Lower River brights) are considered to be part of the Upper Columbia River Summer- and Fall-Run ESU.

Upper Willamette River ESU

The BRT reviewed its previous decision on the designation of the Upper Willamette River ESU. Information provided by ODFW (1998) indicates that at present the only significant natural production of spring-run chinook salmon occurs in the McKenzie River Basin. Previously, Nicholas et al. (1995) had also suggested that a self-sustaining population may exist in the North Santiam River Basin. In general, the BRT considered that any naturally spawning spring-run chinook salmon was part of the ESU, unless it could be shown to have originated from outside of the ESU. The BRT specifically excluded fall-run chinook salmon from this ESU. Fall-run fish are not native to the basin, having been introduced above the Willamette Falls on several occasions throughout this century. The BRT did not determine which, if any, ESU these fall-run fish belonged to.

As described above, the BRT concluded that the current population of naturally spawning spring-run chinook salmon in the Clackamas River is derived from this ESU. The BRT could not determine, based on available information, whether this represents an historical affinity or a recent, human-mediated expansion into the Clackamas River. In any case, the current Clackamas River population represents a genetic resource that might be useful in the recovery of the Upper Willamette River ESU.

Upper Columbia River Spring Run

The BRT discussed several issues related to the designation of this ESU. Although the spring-run chinook salmon populations in this ESU were effectively homogenized during the implementation of the GCFMP (1939-1943), the BRT concurred with its previous conclusion that this ESU contained the only remaining genetic resources of those spring-run chinook salmon that migrated into the upper Columbia River Basin (including fish that would have spawned in Canada) and was distinct from other stream-type chinook salmon ESUs. There was some discussion concerning the extent of introgression by releases of Carson NFH-derivative spring-run broodstock into native populations. Information provided by co-managers suggested that this level of introgression is quite low. The BRT specifically excluded naturally spawning populations that could be shown to be derived from sources outside of the ESU.

RISK ASSESSMENT

Previous and Updated Risk Information for Chinook Salmon ESUs

Puget Sound ESU

Updated abundance information through 1997-98 was obtained for almost all streams in the Puget Sound ESU. Recent estimated escapements of chinook salmon to rivers in this ESU ranged from 38 spring/summer-run chinook salmon in the Dungeness River to almost 7,000 summer/fall chinook salmon in the Skagit River Basin. Most of the 36 streams with data available continue to exhibit declines in estimated abundance. Seven of the 10 streams with positive trends in abundance are considered to be influenced by hatchery fish.

The peak recorded harvest landed in Puget Sound occurred in 1908, when 95,210 cases of canned chinook salmon were packed. This corresponds to a run size of approximately 690,000 chinook salmon at a time when both ocean harvest and hatchery production were negligible. (This estimate, as with other historical estimates, needs to be viewed cautiously; Puget Sound cannery pack probably included a portion of fish landed at Puget Sound ports but originating in adjacent areas, cannery pack represents only a portion of the total catch, and the estimates of exploitation rates used in run-size expansions are not based on precise data.) Bledsoe et al. (1989) estimated that the total Puget Sound catch in 1908 was approximately 670,000 fish (based on a catch of 2.1 million kg.). Recent mean spawning escapements totaling 71,000 correspond to a run entering Puget Sound of approximately 160,000 fish based on run reconstruction of escapement and commercial landings within Puget Sound (BE and LGL 1995). Expanding this estimate by the fraction of 1982-1989 average total harvest mortalities of Puget Sound chinook salmon stocks in intercepting ocean fisheries (exclusive of U.S. net fisheries) and U.S. recreational fisheries would yield a recent average potential run size of 426,000 chinook salmon into Puget Sound (PSC 1994, appendices F and G).

Currently, escapement to rivers in Puget Sound and Hood Canal is monitored by WDFW and the Northwest tribes. Populations least affected by hatcheries are in the northern part of the sound in the Nooksack, Skagit, Stillaguamish, and Snohomish River systems.

The Nooksack River has spring/summer runs in the north and south forks. The North Fork escapement is monitored by carcass surveys and is influenced by a hatchery on Kendall Creek (part of a native stock rebuilding program). Escapement to the South Fork is monitored by redd counts, and the stock is believed to have little hatchery influence. Both stocks were rated as "critical" by WDFW because of chronically low spawning escapements. The Skagit River supports three spring runs, two summer runs and a fall run. Mean spawning escapement of the summer/fall run has been almost 7,000 fish and has been declining (Table 4). Terminal run size has been declining, and escapement has been maintained at the expense of terminal fisheries. Of the six stocks in the Skagit River Basin identified by WDF et al. (1993), two are rated healthy, three depressed, and one of unknown status. On the Stillaguamish River, two runs have been identified. The combined escapement goal has been met only twice since 1978, and the most recent mean abundance consisted of just over 1,000 fish (Table 4). Both runs were rated as "depressed" by WDFW (WDF et al. 1993). Of four runs identified in the Snohomish River system, two are rated depressed, one unknown, and one as healthy. The single stock identified as "healthy" (Wallace River) is considered to be derived from hatchery strays, and it has experienced a severe recent decline.

Both long- and short-term trends for natural chinook salmon runs in North Puget Sound were negative, with few exceptions. In South Puget Sound, both long- and short-term trends in abundance were predominantly positive (Table 4).

In Hood Canal, summer/fall-run chinook salmon spawn in the Skokomish, Union, Tahuya, Duckabush, Dosewallips and Hamma Hamma Rivers. Because of transfers of hatchery fish, these spawning populations are considered a single stock (WDF et al. 1993). Fisheries in the area are managed primarily for hatchery production and secondarily for natural escapement; high harvest rates directed at hatchery stocks have resulted in failure to meet natural escapement goals in most years (USFWS 1997). The 5-year geometric mean natural spawning escapement has been just over 1,000 (Table 4), 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 has a run of spring/summer-run chinook salmon with a 5-year geometric mean natural escapement of only 38 fish (Table 4). WDFW maintains a captive broodstock program using offspring from local redds on the Dungeness River because of the severely depressed numbers (Crawford, 1998). The Elwha River has a 5-year geometric mean escapement of just over 1,500 fish (Table 4), but it contains two hatcheries, both lacking adequate adult recovery facilities. Egg take at the hatcheries is augmented from natural spawners, and hatchery fish spawn in the wild. Consequently, hatchery and natural spawners are not considered discrete stocks (WDF et al. 1993). Both the Dungeness and Elwha River populations exhibit severely declining recent trends in abundance (Table 4). Furthermore, only limited accessible spawning habitat remains in the Elwha River Basin, and it is not certain that the existing population could persist without hatchery intervention.

As reported in the Status Review (Myers et al. 1998), habitat throughout the Puget Sound region has been blocked or degraded. In general, upper tributaries have been negatively affected 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, PSSSRG 1997). Increasing percentages of land in the Puget Sound area are composed of impermeable surfaces, and the reductions in habitat quality due to point- and non-point source pollutants have been widespread (McCain et al. 1988, PSWQA 1988, Palmisano et al. 1993), and the direct and indirect impacts of the reduction in habitat quality on chinook salmon have just begun to be explored. For example, recent research has shown that juvenile chinook salmon from a contaminated estuary in Puget Sound are more susceptible to disease pathogens than are juvenile chinook salmon from a non-urban estuary (Arkoosh et al. 1998a and 1998b).

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. In the Stillaguamish River, summer-run chinook have been supplemented under a wild broodstock program for the last decade. In some years, returns from this program have composed up to 30-50% of the natural spawners, suggesting that the unaided stock is not able to maintain itself (NWIFC 1997). Almost all of the releases of hatchery-origin chinook salmon 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 in some specific regions. 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 are quite high. Ocean exploitation rates on natural stocks averaged 56-59%; total exploitation rates averaged 68-83% for the 1982-89 brood years (PSC 1994). Total exploitation rates on some stocks have exceeded 90% (PSC 1994). Recent changes in hatchery management practices include a program to mass mark hatchery chinook salmon with adipose fin clips (Bruce Sanford, WDFW, 600 Capitol Way N, Olympia, WA 98501-1091. Pers. commun., November, 1998). The mass marking program is designed to assist managers in implementing selective fisheries. The enhanced ability to visually identify chinook salmon of hatchery origin in fisheries and for spawning ground surveys is viewed as a positive outcome of the mass marking program. However, as a byproduct of the mass-marking strategy, a small fraction of hatchery-origin chinook salmon will receive coded-wire tags but will not have their adipose fins removed, in order to estimate the behavior of naturally-produced chinook salmon in selective fisheries. Therefore, it is expected that technical difficulties will increase in detecting coded-wire tagged chinook salmon as a result of changes in the adipose marking program. In addition, valuable stock-specific abundance and mortality schedule information for chinook salmon may be more difficult to obtain if recovery of coded-wire tags is compromised under the new management practices.

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern (Myers et al. 1998). Nehlsen et al. (1991) identified four stocks as extinct, four stocks as possibly extinct, six stocks as at high risk of extinction, one stock as at moderate risk (White River spring run), and one stock (Puyallup River fall run) as of special concern. WDF et al. (1993) considered 28 stocks within the ESU, of which 13 were considered to be of native origin and predominantly natural production. The status of these 13 stocks was: 2 healthy (Upper Skagit River summer run and Upper Sauk River spring run), 5 depressed, 2 critical (South-Fork Nooksack River spring/summer run and Dungeness River spring/summer run), and 4 unknown. The status of the remaining (composite production) stocks was eight healthy, two depressed, two critical, and three unknown. The Nooksack/Samish River fall run and Issaquah Creek summer/fall run were not considered an ESA issue by the BRT (stocks were not historically present in the watershed or current stocks are not representative of historical stocks) but were included to give a complete presentation of stocks identified by WDF et al. (1993).

Lower Columbia River Region

The Lower Columbia River Region includes portions of the Coastal Range, Willamette Valley, and Cascades ecoregions (see Myers et al. 1998). This region is characterized by numerous short and medium-length rivers and streams draining the coast ranges and west slope of the Cascade Mountains and a single large river, the Willamette River. We have no estimates of overall historic abundance of chinook salmon in this region, but there are a few reports from specific streams draining into the lower Columbia River (see ESU-specific sections below). Peak cannery pack for the entire Columbia River Basin occurred in 1883, when 629,400 cases were packed, suggesting a total run size of about 4.6 million chinook salmon.

Chinook salmon in this region have been strongly affected by losses and alterations of freshwater habitats. Bottom et al. (1985), WDF et al. (1993), and Kostow (1995) provide reviews of habitat problems. Timber harvesting and associated road building occur throughout the region on federal, state, and private lands. These activities may increase sedimentation and debris flows and reduce cover and shade, resulting in aggradation, embedded spawning gravel, and increased water temperatures. Timber harvest in the Oregon portion of the region peaked in the 1930s, but habitat impacts remain (Kostow 1995). Agriculture is also widespread in the lower portions of river basins, and has resulted in widespread removal of riparian vegetation, rerouting of streams, degradation of streambanks, and summer water withdrawals. Urban development has had substantial impacts in the lower Willamette Valley, including channelization and diking of rivers, filling and draining of wetlands, removal of riparian vegetation, and pollution (Kostow 1995).

Intensive hatchery programs were initiated more than 100 years ago in this region. Nearly 4.5 billion hatchery-derived fish have been released during the last 70 years, equal to the total for all the other regions combined (see Myers et al. 1998). The majority of these have been tule fall-run chinook salmon released into the lower Columbia River for fisheries enhancement. Because of the advanced degree of maturation that tules exhibit at the time of freshwater entry, the economic value of these fish is rather low; therefore, efforts have been made to introduce Rogue River bright fall-run chinook and upper Columbia River upriver bright fall-run chinook into this region (WDF et al. 1993, Kostow 1995, Marshall et al. 1995). In addition, fall-run chinook salmon from the lower Columbia River were introduced into the upper Willamette River Basin beginning in the 1950s to exploit underutilized habitat.

Lower Columbia River ESU

Updated abundance information through 1997-98 was obtained for many streams in the Lower Columbia River ESU. Smaller tributary streams in the lower reaches of the Columbia River (e.g., Big, Skamokawa and Gnat Creeks, and Elochoman, Youngs, Klaskanine, and Grays Rivers) support naturally-spawning chinook salmon runs numbering in the hundreds of fish. The larger tributaries, such as the Cowlitz River Basin streams, contain natural runs of chinook salmon ranging in size from 100 to almost 1,000 fish (Table 4). It is difficult to obtain precise estimates of natural escapements in many streams within the lower Columbia River Basin because of the presence of hatchery chinook salmon in many areas. Almost all of the streams with data available are exhibiting declines in estimated abundance. All of the streams considered to be influenced by hatchery fish in this ESU are declining in abundance.

Estimates of historic abundance are available for only a few streams in this ESU, but there is widespread agreement that natural production has been substantially reduced over the last century. The ESU also includes spring-run chinook salmon in the Cowlitz, Lewis, Kalama, and Sandy Rivers. Historical estimates of spring-run chinook salmon escapement into the Cowlitz River Basin are available for the early 1950s (WDF 1951, Fulton 1968). The estimated total escapement of spring-run chinook salmon was 10,400 to the Cowlitz River, and this total was distributed as 1,700 spring-run chinook salmon into the mainstem Cowlitz River, 8,100 into the Cispus River, and 200 and 400 fish into the Tilton and Toutle Rivers, respectively (WDF 1951). The historical estimate of spring-run chinook salmon escaping into the Sandy River in the 1950s was 1,000 fish (Fulton 1968), although it may have been as high as 12,000 fish historically (Mattson 1955). Recent abundance of spawners through 1996-97 includes a 5-year geometric mean natural spawning escapement of only 3,600 spring-run fish in the entire ESU (Table 4).

Historical estimates of fall-run chinook salmon in the Lower Columbia River ESU also are available for the early 1950s in the Cowlitz River Basin (WDF 1951, Fulton 1968). The estimated total escapement of fall-run chinook salmon to the Cowlitz River was 31,000 fish, of which 10,900 were estimated to escape to the mainstem Cowlitz River, 8,100 to the Cispus River, 6,500 to the Toutle River, 5,000 to the Coweeman River, and 500 to the Tilton River (WDF 1951). In addition, estimates of fall-run chinook salmon into the smaller tributaries in the lower Columbia River (i.e., Klaskanine, Elokomin, Clatskanie Rivers and Big and Gnat Creeks) was a total of 4,000 fish (Fulton 1968). Fulton (1968) also provided estimates of escapement of fall-run chinook into the Lewis (n=5,000), Washougal (n=3,000) and the Kalama (n=20,000) Rivers for the 1950s. In other words, in the 1950s, at least 63,000 fall-run chinook salmon escaped to spawn in the lower Columbia River region. However, it should be noted that by the 1950s the Lower Columbia River chinook salmon stocks had already declined considerably from pre-European settlement levels, and hatchery production was already substantial.

Currently, spawning escapement to populations on the Washington side of the Columbia River are monitored primarily by peak fish counts in index areas (WDF et al. 1993). Estimates of spring- and fall runs to the mainstem Columbia River tributaries are routinely reported by fishery management agencies (WDFW and ODFW 1994, PFMC 1996). Peak index area spawning counts are expanded to estimate total spawning escapement. In most lower Columbia River tributaries in Oregon, foot surveys are conducted and escapement estimates are based on peak spawner counts or redd counts (Theis and Melcher 1995), and dam counts are available for the Sandy River. For fishery monitoring purposes, individual spawning populations are combined into stock groupings: Lower Columbia River Wild, Lower Columbia River Hatchery, and Spring Creek Hatchery stocks of fall-run chinook salmon (WDFW and ODFW 1994, PFMC 1996). Data through 1996-97 indicate that the fall run currently includes 34,000 natural spawners (Table 4), but according to the accounting of PFMC (1996b), approximately 68% of the natural spawners are first-generation hatchery strays. Long-term trends in escapement for the fall- and spring-run are mixed, with most larger stocks showing positive trends (Table 4). Short-term trends in abundance for both runs are more negative. The only remaining spring-run chinook salmon populations that are not showing severe declines in abundance are those on the Sandy and Hood Rivers (Table 4), and these are both heavily influenced by hatchery fish; however, the spring run in the Hood and Sandy Rivers may not be representative of the native stock (Kostow et al. 1995).

All basins are affected to varying degrees by habitat degradation. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in floodplains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked (or passage substantially impaired) in the Cowlitz (Mayfield Dam 1963, RKm 84), Lewis (Merwin Dam 1931, RKm 31), Clackamas (North Fork Dam 1958, RKm 50), White Salmon (Condit Dam 1917, RKm 5), Hood (Powerdale Dam 1929, RKm 7), and Sandy (Marmot Dam 1912, RKm 48; Bull Run River dams in the early 1900s) Rivers (WDF et al. 1993, Kostow 1995).

Hatchery programs to enhance chinook salmon fisheries abundance in the lower Columbia River began in the 1870s, expanded rapidly, and have continued throughout this century. Although the majority of the stocks have come from within this ESU, over 200 million fish from outside the ESU have been released since 1930 (Myers et al. 1998). A particular concern at the time the Status Review was prepared is the straying by Rogue River fall-run chinook salmon, large numbers of which are released into the lower Columbia River to augment harvest opportunities (Myers et al. 1998). Beginning in 1997, ODFW began restricting the release sites of the Rogue River hatchery fall-run chinook salmon to Youngs Bay in the Lower Columbia River, where an intensive chinook salmon fishery occurs (ODFW 1998). ODFW hopes that reducing the number of sites where the Rogue River fish are released and targeting those hatchery fish in an active chinook salmon fishery will reduce the incidence of straying of non-ESU fish into lower Columbia

River tributaries (ODFW 1998). Available evidence indicates a pervasive influence of hatchery fish on natural populations throughout this ESU, including both spring- and fall-run populations (Howell et al. 1985, Marshall et al. 1995). In addition, the exchange of eggs among hatcheries in this ESU apparently has led to extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

Harvest rates on fall-run stocks are moderately high, with an average total exploitation rate of 65% (1982-89 brood years) (PSC 1994). The average ocean exploitation rate for this period was 46%, while the freshwater harvest rate on the fall run has averaged 20%, ranging from 30% in 1991 to 2.4% in 1994. Harvest rates are somewhat lower for spring-run stocks, with estimates for the Lewis River averaging 24% ocean and 50% total exploitation rates in 1982-89 (PSC 1994). In fisheries within the river, approximately 15% of the lower river hatchery stock is harvested, 29% of the lower river wild stock is harvested, and 58% of the Spring Creek hatchery stock is harvested (PFMC 1996). The average in-river exploitation rate on the stock as a whole is 29% (1991-1995).

Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern (Myers et al. 1998). Nehlsen et al. (1991) identified two stocks as extinct (Lewis River spring run and Wind River fall run), four stocks as possibly extinct, and four stocks as at high risk of extinction. The Sandy River spring run and Hood River spring and fall runs were not considered an ESA issue by the BRT (stocks were not historically present in the watershed or current stocks are not representative of historical stocks) but were included to give a complete presentation of stocks identified by Nehlsen et al. (1991). WDF et al. (1993) considered 20 stocks within the ESU, of which only 2 were considered to be of native origin and predominantly natural production (Lewis River and East Fork Lewis River fall runs). The status of these two stocks was considered to be healthy. The status of the remaining (not native/natural) stocks was: 14 healthy and 4 depressed. Huntington et al. (1996) identified one healthy Level I stock in their survey (Lewis River fall run).

ODFW provided the BRT with an overview of the conservation status of Lower Columbia River chinook salmon stocks (ODFW 1998). ODFW identified the chinook salmon populations in the Lower Columbia River ESU that were naturally self-sustaining and provided the agency's best estimate of the conservation status of each population and the percentage of hatchery fish in natural spawning escapements. The list of populations included fall-run chinook salmon on the Sandy, Clackamas, White Salmon, Wind, North Fork Lewis, East Fork Lewis, Coweeman and mainstem Columbia Rivers. Estimated average minimum escapements over the last 5 years for fall runs ranged from 100 to 11,600, and the estimated percentages of hatchery fish in natural spawning escapements ranged from 0 to 8% (ODFW 1998). ODFW classified seven of the fall-run populations as "depressed/stable" and as "healthy/stable". Spring-run chinook salmon populations included on the list were those in the Sandy and Clackamas Rivers. Estimated escapements ranged from 3,000 to 3,700 fish, and the estimated percentage of spawners of hatchery origin ranged from 10-50% (ODFW 1998). ODFW classified the Sandy River spring-run population status as "unknown/increasing" and the Clackamas spring-run population status as "unknown/stable."

Upper Willamette River ESU

Updated abundance information for chinook salmon in the Upper Willamette River ESU through 1997-98 was obtained for the total abundance estimate of spring chinook salmon at Willamette Falls and counts at Leaburg Dam on the McKenzie River (Table 4). Spring chinook salmon runs at both sites continue to exhibit declines in estimated abundance. For fishery monitoring purposes, the Clackamas River spring-run chinook salmon are included with the

Willamette River (ODFW 1994). Consistent with ODFW's approach, the BRT concluded that the spring-run chinook salmon in the Clackamas River should be considered part of the Upper Willamette River ESU (see previous section). Historical estimates of chinook salmon abundance in the Clackamas River are available for the mid 1800s. One hundred and forty and 100 tons of chinook salmon were harvested from the Clackamas River in 1893 and 1894, respectively. Given an average of 22.8 pounds per fish, an estimated 12,000 and 8,000 chinook salmon were caught in those two years (ODFW 1992). ODFW (1992) reported that most of the chinook salmon caught in the Clackamas River fisheries were spring-run. Updated dam counts for spring-run chinook salmon on the Clackamas River were obtained by the BRT through 1997, and the resulting 5-year geometric mean estimate of naturally spawning spring-run chinook salmon is just over 6,000 fish (Streamnet 1998). Because of the heavy influence of spring-chinook salmon of hatchery origin in the Clackamas River, the BRT did not weigh Clackamas River abundance estimates heavily in their risk determinations for the Upper Willamette River ESU.

The spring run has been counted at Willamette Falls since 1946 (ODFW and WDFW 1995), but counts were not differentiated into adults and jacks until 1952. In the first 5 years (1946-50), the geometric mean of the counts for adults and jacks combined was 31,000 fish. The most recent 5-year (1993-97) geometric mean escapement above Willamette Falls was 24,000 adults (Table 4). Willamette River spring-run chinook salmon are targeted by commercial and recreational fisheries in the lower Willamette and Columbia Rivers. During the 5-year period from 1992-1996, the geometric mean of the run-size to the mouth of the Columbia River was 48,000 fish (PFMC 1997b). The majority of the Willamette River fish are hatchery produced.

Estimates of the naturally produced run have been made only for the McKenzie River from 1994 to 1998 (Nicholas 1995, ODFW 1998). Nicholas (1995) estimated the escapement of naturally produced spring-run chinook salmon in the McKenzie River to be approximately 1,000 spawners. Updated information using an estimation from counts at Leaburg Dam suggest that the most recent 5-year geometric mean escapement of naturally-spawning spring-run chinook salmon in the McKenzie River was 1,500 fish (ODFW 1998, Table 4). Until the 1940s, as many as 11 million chinook salmon fry and fingerlings were released into the McKenzie River and tributaries annually (Howell et al. 1988, Wallis 1961). Although returns from these releases were poor, there has been a shift in the spawn timing in the McKenzie River Basin from historical times. In the early 1900s, peak spawning occurred during early September, and now peak spawning occurs during late September/early October (Howell et al. 1988, Wallis 1961). It is possible that the shift in spawn timing of chinook salmon in the McKenzie River Basin is due in part to influences from hatchery-derived fish. Alternatively, alterations in the thermal regime due to dam projects may have caused the shift in spawn timing.

Long-term trends in escapement of spring-run chinook salmon to the Upper Willamette River ESU are mixed, ranging from slightly upward to moderately downward (Table 4). Short-term trends in abundance are all strongly downward.

Although the abundance of Willamette River spring-run chinook salmon has been relatively stable over the long term, and there is evidence of some natural production, it is apparent that at present production and harvest levels the natural population is not replacing itself. With natural production accounting for only 1/3 of the natural spawning escapement, it is questionable whether natural spawners would be capable of replacing themselves even in the absence of fisheries. Although hatchery programs in the Willamette River Basin have maintained broodlines that are relatively free of genetic influences from outside the basin, they may have homogenized stocks, reducing the population structure within the ESU. Prolonged artificial propagation of the majority of the production from this ESU may also have reduced the ability of Willamette River spring-run chinook salmon to reproduce successfully in the wild.

Habitat blockage and degradation are significant problems in this ESU. Available habitat has been reduced by construction of dams in the Santiam, McKenzie, and Middle Fork Willamette River Basins, and these dams have probably adversely affected remaining production via thermal effects. Agricultural development and urbanization are the main activities that have adversely affected habitat throughout the basin (Bottom et al. 1985, Kostow 1995).

Historically, only spring-run fish were able to ascend Willamette Falls to access the upper Willamette River (Fulton 1968). Following improvements in the fish ladder at Willamette Falls, some 200 million fall-run chinook salmon have been introduced into this ESU since the 1950s. In contrast, the upper Willamette River has received relatively few introductions of non-native spring-run fish from outside this ESU (Myers et al. 1998). Artificial propagation efforts have been undertaken by a limited number of large facilities (McKenzie, Marion Forks, South Santiam, and Willamette (Dexter) Fish Hatcheries). These hatcheries have exchanged millions of eggs from various populations in the upper Willamette River Basin. The result of these transfers has been the loss of local genetic diversity and the formation of a single breeding unit in the Willamette River Basin (Kostow 1995). Considerable numbers of hatchery spring-run strays have been recovered from natural spawning grounds, and an estimated two-thirds of natural spawners are of hatchery origin (Nicholas 1995). There is also evidence that introduced fall-run chinook salmon have successfully spawned in the upper Willamette River (Howell et al 1985). Whether hybridization has occurred between native spring-run and introduced fall-run fish is not known.

Total harvest rates on stocks in this ESU are moderately high, with the average total harvest mortality rate estimated to be 72% in 1982-89, and a corresponding ocean exploitation rate of 24% (PSC 1994). This estimate does not fully account for escapement, and ODFW is in the process of revising harvest rate estimates for this stock; revised estimates may average 57% total harvest rate, with 16% ocean and 48% freshwater components (Kostow 1995). The in-river recreational harvest rate (Willamette River sport catch / estimated run size) for the period from 1991 through 1995 was 33% (data from PFMC 1996). ODFW (1998) provided information indicating that total (marine and freshwater) harvest rates on upper Willamette River spring run stocks have been reduced considerably for the 1991-93 broodyears to an average 21%.

The only previous assessment of risk to stocks in this ESU is that of Nehlsen et al. (1991), who identified the Willamette River spring-run chinook salmon as of special concern (Myers et al. 1998). They noted vulnerability to minor disturbances, insufficient information on population trends, and the potential loss of unique run-timing characteristics of this stock as causes for concern.

Upper Columbia River Spring Run ESU

We have no estimates of historical abundance specific to this ESU. WDFW monitors nine spring-run chinook salmon stocks geographically located within this ESU. Escapements to most tributaries are monitored by redd counts, which are expanded to total live fish based on counts at mainstem dams. Updated abundance information for spring-run chinook salmon in the Upper Columbia River ESU through 1997-98 was obtained for redd counts on all streams monitored in this ESU (Table 4). Escapements continue to be critically low in all rivers, and the redd counts still are declining severely. Individual populations within the ESU are all quite small, with none averaging over 150 adults annually in recent years (Table 4).

Long-term trends in estimated abundance are mostly downward, with annual rates of change ranging from -6% to +1% over the full data set. All ten short-term trends were downward, with 5 populations exhibiting rates of decline exceeding 20% per year (Table 4).

Access to a substantial portion of historical habitat was blocked by Chief Joseph and Grand Coulee Dams. There are local habitat problems related to irrigation diversions and hydroelectric development, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Mainstem Columbia River hydroelectric development has resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat. Fish in some populations in this ESU must migrate through nine mainstem dams as both juveniles and adults.

Artificial propagation efforts have had a significant impact on spring-run populations in this ESU, either through hatchery-based enhancement or the extensive trapping and transportation activities associated with the GCFMP. Prior to the implementation of the GCFMP, spring-run chinook salmon populations in the Wenatchee, Entiat, and Methow Rivers were at severely depressed levels (Craig and Suomela 1941). Therefore, it is probable that the majority of returning spring-run adults trapped at Rock Island Dam for use in the GCFMP were probably not native to these three rivers (Chapman et al. 1995). All returning adults were either directly transported to river spawning sites or spawned in one of the NFHs built for the GCFMP.

In the years following the GCFMP, several stocks were transferred to the NFHs in this area, most importantly Carson NFH spring-run chinook salmon or other stocks derived from the Carson NFH stock (WDF et al. 1993, Chapman et al. 1995, Marshall et al. 1995). Naturally spawning populations in tributaries upstream of hatchery release sites have apparently undergone limited introgression by hatchery stocks, based on CWT recoveries and genetic analysis (Chapman et al. 1995). Utter et al. (1995) found that the Leavenworth and Winthrop NFH spring runs were genetically indistinguishable from the Carson NFH stock, but distinct from naturally spawning populations in the White and Chiwawa Rivers and Nason Creek. Artificial propagation efforts have recently focused on supplementing naturally spawning populations in this ESU (Bugert 1996), although it should be emphasized that these naturally spawning populations were founded by the same GCFMP homogenized stock. Furthermore, the potential for hatchery-derived non-native stocks to genetically impact naturally spawning populations exists, especially given the recent low numbers of fish returning to rivers in this ESU. The hatchery contribution to escapement may be moderated by the homing fidelity of spring-run fish that could reduce the potential for hybridization (Chapman et al. 1995). For example, the hatchery contribution to naturally spawning escapement was recently estimated as 39% in the mainstem Methow River (where the hatcheries are located), but averaged only 10% in the tributaries--Chewuch, Lost, and Twisp Rivers--that are upstream of the hatcheries (Spotts 1995). In contrast, WDFW (1997) reported that in 1996 the Chewuch and Twisp runs were 62% and 72% hatchery fish, respectively.

In two recent years (in 1996 and 1998), 100% of the production in the Methow River Basin has come from hatchery-reared fish. The returns to Methow River tributaries were so low in those years that all adults returning to Wells Dam were intercepted for emergency artificial propagation at the Methow Fish Hatchery and the Winthrop National Fish Hatchery (L. Brown, WDFW, 3860 Chelan Highway, Wenatchee, WA 98801.Pers. commun., November, 1998). In addition, captive broodstock programs are underway on the Twisp River and are just beginning on the White River and Nason Creek (NMFS et al. 1998). Production of the non-native Carson hatchery stock will be discontinued at the Winthrop National Fish Hatchery (NMFS et al. 1998).

Howell et al. (1985), Chapman et al. (1991), Mullan et al. (1992), and Chapman et al. (1995) have suggested that the prevalence of bacterial kidney disease (BKD) in upper Columbia and Snake River hatcheries is directly responsible for the low survival of hatchery stocks. These authors also suggest that the high incidence of BKD in hatcheries impacts wild populations, and reduces the survival of hatchery fish to such an extent that naturally spawning adults are "mined" to perpetuate hatchery stocks (Chapman et al. 1991). There may also be direct horizontal transmission of BKD between hatchery and wild juveniles during downstream migration (specifically in smolt collection and transportation facilities) or vertical transmission from hatchery-reared females on the spawning grounds.

Harvest rates are low for this ESU--ocean harvest is very low and instream harvest is moderate. Harvest rates have been declining recently, and currently are less than 10% (ODFW and WDFW 1995).

Previous assessments of stocks within this ESU have identified several populations as being at risk or of concern (Myers et al. 1998). Nehlsen et al. (1991) identified six stocks as extinct. Due to lack of information on chinook salmon stocks that are presumed to be extinct, the relationship of these stocks to existing ESUs is uncertain. They are listed in Table 4 based on geography and to give a complete presentation of the stocks identified by Nehlsen et al. (1991). WDF et al. (1993) considered nine stocks within the ESU, of which eight were considered to be of native origin and predominantly natural production. The status of all nine stocks was considered depressed. Populations in this ESU have experienced record low returns for the last few years.

Another recent risk evaluation for chinook salmon in this ESU was conducted by an interagency working group as part of the Mid-Columbia River HCP development (NMFS et al. 1998). To determine the need for hatchery supplementation programs in the HCP region (an area including the Wenatchee, Entiat and Methow River Basins), a panel of experts was asked to estimate (using best professional judgement) the probability that the spring-run chinook salmon populations in those 3 river basins would have a certain status (extinct, nearly extinct, <100 fish/year, 100-500 fish/year, and >500 fish/year) after 10-50 years under current conditions and without hatchery supplementation. In all river basins within this Upper Columbia River Spring-Run ESU geographic area, the experts estimated that there was a greater than 50% chance that the chinook salmon would be nearly extinct or extinct within 50 years, assuming current conditions continue into the future. Furthermore, the experts predicted that there was only a 4 to 17% chance that after 50 years there would be more than 100 spring-run chinook salmon in any river (NMFS et al. 1998).

Overall Evaluation of Risk and Uncertainty

To tie the various risk considerations into an overall assessment of extinction risk for each ESU, the BRT members scored risks in a number of categories using a matrix form, then drew conclusions regarding overall risk to the ESU after considering the results. The general risk categories evaluated were: abundance, trends in abundance/productivity/variability, genetic integrity, and "other risks". More detailed explanation of these categories and of the nature and use of this matrix approach is provided in Myers et al. (1998, Appendix E). The summary of overall risk to an ESU uses categories that correspond to definitions in the Endangered Species Act: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (Note, however, that these votes on overall risk do not correspond to recommendations for a particular listing action. They are based only on past and present biological condition of the populations and do not contain a complete evaluation of conservation measures as required under the ESA for a listing determination.) The risk summary votes do not reflect a simple average of the risk factors for individual categories, but rather a judgement of overall risk based on likely interactions among, and cumulative effects of, the different factors. A single factor with a "high risk" score may be sufficient for an overall conclusion of "in danger of extinction," but such an overall determination could result from a combination of several factors with low or moderate risk scores.

The BRT used two methods to characterize the uncertainty underlying their risk evaluations. One way the BRT captured the levels of uncertainty associated with the overall risk assessments was for each member to attach a certainty score (1=low, 5=high) to their overall risk evaluation for each ESU. For example, a BRT member who felt strongly that an ESU was likely to become endangered in the foreseeable future (or not currently at significant risk) would vote for that category of risk and assign a certainty score of 4 or 5; if that member was less sure about the level of risk, a lower certainty score would be given to the risk vote.

The second method for characterizing uncertainty was fashioned after an approach used by the Forest Ecosystem Management Assessment Team (FEMAT 1993). Each BRT member was given 12 total "likelihood" points to distribute in any way among the three risk categories. For example, complete confidence that an ESU should be in one risk category would be represented by most or all of the 12 points allocated to that category. Alternatively, a BRT member who was undecided about whether the ESU was likely to become endangered but who felt the ESU was at some risk could allocate the same (or nearly the same) number of points into each of the "likely to become endangered" and "not likely to become endangered" categories. This assessment process follows well-documented peer-reviewed methods for making probabilistic judgements (references in FEMAT 1993, p. IV, 40-45). The BRT interpretation of these scores was similar to FEMAT's, which said "the likelihoods are not probabilities in the classical notion of frequencies. They represented degrees of belief [in risk evaluations], expressed in a probability-like scale that could be mathematically aggregated and compared across [ESUs]" (FEMAT 1993 p. IV-44).

General Risk Conclusions

The two methods used by the BRT to characterize uncertainty in risk assessments generally were consistent in their outcomes. In the first method, the certainty scores for most ESUs were moderate to high (in the range of 3 to 5), reflecting a fair amount of certainty regarding the conservation status of chinook salmon in the ESUs evaluated. Results from the "FEMAT" method were generally concordant with and support information provided by the first method. That is, when the majority of BRT votes fell in a particular risk category, the majority of likelihood points also fell in the same category. For all ESUs, a small fraction of likelihood votes occurred in the "in danger of extinction" category. This result reflects the limited information available for conducting risk evaluations for chinook salmon. Although in many cases available information did not provide conclusive evidence of high risk, it also did not clearly demonstrate that the ESUs were not at risk. As a result, at least some BRT members felt that they could not completely exclude the possibility that a particular ESU is presently in danger of extinction. However, when asked to pick only one risk category (the first method), in only one case (Upper Columbia River Spring-Run ESU) did BRT members conclude that an ESU is presently in danger of extinction.

Discussion and Conclusions of ESU Risk Analyses

Puget Sound ESU

A majority of the BRT concluded that chinook salmon in the Puget Sound ESU are not presently in danger of extinction, but they are likely to become endangered in the foreseeable future. A minority felt that this ESU is neither presently in danger of extinction nor is it likely to become so in the foreseeable future. The BRT was moderately certain in its risk determinations–a majority of the certainty scores were 3 or 4, but the overall scores ranged from 2 to 5. Similarly, a majority of the likelihood points used in the "FEMAT" voting method were distributed in the "likely to become endangered" category.

Most of the concerns the BRT had about the status of this ESU were related to the trends and productivity risk category (Table 5). The BRT felt that widespread declines and outright losses of the spring- and summer-run chinook populations represent a significant reduction in the life history diversity of this ESU. Additionally, the BRT was concerned about the significant declines in abundance from historical levels in many streams in Puget Sound. The population sizes in many streams are small enough that stochastic genetic and demographic processes could become important risk factors. Two of the three largest remaining chinook salmon runs in this ESU that are not heavily influenced by hatchery fish (Skagit and Snohomish Rivers) are declining in abundance. Indeed, in most streams for which abundance data are available, both long- and short-term trends in abundance are declining.

Degradation and loss of freshwater and estuarine habitat throughout the range of the ESU were additional sources of risk to chinook salmon in Puget Sound identified by the BRT. Furthermore, recent studies suggest that effects of pollutants on early life history stages of chinook salmon also contribute to the stress on fish in this ESU. Historically high harvest rates in ocean and Puget Sound fisheries were likely to be a significant source of risk in the past; the BRT was hopeful that recently established lower harvest targets for Puget Sound stocks will reduce threats to persistence of the ESU due to reductions in direct mortality and size-selective fisheries.

Hatchery chinook salmon are widespread in the Puget Sound ESU, although there are no precise estimates of the proportion of natural spawners that are of hatchery origin. The BRT felt that chinook salmon are relatively well-distributed geographically in the Puget Sound region, but the extensive transplanting of hatchery fish throughout the area makes identifying native, naturally self-sustaining runs difficult. Recent practices involving mass marking of hatchery fish were considered by the BRT to be mostly a positive effort. Marked hatchery fish will provide important information relating to the origin of chinook salmon on spawning grounds and for use in selective fisheries, both of which will help in assessing the status and managing abundance of fish in this ESU. On the other hand, the resulting technical difficulties associated with detecting coded-wire tagged fish under the new marking design may hinder collection efforts for that important data base and compromise the management tools currently used to manage chinook salmon in Canadian and U. S. fisheries.

Lower Columbia River ESU

A majority of the BRT concluded that the Lower Columbia River ESU is likely to become endangered in the foreseeable future. A minority felt that chinook salmon in this ESU are not presently in danger of extinction, nor are they likely to become so in the foreseeable future. There was moderate certainty among BRT members in this risk evaluation--most of the certainty scores were 3's, and they ranged from 2 to 4. The results from the "FEMAT" method of risk evaluation also reflected only moderate certainty among BRT members, but a majority of the likelihood points were allocated to the "likely to become endangered" risk category.

The BRT's concerns regarding the status of this ESU were evenly divided among the abundance/distribution, trends/productivity and genetic integrity risk categories (Table 5). The BRT was concerned that there are very few naturally-self-sustaining populations of native chinook salmon remaining in the lower Columbia River ESU. With input from co-managers, the BRT identified a list of streams containing primarily native runs of chinook salmon with minimal influence from hatchery fish in order to get a better understanding of the present distribution and population sizes of potentially self-sustaining chinook salmon runs in the lower Columbia River ESU (ODFW 1998). Populations of "bright" fall-run chinook salmon identified included those on the North Fork and East Fork of the Lewis River and the Sandy River; "tule" fall-run chinook salmon populations identified as naturally reproducing were those on the Clackamas, East Fork of the Lewis and Coweeman Rivers. Estimated average escapements over the past 5-10 years for these populations ranged from 300 (Tule fall-run chinook on the East Fork of the Lewis River) to over 11,000 (fall-run chinook on the North Fork Lewis River). These populations are the only bright spots in the ESU for relatively high abundance and low hatchery influence for fall-run chinook salmon. These populations identified by the BRT do not include some populations that ODFW suggested should be considered for risk evaluations. Some of the populations of fall-run chinook salmon suggested by ODFW as naturally self-sustaining are smaller, have extensive hatchery components, or were determined by the BRT to be in a different ESU (see ESU section). The BRT discussed the likely possibility that smaller streams draining into the Columbia River below the Cowlitz River historically had small populations of tule fall-run chinook salmon. It was not clear to the BRT whether these small populations of tules historically were self-sustaining, and the widespread presence of tule hatchery fish in this area makes their present status difficult to evaluate.

The few remaining populations of spring chinook salmon in the ESU were not considered to be naturally self-sustaining because of either small size, extensive hatchery influence, or both. The BRT felt that the dramatic declines and losses of spring-run chinook salmon populations in the Lower Columbia River ESU represent a serious reduction in life-history diversity in the region.

Long-term trends in chinook salmon abundance are mixed in this ESU, but the BRT was concerned that short-term trends are predominantly downward, some strongly so. It is difficult to predict whether the high variability in abundance estimates for chinook salmon in many streams in this ESU reflect natural fluctuations in the numbers of wild fish or periodic influences from hatchery fish. Exceptions are the Coweeman and Green River tule fall runs, where short-term trends in abundance are positive.

The BRT felt that the presence of hatchery chinook salmon in this ESU poses an important threat to the persistence of the ESU and also obscures trends in abundance of native fish. At the time of the status review, approximately 68% of the naturally spawning chinook salmon in the lower Columbia River ESU were estimated to be first-generation hatchery fish; no new information was available to the BRT to suggest that this percentage has appreciably changed. The BRT discussed the difficulty in ascribing "native, naturally self-sustaining" status to tule fall-run chinook salmon runs because of the extensive within-ESU transfers of these fish. The BRT was encouraged by the recent changes in hatchery release practices adopted by ODFW designed to reduce straying of introduced Rogue River fall-run chinook salmon into lower Columbia River streams. Nevertheless, the BRT noted that straying from these out-of-ESU fish still could occur into lower Columbia River streams.

In summary, habitat degradation and loss due to extensive hydropower development projects, urbanization, logging and agriculture continue to threaten the chinook salmon spawning and rearing habitat in the lower Columbia River. Recent reductions in harvest levels in the mainstem Columbia River and tributary fisheries were encouraging to the BRT. Nevertheless, the BRT concluded that documented extinctions in fall- and spring-run chinook salmon populations, the near complete demise of the spring-run life history form, extensive mixing of fall-run tule chinook salmon populations within the ESU and the widespread occurrence of hatchery fish have combined to pose significant threats to the persistence of chinook salmon in the lower Columbia River ESU.

Upper Willamette River ESU

A majority of the BRT concluded that the Upper Willamette River ESU is not presently in danger of extinction, but it is likely to become so in the foreseeable future. A minority of the BRT felt that this ESU is neither presently endangered nor likely to become so in the foreseeable future. The certainty scores ranged from 2 to 5, but most BRT members gave their risk vote a certainty score of 4. BRT members who felt that this ESU was likely to become endangered were more certain than those who felt it was not at risk. The results from the "FEMAT" risk evaluation method emphasized more strongly the certainty BRT members had that this ESU faces substantial risk. A majority of the likelihood points in this method fell into the "likely to become endangered" category, and most of the remaining likelihood points were allocated into the "presently in danger of extinction" risk category.

Most of the concerns the BRT had regarding the status of the Upper Willamette River ESU fell into the abundance/distribution risk category (Table 5). The 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 recent average total abundance of spring chinook salmon in this ESU has been 24,000 fish, of which only 4,000 are believed to be spawning naturally. In addition, it is estimated that two-thirds of the naturally-spawning spring chinook salmon are first generation hatchery fish. In other words, the high proportion of hatchery fish in the total return and on spawning grounds indicate that populations of chinook salmon in this ESU are not self sustaining. 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. Severe declines in short-term abundance have occurred throughout the ESU, and the McKenzie River population continues to decline precipitously, indicating that it may not be self-sustaining.

As stated in the Status Review (Myers et al. 1998), the potential for interactions between native spring-run and introduced fall-run chinook salmon has increased relative to historical times due to fall-run chinook salmon hatchery programs and the laddering of Willamette Falls. There is no direct evidence of interbreeding between the two forms, but they do exhibit overlap in spawning times and locations. No new evidence was presented to the BRT indicating significant changes in the conditions that affect the potential for negative interactions between native and hatchery spring-run chinook salmon in this ESU.

The declines in spring chinook salmon in the Upper Willamette River ESU can be attributed in large part to the extensive habitat blockages caused by dam construction. The overall reduction in available spawning and rearing habitat, combined with altered water flow and temperature regimes, have probably had a major deleterious effect on spring chinook salmon abundance in this ESU. Furthermore, historically high harvest levels have occurred on chinook salmon in this ESU in ocean and lower Columbia River fisheries. The BRT was encouraged by recent 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.

Upper Columbia River Spring-Run ESU

A majority of the BRT concluded that chinook salmon in the Upper Columbia River

Spring-Run ESU are presently in danger of extinction. A minority felt that this ESU is not presently at risk of extinction, but it is likely to become so in the foreseeable future. Almost all BRT members attached certainty scores of 4 or 5 to their risk evaluations; the lowest certainty score was a 3. The risk evaluation results using the "FEMAT" method were consistent with the certainty scores. The majority of likelihood points were allocated to the "presently in danger of extinction" risk category.

The BRT was mostly concerned about risks falling under the abundance/distribution and trends/productivity risk categories for this ESU (Table 5). The 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 abundance of the spring chinook salmon returning to the Methow River Basin has been so low that all fish returning in 1996 and 1998 were intercepted at Wells Dam and were incorporated into artificial propagation programs at Methow fish hatchery. In addition, the captive broodstock programs underway on the Twisp and White Rivers and Nason Creek indicate the severity of the population declines to critically small sizes.

The BRT was encouraged that there are plans to discontinue production of the non-native Carson hatchery stock at the Winthrop National Fish Hatchery. Nevertheless, the extensive introductions of spring-run chinook salmon from outside the ESU and within-ESU egg transfers that occurred in the past have left their mark on the genetic legacy of the fish remaining in the ESU. Furthermore, as mentioned above, because of the extremely low population sizes in some streams in some years, 100% of the offspring for an entire basin were produced in a hatchery from a mixture of populations. The such extreme measures have been considered necessary speaks to the seriousness of the risks faced by the natural populations.

Habitat degradation, blockages and hydrosystem passage mortality all have contributed to the significant declines in spring chinook salmon production in this ESU. In addition to at least 6 known extinctions, all remaining populations are small and declining in number. In support of the BRT's conclusions, a panel of fisheries experts convened to evaluate a management plan for an HCP in this region concluded in their risk evaluations that the probability of extinction for spring-run chinook salmon was high. The BRT discussed the possible significance of a noted increase in non-migratory jacks in some areas, and was not able to conclude whether their presence represented a permanent change in age structure or merely a facultative shift in life history strategy due to changes in the selective environment. Finally, due to near elimination of in-river harvest during the last two decades and the absence of a significant marine harvest on these populations, the BRT was concerned that the remaining avenues for recovery would take years to implement and that the ESU may go extinct before any improvements could take effect.

REFERENCES

Abernethy, A.S. 1886. Salmon in the Clackamas River. Bulletin of the United States Fish Commissioner. 8: 332.

Arkoosh, M. R., E. Casillas, E. Clemons, A.N. Kagley, R. Olson, P. Reno and J.E. Stein. 1998a. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10: 182-190.

Arkoosh, M.R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein and U. Varanasi. 1998b. Increased susceptibility of juvenile chinook salmon from a contaminated estuary to *Vibrio anguillarum*. Transactions of the American Fisheries Society 127: 360-374.

Bairn, L.T. 1886. Salmon in the Clackamas River. Bulletin of the United States Fish Commissioner. 8: 111-112.

Bentzen, P., J. Olsen, and J. Britt. 1998. Microsatellite DNA polymorphism in spring chinook salmon (*Oncorhynchus tshawytscha*) from Clackamas Hatchery, the upper Sandy River and the Bull Run River and its implications for population structure. Final report to City of Portland, Bureau of Water Works. 14 p. (Available from Protected Resources Division, NMFS, 525 N.E. Oregon St. , Suite 500, Portland, Oregon 97232).

Big Eagle & Associates, and LGL Limited (BE and LGL). 1995. Chinook salmon catch, escapement, and historical abundance data. Report prepared for NOAA, NMFS, Northwest Fisheries Science Center. (Available from Natl. Mar. Fish. Serv., 2725 Montlake Blvd. E., Seattle, WA 98112.)

Bishop, S., and A. Morgan, (editors). 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. (Available from Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98506.)

Bledsoe, L.J., D.A. Somerton, C.M. Lynde. 1989. The Puget Sound runs of salmon: an examination of the changes in run size since 1896. p. 50-61 *In*: C.D. Levings, L.B. Holtby, and M.A. Henderson (eds.) Proceedings of the national workshop on effects of habitat alteration on salmonid stocks Canadian Special Publication Fisheries and Aquatic Sciences. No. 105.

Bottom, D. L., P. J. Howell, and J. D. Rodgers. 1985. The effects of stream alterations on salmon and trout habitat in Oregon. Oreg. Dep. Fish Wildl., Portland, OR, 70 p. (Available from Oregon Department of Fish and Wildlife, P.O. Box 59, Portland, OR 97207.)

Bugert, R.M. 1996. Potential to increase anadromous salmonid productivity in the mid-Columbia region using artificial propagation. Mid-Columbia Mainstem Conservation Plan. (Available from the Chelan County Public Utility District, P.O. Box 1231, Wenatchee, WA, 98807-7231.)

Bryant, F. G. 1949. A survey of the Columbia River and its tributaries with special references to management of its fishery resources. 2. Washington streams from the mouth of the Columbia River to and including the Klickitat River (Area I). Special Scientific Report 62. 110 p.

Chapman, D., A. Giorgi, M. Hill, A. Maule, S. McCutcheon, D. Park, W. Platts, K. Prat, J. Seeb, L. Seeb and others. 1991. Status of Snake River chinook salmon. Pacific Northwest Utilities Conference Committee, 531 p. (Available from Don Chapman Consultants, 3653 Rickenbacker, Ste. 200, Boise, ID 83705.)

Chapman, D., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring chinook salmon in the mid-Columbia River. Don Chapman Consultants, Inc., 477 p. (Available from Don Chapman Consultants, 3653 Rickenbacker, Ste. 200, Boise, ID 83705.)

Clark, J.H., D. Eggers, J. Carlile, D. Guadet, and J. Koenings. 1998. State of Alaska review comments concerning NMFS March 9, 1998, proposed rule regarding endangered and threatened species for west coast chinook salmon. Alaska Department of Fish and Game. 37 p.

Craig, J.A., and A.J. Suomela. 1940. A survey of the Sandy River and its tributaries, 1940. with reference to fish management. U.S. Fish and Wildlife Special Scientific Report No. 14. 20 p.

Craig, J. A., and Suomela. 1941. Time of appearance of the runs of salmon and steelhead trout native to the Wenatchee, Entiat, Methow, and Okanogan rivers. U.S. Fish Wildl. Serv. Reprinted in Mullan et al. 1992.

Crawford, B. 1998. Letter from B. Crawford (Washington Department of Fish and Wildlife (WDFW)) to R. Waples (Conservation Biology Division, Northwest Fisheries Science Center) dated 10 October 1998. 3 p. + attachment.

Feldmann, C. 1998. Letter from C. Feldmann (Puget Sound Energy, Inc.) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 30 June 1998. 8 p. + attachment.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: an ecological, economic, and social assessment. U.S. Forest Service, National Marine Fisheries Service, Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, U..S. Environmental Protection Agency. Portland, Oregon, and Washington D.C. 843 p + appendices.

Fuller, R. 1998. Letter from R. Fuller (Washington Department of Fish and Wildlife (WDFW)) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 26 May 1998. 5 p.

Fulton, L. A. 1968. Spawning areas and abundance of chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin–past and present. United States Fish and Wildlife Service Special Scientific Report–Fisheries No. 571. 26 p.

Hayman, R. 1998. Letter from R. Hayman (Skagit System Cooperative) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 22 June 1998. re: 3 pp. + attachment. re. "Public comment on status review of chinook salmon from Washington, Idaho, Oregon, and California."

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Knedra, and D. Orrmann. 1985. Stock assessment of Columbia River anadromous salmonids. Vol: I. U.S. Dep. Energy, Bonneville Power Administration. Project No. 83-335, 558 p.

Hymer, J. 1997. Results of studies on chinook spawning in the mainstem Columbia River below Bonneville Dam. Columbia River Progress Report 97-9. Washington Department of Fish and Wildlife. 6 p.

Kailin, E. 1998. Letter from E. Kailin (Protect the Peninsula's Future) to J. Herkelrath (Protected Resources Division, NMFS Northwest Region) dated 27 May 1998. 4 p. + attachments.

Kostow, K. 1995. Biennial Report on the Status of Wild Fish in Oregon. Oreg. Dep. Fish Wildl. Rep., 217 p. + appendix. (Available from Oregon Department of Fish and Wildlife, P.O. Box 59, Portland, OR, 97207.)

Leach, G.C. 1923. Propagation and distribution of food fishes, Fiscal Year 1922. Report of the United States Commissioner of Fisheries for the Fiscal Year 1922. 100 p.

Leach, G.C. 1932. Propagation and distribution of food fishes, Fiscal Year 1931. Report of the United States Commissioner of Fisheries for the Fiscal Year 1931, p. 627-696.

Marshall, A. 1997. Genetic analysis of Abernathy Creek juvenile chinook. Investigation of natural reproduction by Rogue River stock hatchery-origin chinook. Washington Department of Fish and Wildlife. 13 p.

Marshall, A. 1998. Genetic analysis of mainstem Columbia River, below Bonneville Dam, chinook spawner. Memo to K. Harlan, 9 Feb. 1998. 2 p.

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 (editors), 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.)

Mathews, S.B. 1997. Analysis of chinook salmon harvest management. Consulting Report for Long-Live-the-Kings and Oregon Trout. 95 p

McCain, B. B. and six coauthors. 1988. Marine pollution problems, North American west coast. Aquatic Toxicology 11: 143-162.

Mattson, C.R. 1955. Sandy River and its anadromous salmonid populations. Oregon Fish Commission. (unpublished report) 15 p.

Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in the mid-Columbia River tributary streams. U.S. Fish and Wildlife Service, Monograph I. 489 p.

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. Dept. Commer., NOAA Tech. Memo NMFS-NWFSC-35, 443 p.

National Marine Fisheries Service (NMFS). 1991. Policy of applying the definition of species under the Endangered Species Act to Pacific salmon. Federal Register [Docket No. 9120248-1255, 20 November 1991] 56(224):58612-58616.

National Marine Fisheries Service (NMFS). 1994. Listing endangered and threatened species and designating critical habitat: Initiation of status reviews for pink salmon, chum salmon,chinook salmon, and sea-run cutthroat trout populations in Washington, Oregon, Idaho, and California. Federal Register [I.D. 081694D, 12 September 1994] 59(175):46808-46810.

National Marine Fisheries Service (NMFS), U. S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Confederated Tribes of the Yakama Indian Nation, Confederated Tribes of the Colville Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, Chelan County Public Utility District, Douglas County Public Utility District. April 1998. Biological Assessment and Management Plan. Mid-Columbia River Hatchery Program. Unpubl. manuscript. 176 p.

National Marine Fisheries Service (NMFS). 1998a. Endangered and threatened species: proposed endangered status for two chinook salmon ESUs and proposed threatened status for five chinook salmon ESUs; proposed redefinition, threatened status, and revision of critical habitat for one chinook salmon ESU; proposed designation of chinook salmon critical habitat in California, Oregon, Washington, Idaho. Federal Register [Docket No. 980225050-8050-01; I.D. 022398C] 63(45): 11482-11520.

National Marine Fisheries Service (NMFS). 1998b. Factors contributing to the decline of chinook salmon: an addendum to the 1996 West Coast steelhead factors for decline report. 74 p. (Available from Protected Resources Division, NMFS, 525 N.E. Oregon St. , Suite 500, Portland, Oregon 97232).

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.

Nicholas, J. 1995. Status Willamette spring-run chinook salmon relative to the Federal Endangered Species Act. Report to the National Marine Fisheries Service. Oregon Department of Fish and Wildlife, 44 p.

Northwest Indian Fisheries Commission (NWIFC) 1997. Documents submitted to the ESA Administrative Record for west coast chinook salmon by M. Messenger, 19 September 1997. 1p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Olsen, E., P. Pierce, M. McLean, and K. Hatch. 1992. Stock Summary Reports for Columbia River Anadromous Salmonids Volume I: Oregon. U.S. Dep. Energy., Bonneville Power Administration. Project No. 88-108. (Available from Bonneville Power Administration, Division of Fish and Wildlife, Public Information Officer - PJ, P.O. Box 3621, Portland, OR 97208.)

Olson, D. 1998. Letter from D. Olson (peer reviewer) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 22 June 1998. re: 3 p.

Oregon Department of Fish and Wildlife (ODFW). 1990. Sandy River Subbasin. Salmon and steelhead production plan. 263 p.

Oregon Department of Fish and Wildlife (ODFW). 1992. Clackamas River Subbasin. Fish Management Plan. 174 p.

Oregon Department of Fish and Wildlife (ODFW) 1997. Documents submitted to the ESA Administrative Record for west coast chinook salmon by D. Swartz, 23 April 1997, 10 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Oregon Department of Fish and Wildlife (ODFW). 1998. Documents submitted to the ESA Administrative Record for west coast chinook salmon by J.W. Greer, 13 October 1998. (Available from Protected Resources Division, NMFS, 525 N.E. Oregon St., Suite 500, Portland, OR 97232.)

Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). 1995. Status report: Columbia River fish runs and fisheries 1938-94. Oreg. Dep. Fish Wildl., Wash. Dep. Fish Wildl., 291 p.

Pacific Fishery Management Council (PFMC). 1996. Review of the 1995 ocean salmon fisheries. Pacific Fishery Management Council, 115 p. + appendixes. (Available from Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 234, Portland, OR 97201.)

Pacific States Marine Fisheries Commission (PSMFC) 1997. Streamnet Microsoft Access computerized database submitted to the ESA Administrative Record for west coast chinook salmon by D. Anderson, May 1997. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Pacific Fishery Management Council (PFMC) 1998. Review of 1997 Ocean Salmon Fisheries. Pacific Fishery Management Council, 107 p. + appendices. (Available from Pacific Fishery Management Council, 2130 SE Fifth Avenue, Suite 224, Portland, Oregon, 97201.)

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

Palmisano, J.F., R.H. Ellis, and V.W. Kaczynski. 1993. The impact of environmental and management factors on Washington's wild anadromous salmon and trout. Report for Washington Forest Protection Association and Washington Department of Natural Resources, Olympia, WA, 371 p.

Palmisano, J., and V.W. Kaczynski. 1998. Comments of the Northwest Forest Resource Council to the National Marine Fisheries Service, Portland, Oregon, regarding proposed listing of six evolutionary significant units of chinook salmon (*Oncorhynchus tshawytscha*) one as endangered upper Columbia River spring-run, and five as threatened: Puget Sound, Deschutes River fall, Lower Columbia River, upper Willamette River, and southern Oregon and coastal California and proposed designation of critical habitat for these six ESUs. 156 p. (Available from John Palmisano Biological Consultants, 1990 NW 156th Avenue, Beaverton, Oregon 97006-5307)

Parkhurst, Z.E., F.G. Bryant, and R.S. Nielson. 1950. Survey of the Columbia River and its tributaries. Part 3. Special Scientific Report - Fisheries, No. 36. 103 p.

Peven, C.M. and T.R. Mosey. 1996. Spring and summer chinook spawning ground surveys on the Wenatchee River Basin, 1996. Chelan County Public Utility District. 29 p. + appendices. (Available from Chelan Co. PUD, Fish Wild. Oper., PO Box 1321, Wenatchee, WA 98801.)

Professional Resource Organization-Salmon (PRO-Salmon). 1994. Petition for a rule to list nine Puget Sound salmon populations as threatened or endangered under the Endangered Species Act and to designate critical habitat. Unpublished manuscript, 86 p. (Available from PRO-Salmon, Washington Public Employees Association, 124 10th Ave. S.W., Olympia, WA 98501

Puget Sound Salmon Stock Review Group (PSSSRG). 1997. An assessment of the status of Puget Sound chinook and Strait of Juan de Fuca coho stocks as required under the Salmon Fishery Management. Pacific Fishery Management Council Review Draft, 78 p. (Available from the Pacific Fishery Management Council, 2130 Fifth Ave, Ste. 224, Portland, OR 97201.)

Puget Sound Water Quality Authority (PSWQA). 1988. Proceedings, First Annual Meeting on Puget Sound Research. Seattle, WA. 787 p.

Ravenel, W. de C. 1898a. Report on the Propagation and Distribution of Food-Fishes. Part XXIII. The Report of the Commissioner for the Year ending June 30, 1897. p. vii-xxix.

Ravenel, W. de C. 1898b. Report on the Propagation and Distribution of Food-Fishes. Part XXIV. The Report of the Commissioner for the Year ending June 30, 1898. p. vii-xxix.

Schreck, C. B., H. W. Li, C. S. Sharpe, K. P. Currens, P. L. Hulett, S. L. Stone, and S. B. Yamada. 1986. Stock identification of Columbia River chinook salmon and steelhead trout. U.S. Dep. Energy, Bonneville Power Administration. Project No. 83-45, 184 p. (Available from Bonneville Power Administration, Division of Fish and Wildlife, Public Information Officer-PJ, P.O. Box 3621, Portland, OR 97208.)

Smith, C. 1998. Letter from C. Smith (peer reviewer) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 13 July 1998, re. "Comments on determinations and proposed rules for West Coast chinook, sockeye, and steelhead." 10 p. + attachment.

Streamnet 1998. Northwest Aquatic Information Network (Available through Online Internet database http://www.streamnet.org/index.html.)

Strong, T. 1998. Letter from T. Strong (Columbia River Inter-Tribal Fish Commission) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 30 June 1998, re. "Comments on determinations and proposed rules for West Coast chinook, sockeye, and steelhead." 6 p. + attachment.

Taylor, W.R. 1998. Letter from W. R. Taylor (U.S. Department of the Interior) to G. Griffin (Protected Resources Division, NMFS Northwest Region) dated 23 July 1998. 3 p.

Theis, L., and K. Melcher. 1995. Oregon Lower Columbia River fall and winter chinook spawning ground surveys, 1948-1994. Oreg. Dep. Fish Wildl., 13 p. (Available from Oregon Department of Fish and Wildlife, 2501 SW First Ave., PO Box 59, Portland, OR, 97207.)

U.S. Fish and Wildlife Service (USFWS). 1997. Documents submitted to the ESA Administrative Record for west coast chinook salmon by D. Finberg, 26 February 1997. 4 p. (Available from Environmental and Technical Services Division, National Marine Fisheries Service, 525 N.E. Oregon St., Suite 500, Portland, OR 97232).

Utter, F., G. Milner, G. Stahl, and D. Teel. 1989. Genetic population structure of chinook salmon (*Oncorhynchus tshawytscha*), in the Pacific Northwest. Fish. Bull. 87:239-264.

Utter, F. M., D. W. Chapman, and A. R. Marshall. 1995. Genetic population structure and history of chinook salmon of the Upper Columbia River. Am. Fish. Soc. Symp. 17:149-165.

Wallis, J. 1961. An evaluation of the McKenzie River Salmon Hatchery. Oregon Fish Commission Research Laboratory Report. 56 p.

Wallis, J. 1962. An evaluation of the Willamette River Salmon Hatchery. Oregon Fish Commission Research Laboratory Report. 94 p.

Wallis, J. 1966. An evaluation of the Sandy River Salmon Hatchery. Oregon Fish Commission Research Laboratory Report. 76 p.

Wallis, J. 1966. An evaluation of the Sandy River Salmon Hatchery. Oregon Fish Commission Research Laboratory. 76 p.

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. American Fisheries Society Symposium 17:8-27.

Waples, R. S. 1998. Evolutionarily significant units, distinct population segments, and the Endangered Species Act: Reply to Pennock and Dimmick. Conserv. Biol. 12:718-721.

Washington Department of Fisheries (WDF). 1951. Lower Columbia River fisheries development program. Cowlitz Area. Washington 49 pp.

Washington Department of Fisheries (WDF), 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, WA, 212 p. + 5 regional volumes. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091.)

Washington Department of Fish and Wildlife (WDFW) 1997a. Documents submitted to the ESA Administrative Record for west coast chinook salmon by C. Smith, January, March, and September 1997. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1997b. Documents submitted to the ESA Administrative Record for west coast chinook salmon by A. Blakely, May, June, and September 1997. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1997c. Documents submitted to the ESA Administrative Record for west coast chinook salmon by R. Woodward, 5 May and 26 September 1997. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1997d. Documents submitted to the ESA Administrative Record for west coast chinook salmon by C. Busack, February 1997. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1998a. Documents submitted to the ESA Administrative Record for west coast chinook salmon by B. Sanford, 6 October 1998. 1p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1998b. Documents submitted to the ESA Administrative Record for west coast chinook salmon by L. Wood, 28 October 1998. 1p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW) 1998c. Documents submitted to the ESA Administrative Record for west coast chinook salmon by L. Brown, 16 November 1998. 1p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Washington Department of Fish and Wildlife (WDFW), and Oregon Department of Fish and Wildlife (ODFW). 1994. Status report: Columbia River fish runs and fisheries 1938-1993. Wash. Dep. Fish Wildl., Oreg. Dep. Fish and Wildl., 271 p.

Williams, R. W., R. M. Laramie, and J. J. Ames. 1975. A catalog of washington streams and salmon utilization. Volume 1. Puget Sound Region. Wash. Dep. Fish. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia WA 98501-1091.)

Willis, C.F., S.P. Cramer, D. Cramer, M. Smith, T. Downey, and R. Montagne. 1995. Status of Willamette River spring chinook salmon in regards to the Federal Endangered Species Act. Part 1. Portland General Electric company and Eugene Water and Electric Board, 74 p. (Available from S.P. Cramer & Associates, Inc. 300 S.E. Arrow Creek Lane, Gresham, OR 97080.)

Table 1. Samples of chinook salmon used in Figure 1 (Multidimensional Scaling plot). Samples are referred to in figure by the sample codes shown here. Numbers indicate samples from the NMFS 1998 coast wide chinook salmon status review (Myers et al. 1998); letters indicate new samples. Genetic data were provided by Anne Marshall (Washington Department of Fish and Wildlife (Laboratory 1), and the National Marine Fisheries Service (Laboratory 2). Asterisks indicate samples from neighboring populations that were combined in the genetic analysis.

Sample No.	Source	Run	N	Date	Laboratory
Lower Columbia River					
48	Cowlitz Hatchery	spring	152	1982,1987	1,2
49	Cowlitz Hatchery	fall	198	1981,1982,1988	1,2
50	Kalama Hatchery	spring	159	1982,1990	1,2
51	Kalama Hatchery	fall	199	1982,1988,1989	1,2
52	Lewis Hatchery	spring	135	1988	1
53	Lewis River	fall	120	1990	1
54*	Mckenzie and Dexter Hatcheries	spring	248	1982,1987,1988	1,2
55	Clackamas Hatchery	spring	100	1988	1
56	North Fork Clackamas River	spring	80	1996	2
57	Marion Forks Hatchery	spring	100	1990	1
NS	North Santiam River (natural)	spring	99	1997	2
M	McKenzie River (natural)	spring	100	1997	2
S	Sandy River (natural)	spring	93	1997	2
58	Sandy River	fall	140	1990,1991,1992	1
59*	Spring Creek and Big Creek Hatcheries	fall	504	1982,1987,1990	1,2
Mid and Upper Columbia River spring run					
60	Carson Hatchery	spring	250	1982,1989	1,2
61	Klickitat River	spring	261	1990,1991, 1992,1993	1
62*	Warm Springs Hatchery and River	spring	210	1982,1987	2
63	Round Butte Hatchery	spring	159	1982,1990	1,2
64	North Fork John Day River	spring	85	1990,1991,1992	1
65*	Yakima and Cle Elum Rivers	spring	401	1986,1989,1990	1
66	American River	spring	226	1986,1989,1990	1
67*	Naches, Little Naches, and Bumping Rivers	spring	251	1989,1990	1
68	White River	spring	137	1989,1991,1992	1
69	Nason River	spring	122	1989,1992	1
70	Chiwawa River	spring	247	1989,1990, 1991,1992	1
71	Methow River	spring	93	1993	1
72	Chewack River	spring	151	1992,1993	1
73	Twisp River	spring	107	1992,1993	1
Mid and upper Columbia River summer and fall run					
74	Klickitat River	summer	324	1991,1992, 1993,1994	1

Table 1. continued.

Sample No.	Source	Run	N	Date	Laboratory
75	Klickitat River	fall	250	1991,1992, 1993,1994	1
76	Bonneville Hatchery	fall	200	1989,1990	1
77	Little White Salmon Hatchery	fall	200	1989,1990	1
78	Deschutes River	fall	179	1982,1985,1990	1,2
79	Yakima River	fall	109	1990	1
80	Marion Drain	fall	153	1989,1990	1
81	Hanford Reach	fall	258	1982,1990	1,2
82	Priest Rapids Hatchery	fall	300	1981,1986, 1987,1990	1,2
83	Wenatchee River	summer	350	1985,1988, 1989,1990	1,2
84	Similkameen River	summer	206	1991,1992,1993	1
85	Methow River	summer	59	1992,1993	1
Snake River					
86	Lyons Ferry Hatchery	fall	399	1985,1986, 1987,1990	1,2
87	Tucannon Hatchery	spring	758	1985,1986,1987, 1988,1989,1990	1,2
88	Rapid River	spring	293	1982,1985,1990	2
89	Lookingglass Hatchery	spring	100	1991	2
90	Minam River (Grande Ronde River)	spring	100	1990	2
91	Lostine River (Grande Ronde River)	spring	297	1989,1990,1991	2
92	Catherine Creek (Grande Ronde River)	spring	100	1990	2
93	McCall Hatchery	summer	350	1982,1989, 1990,1991	2
94	Secesh River	summer	254	1989,1990,1991	2
95	Johnson Creek	summer	316	1982,1989, 1990,1991	2
96	Marsh Creek	spring	259	1989,1990,1991	2
97	Sawtooth Hatchery	spring	350	1982,1989, 1990,1991	2
98	Valley Creek	spring	279	1989,1990,1991	2
99	Upper Salmon River at Blaine Bridge	spring	60	1989	2
100	Upper Salmon River at Frenchman Creek	spring	60	1991	2
101	Upper Salmon River at Sawtooth	spring	100	1991	2
102	Imnaha River and Hatchery	summer	480	1989,1990, 1991	2

Table 2. Spring-run chinook salmon egg transfers to the Clackamas River Basin from upper Willamette River Basin hatcheries (1896-1960). Data are from Wallis (1961,1962,1963).

	Transfers In	
Year	Source	Eggs Transferred
1913	McKenzie River H.	10,000
1914	McKenzie River H.	2,858,000
1926	North Santiam River H.	2,010,800
1927	McKenzie River H.	1,003,520
1928	McKenzie River H.	2,004,480
1929	McKenzie River H.	1,000,020
1930	McKenzie River H.	1,003,520
1932	Willamette Hatchery	1,125,000
1933	McKenzie River H.	600,000
1934	McKenzie River H.	1,500,000
1935	McKenzie River H.	2,000,000
1936	McKenzie River H.	2,000,000
1937	Willamette River H.	650,000
1938	McKenzie River H.	1,000,000
1956	Willamette Hatchery	50,000
1956	McKenzie River H.	200,000
1957	McKenzie River H.	770,000
1958	North Santiam River H.	1,008,000
1959	McKenzie River H.	517,903
		21,311,243

Table 3. Spring-run chinook salmon egg take and transfer activities in the Sandy River Basin (1896-1960). Egg collection data from Oregon State Fish Commission and U.S. Bureau of Fisheries Hatcheries are combined. (F & S) - combined egg collection from fall-and spring-run chinook salmon. Data are from Craig and Suomela (1940) and Wallis (1966).

Egg Take (On Station)			Transfers In		Transfers Out	
Year	Site	Total Take	Number	Source	Number	Destination
1896	Salmon R.	2,600,000			2,340,000	Clackamas H.
1897	Salmon R.	1,216,600			1,066,600	Clackamas H.
1898	Salmon R.	74,200			43,000	Clackamas H. Portland
1899	Salmon R.	600,000				
1900	Salmon R.	1,260,000				
1901	Salmon R.	1,742,000	427,000	Swan Falls (Idaho)		
1901	Boulder Cr.	891,000				
1902	Salmon R.	1,586,600				
1904	Salmon R.	1,645,333				
1905	Salmon R.	1,230,000				
1906	Salmon R.	875,000				
1907	Salmon R.	565,000				
1908	Salmon R.	553,340				
1909	Salmon R.	500,936			501,336	Bonneville H.
1910	Salmon R.	269,140			389,710	Bonneville H.
1912	Salmon R.	2,009,000			2,067,800	Bonneville H. Klaskanine H.
1913	Sandy R.	2,762,258			1,985,498	Bonneville H. Klaskanine H.
1921	Sandy R.	1,637,000			1,637,000	Clackamas H.
1922	Sandy R.	461,900				
1938	Marmot D.	60,904	500,000	Willamette R.		
1939	Marmot D.	1,614,000				
1940	Marmot D.	624,000	500,000	McKenzie H.		
1941	Marmot D.	0	1,000,000	McKenzie H.		
1942	Marmot D.	238,000				
1943	Marmot D.	12,000				
1945	Marmot D.	412,200				
1946	Marmot D.	1,027,367				
1947	Marmot D.	43,550				
1948	Marmot D.	441,000			441,000	Bonneville H.
1950	Marmot D.	597,520			597,520	Bonneville H.
1951	Marmot D.	530,530				
1952	Marmot D.	135,030				
1953	Marmot D.	175,105				
1954	Marmot D.	592,480				
1955	Marmot D.	10,280	62,949	Willamette R.		

Table 3. continued

Egg Take (On Station)			Transfers In		Transfers Out	
Year	Site	Total Take	Number	Source	Number	Destination
1956	Cedar Cr.	94,385 (F & S)				
1957	Cedar Cr.	1,619,650 (F & S)				
1959	Cedar Cr.	11,256				

Table 4: Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU / River Basin	Sub-basin	Run[1]	Production[2]	Status summaries[3] A	B	C	D	E	P?[4]	Recent abundance Data Years	Data Type[5]	5 Year Geomean[6]	Long-term Trend[7]	1987-97 Short-term Trend[8]	Data References
8-Puget Sound															
Nooksack/Samish	Nooksack R, N Fk	Sp/Su	Mixed	A			NCC			1984-97	CS	79	+8.4	+10.0	BE and LGL 1995, WDFW 1997a, PFMC 1998
	Nooksack R, S Fk	Sp/Su	Natural	A			NWC			1984-97	TL	198	-5.9	-5.4	BE and LGL 1995, WDFW 1997a, PFMC 1998
Skagit R		Sp	Natural							1968-97	TL	1,074	-1.1	-6.8	BE and LGL 1995, WDFW 1997a, PFMC 1998
		Su/Fa	Natural							1968-97	TL	6,918	-2.8	-4.6	BE and LGL 1995, WDFW 1997a, 1998
	Lower Skagit R	Fa	Natural				NWD		P	1974-97	TL	808	-6.8	-14.1	BE and LGL 1995, WDFW 1997b, 1998b
	Upper Skagit R	Su	Natural				NWH		P	1974-97	TL	5,189	-1.8	-3.1	BE and LGL 1995, WDFW 1997b, 1998b
	Lower Sauk R	Su	Natural				NWD		P	1974-97	TL	281	-7.0	-10.9	BE and LGL 1995, WDFW 1997b, 1998b
	Upper Sauk R	Sp	Natural				NWH		P	1967-97	TL	403	+1.4	-8.3	BE and LGL 1995, WDFW 1997b, 1998b
	Suiattle R	Sp	Natural				NWD		P	1967-97	TL	287	-3.4	-9.2	BE and LGL 1995, WDFW 1997b, 1998b
	Upper Cascade R	Sp	Natural				NWU		P	1984-97	PR	203	+13.8	+17.8	BE and LGL 1995, WDFW 1997b, 1998b
Stillaguamish R		Sp		A+					P						
		Su	Mixed				NCD		P	1985-96	TL	648	-2.8	+0.4	BE and LGL 1995, WDFW 1997b
		Su/Fa	Natural							1968-97	TL	1,031	+1.2	+1.5	BE and LGL 1995, NWIFC 1997, WDFW 1997a,b, 1998a
		Fa	Natural				UWD		P	1985-96	TL	155	+4.1	+3.9	BE and LGL 1995, WDFW 1997b
Snohomish R		Sp		X					P						
		Su	Natural				NWD		P	1979-96	TL	664	-3.2	-2.4	BE and LGL 1995, WDFW 1997b
		Su/Fa	Natural							1968-97	TL	3,922	-1.5	-0.1	BE and LGL 1995, NWIFC 1997, WDFW 1997a,b, 1998a
Snohomish R		Fa	Natural				NWD		P	1979-96	TL	1,474	-0.7	-1.7	BE and LGL 1995, WDFW 1997b
	Wallace R	Su/Fa	Mixed				MCH		P	1979-97	TL	373	-9.4	-1.3	BE and LGL 1995, WDFW 1997b, 1998b
	Bridal Veil Cr	Fa	Natural				NWU		P	1992-96	TL	634	+19.3		WDFW 1997b
Lk Washington		Su/Fa	Natural							1983-97	TL	457	-9.3	-12.0	BE and LGL 1995, NWIFC 1997, WDFW 1997a,b, 1998a

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU River Basin	Sub-basin	Run[1]	Production[2]	Status summaries[3] A	B	C	D	E	P?[4]	Recent abundance Data Years	Data Type[5]	5 Year Geomean[6]	1987-97 Long-term Trend[7]	Short-term Trend[8]	Data References
8-Puget Sound															
Lk Washington	Cedar R	Su/Fa	Natural				NWU		P	1964-97	TL	319	-2.5	-10.9	BE and LGL 1995, WDFW 1997b, 1998b
	Issaquah Cr	Su/Fa	Mixed				XCH			1986-97	CS	1,390	-6.0	-3.8	BE and LGL 1995, WDFW 1997b, 1998b
	N Lk Washington Tribs	Su/Fa	Natural				NWU		P	1983-96	TL	145	-11.1	-16.6	BE and LGL 1995, WDFW 1997b
Duwamish/Green R		Sp		X					P						
		Su/Fa	Natural				MCH		P	1968-97	TL	5,405	+1.6	-4.8	BE and LGL 1995, WDFW 1997b 1998b
	Duwamish R	Unknown	Natural							1965-88	PI	5,216	-1.4		BE and LGL 1995
	Newaukum Cr	Su/Fa					MWH		P						
Puyallup R		Sp		X											
		Su/Fa	Natural						P	1968-97	TL	2,202	+2.3	+4.5	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
		Fa	Mixed	C			UCU			1953-92	IT	60	+0.2		BE and LGL 1995, WDFW 1997b
	White R	Sp	Natural	B			NCC			1970-96	TC	473	+0.2	+23.9	WDFW 1997a,b
		Su/Fa					UWU		P						
Nisqually R		Sp/Su		X											
		Su/Fa	Natural				MCH		P	1968-97	TL	882	+0.7	+2.3	BE and LGL 1995, WDFW 1997a,b 1998a
South Sound Tribs.		Su/Fa	Mixed				MCH		P	1972-96	TL	5,449	+15.3	+8.3	BE and LGL 1995, WDFW 1997b
Misc 13B Streams		Su/Fa	Natural							1968-97	TL	587	+8.3	-9.1	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998b
Misc 10E - Port Orchard		Su/Fa	Natural							1968-97	TL	780	+5.0	+10.3	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
Hood Canal		Su/Fa	Mixed				MCH		P	1968-97	TL	1,049	-3.2	-9.0	BE and LGL 1995, WDFW 1997b, 1998a
	SE Hood Canal	Su/Fa	Natural							1968-97	TL	21	-11.4	-18.0	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
Skokomish R		Sp		A+					P						
		Su/Fa	Natural						(P)	1968-97	TL	831	-1.4	-10.1	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
Hamma Hamma R		Su/Fa	Natural						(P)	1987-97	TL	3	-4.3	-4.3	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
Duckabush R		Su/Fa	Natural						(P)	1987-97	TL	8	-15.4	-15.4	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
		Fa		A											

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU River Basin	Sub-basin	Run[1]	Production[2]	Status summaries[3] A	B	C	D	E	P?[4]	Recent abundance Data Years	Data Type[5]	5 Year Geomean[6]	Long-term Trend[7]	1987-97 Short-term Trend[8]	Data References
8-Puget Sound															
Dosewallips R		Sp		A+											
		Su/Fa	Natural						(P)	1987-97	TL	1	+18.0	+18.0	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
		Fa		A											
Dungeness R		Sp		A											
		Sp/Su	Natural				NWC			1986-97	TL	38	-21.0	-22.5	BE and LGL 1995, WDFW 1997a,b, 1998a
		Fa		A											
Elwha R		Sp		A+					P						
		Su/Fa	Natural				NCH		P	1976-97	TL	1,589	+5.1	-11.7	BE and LGL 1995, NWIFC 1997, WDFW 1997a, 1998a
9-Lower Columbia River															
Lower Columbia Small Tributaries		Fa		A+											
Youngs Bay	Lewis and Clark R	Fa	Natural						P	1951-96	PI	45	+9.6		BE and LGL 1995, PSMFC 1997
			Natural							1978-86	TL	277	+63.9		BE and LGL 1995, PSMFC 1997
			Natural							1963-96	RC	16	+9.8		ODFW 1998
	Youngs R	Fa	Natural						P	1951-97	PI	16	-1.1		BE and LGL 1995, PSMFC 1997, ODFW 1998
Youngs Bay			Natural							1980-86	TL	10	-15.2		BE and LGL 1995, PSMFC 1997
	Youngs R		Natural.							1963-97	RC	5	+1.7		ODFW 1998
Klaskanine R		Fa							P						
	South Fork	Fa	Natural							1968-97	PI	16	-0.1		BE and LGL 1995, PSMFC 1997, ODFW 1998
			Natural							1967-97	RC	9	+0.4		ODFW 1998
	North Fork	Fa	Natural							1951-97	PI	9	-3.6		BE and LGL 1995, PSMFC 1997, ODFW 1998
			Natural							1964-97	RC	9	-2.9		ODFW 1998
Grays R		Fa	Natural				MCH		P	1964-96	TL	39	-3.0	-29.9	BE and LGL 1995, WDFW 1997c
Bear Cr		Fa	Natural						P	1983-97	PI	12	-23.2	-17.0	BE and LGL 1995, PSMFC 1997, Streamnet 1998
			Natural							1983-97	RC	12	-13.5	-2.2	ODFW 1998
Big Cr.		Fa	Natural						P	1970-97	PI	869	-1.5	-6.0	BE and LGL 1995, PSMFC 1997, Streamnet 1998
			Natural							1970-97	RC	110	-3.1	-7.0	ODFW 1998

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU River Basin	Sub-basin	Run[1]	Production[2]	Status summaries[3] A	B	C	D	E	P?[4]	Recent abundance Data Years	Data Type[5]	5 Year Geomean[6]	Long-term Trend[7]	1987-97 Short-term Trend[8]	Data References
9-Lower Columbia River															
Big Cr		Fa	Natural							1977-86	TL	2,663	+19.6		BE and LGL 1995, PSMFC 1997
Gnat Cr		Fa	Natural						P	1970-97	PI	24	-4.5	-19.6	BE and LGL 1995, PSMFC 1997, Streamnet 1998
			Natural							1970-97		6	-7.2	-5.4	ODFW 1998
			Natural							1977-86	TL	53	-3.7		BE and LGL 1995
Skamokawa Cr		Fa	Natural				MCH		P	1964-96	TL	148	-9.5	-22.0	BE and LGL 1995, PSMFC 1997, WDFW 1997c
Hunt Cr		Fa							P						
Elochoman R		Fa	Natural				MCH		P	1964-96	TL	317	+0.7	-10.7	BE and LGL 1995, PSMFC 1997, WDFW 1997c
Plympton Cr		Fa	Natural						P	1968-97	PI	717	+4.5	-1.7	BE and LGL 1995, PSMFC 1997, Streamnet 1998
			Natural							1968-97	RC	38	-0.1	+18.1	ODFW 1998
			Natural							1977-86	TL	1,161	+3.4		BE and LGL 1995, PSMFC 1997
Clatskanie R		Fa	Natural						P	1951-97	TL	8	+1.6	+5.5	BE and LGL 1995, PSMFC 1997, Streamnet 1998
			Natural							1963-97	RC	4	-2.3	-15.0	ODFW 1998
Mill Cr		Fa (tule)	Natural				MCH		P	1984-97	TL	92	+11.1	-30.1	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
Abernathy Cr		Fa (tule)	Natural				MCH		P	1981-96	TL	418	-10.0	-14.1	BE and LGL 1995, PSMFC 1997, WDFW 1997c
Germany Cr		Fa (tule)	Natural				MCH		P	1981-96	TL	183	-0.6	-12.4	BE and LGL 1995, PSMFC 1997, WDFW 1997c
Cowlitz R		Sp	Natural				MCH		P	1980-97	TL	186	-2.6	-2.4	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
		Fa (tule)	Natural	A			MCH		P	1964-97	TL	2,328	-3.2	-12.0	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
	Coweeman R	Fa (tule)	Natural				MCH		P	1964-97	TL	849	+6.2	+18.3	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
	Toutle R	Sp							P						
		Fa	Natural							1964-81	PI	103	-8.3		BE and LGL 1995, PSMFC 1997
	Toutle R, N Fork	Fa (tule)	Natural							1964-81	TL	478	-10.8		BE and LGL 1995, PSMFC 1997
	Green R	Fa (tule)	Mixed				UCD		P	1964-97	TL	464	-7.2	+30.5	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU				Status summaries[3]						Recent abundance				1987-97	
River Basin	Sub-basin	Run[1]	Production[2]	A	B	C	D	E	P?[4]	Data Years	Data Type[5]	5 Year Geomean[6]	Long-term Trend[7]	Short-term Trend[8]	Data References
9-Lower Columbia River															
Cowlitz R	Toutle R, S Fork	Fa (tule)	Natural				UCD		P	1964-96	TL	38	-6.3		BE and LGL 1995, PSMFC 1997, WDFW 1997c
Kalama R		Sp	Natural				MCH		P	1980-97	TL	181	-11.1	-8.6	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
		Fa (tule)	Natural				MCH		P	1964-97	TL	3,470	+0.1	-12.7	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
Lewis R		Sp	Natural	X			MCH		P	1980-97	TL	525	-3.4	-26.2	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
		Fa	Natural				NWH	H-I	P	1964-97	TL	10,182	-0.1	-6.3	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
	East Fork	Fa (tule)	Natural				NWH		P	1964-97	TL	253	-3.7	-3.1	BE and LGL 1995, PSMFC 1997, WDFW 1997c, Streamnet 1998
Milton Cr		Fa							P						
Scappoose Cr		Fa							P						
Sandy R		Sp	Natural	A+					P	1977-96	DC	2,750	+11.8	+5.9	BE and LGL 1995, Nicholas 1995, PSMFC 1997
		Fa	Natural	A						1975-87	TL	1,027	+1.0		BE and LGL 1995, PSMFC 1997
		Fa (early run)	Natural						P	1988-97	PI	97	-16.8	-16.8	BE and LGL 1995, PSMFC 1997, Streamnet 1998
		Fa (late run)	Natural						P	1951-97	PI	674	+8.0	-3.0	BE and LGL 1995, PSMFC 1997, Streamnet 1998
		Fa (early run)	Natural							1988-97	RC	72	-20.5		ODFW 1998
		Fa (late run)	Natural							1951-97	RC	390	+4.2	-7.2	ODFW 1998
	Trout Cr	Fa	Natural							1957-97	PI	4	-3.1		BE and LGL 1995, PSMFC 1997, Streamnet 1998
		Wi	Natural							1957-97	RC	4	-7.9		ODFW 1998
	Gordon Cr	Wi	Natural							1954-97	RC	4	-5.9		ODFW 1998
Washougal R		Fa (tule)	Natural	A+			MCH		P	1964-96	TL	3,638	+10.4	+0.7	BE and LGL 1995, PSMFC 1997, WDFW 1997d, Streamnet 1998
Wind R		Fa	Natural	X						1960-84	PI	83	-0.5		BE and LGL 1995, PSMFC 1997
		Fa (tule)	Natural				MCD		P	1964-96	TL	30	-7.2	-31.3	BE and LGL 1995, PSMFC 1997, WDFW 1997c
White Salmon R		Fa	Natural	A+						1965-83	PI	238	-4.1		BE and LGL 1995, PSMFC 1997
		Fa (tule)	Natural				MCD		P	1965-96	TL	127	-9.2	-9.7	BE and LGL 1995, PSMFC 1997, WDFW 1997c

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU / River Basin	Sub-basin	Run[1]	Production[2]	Status summaries[3] A	B	C	D	E	P?[4]	Recent abundance Data Years	Data Type[5]	5 Year Geomean[6]	1987-97 Long-term Trend[7]	Short-term Trend[8]	Data References
10-Upper Willamette River															
Clackamas R		Sp	Mixed						P	1951-97	DC	1,648	+5.1	-9.7	BE and LGL 1995, Nicholas 1995, PSMFC 1997, Streamnet 1998
		Sp	Natural							1951-96	TL	6,025	+2.7	-2.7	BE and LGL 1995, PSMFC 1997
		Fa	Natural						P	1967-94	RC	116	-2.0	+4.8	BE and LGL 1995, PSMFC 1997
Willamette R		Sp	Natural	C						1951-97	DC	23,912	+0.2	-12.4	BE and LGL 1995, ODFW 1997, PSMFC 1997, PFMC 1998
	Molalla R	Sp	Natural						P	1961-93	TL	341	-0.8		BE and LGL 1995, PSMFC 1997
										1961-96	FM	6	-1.1	-14.4	BE and LGL 1995, PSMFC 1997
	Abiqua Cr	Sp							P						
	Mill Cr	Sp							P						
	N Santiam R	Sp	Natural						P	1960-88	DC	1,136	-3.7		BE and LGL 1995, PSMFC 1997
	Marion Fks Hatchery	Sp							P						
	S Santiam R	Sp							P						
	S Santiam Hatchery	Sp							P						
	McKenzie R	Sp	Natural						P	1970-98	DC	1,532	-0.2	-15.8	BE and LGL 1995, Nicholas 1995, PSMFC 1997, ODFW 1998
	McKenzie Hatchery	Sp							P						
	Fall Cr	Sp	Natural							1966-87	DC	241	-1.0		BE and LGL 1995, PSMFC 1997
13-Upper Columbia River Spring-Run															
Wenatchee R		Sp	Natural				NWD		P	1977-95	TL	27	-11.5	-37.4	BE and LGL 1995, WDFW 1997d
			Natural							1959-96	RC	7	-2.1	-36.6	BE and LGL 1995, Pevan and Mosey 1996, PSMFC 1997
	Chiwawa R	Sp	Natural				NWD		P	1977-95	TL	134	-8.1	-29.3	BE and LGL 1995, WDFW 1997d
			Natural							1958-98	RC	23	-2.9	-18.7	BE and LGL 1995, Pevan and Mosey 1996, WDFW 1998c
	Nason Creek	Sp	Natural				NWD		P	1977-95	TL	85	-9.0	-26.0	BE and LGL 1995, WDFW 1997d
			Natural							1958-98	RC	20	-4.2	-15.3	BE and LGL 1995, Pevan and Mosey 1996, WDFW 1998c
	Little Wenatchee	Sp	Natural				NWD		P	1978-95	TL	57	-5.5	-25.8	BE and LGL 1995, WDFW 1997d
			Natural							1958-98	RC	10	-1.6	-21.7	BE and LGL 1995, Pevan and Mosey 1996, WDFW 1998c
	White R	Sp	Natural				NWD		P	1977-95	TL	25	-10.6	-35.9	BE and LGL 1995, WDFW 1997d

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

ESU				Status summaries[3]						Recent abundance			1987-97		
River Basin	Sub-basin	Run[1]	Production[2]	A	B	C	D	E	P?[4]	Data Years	Data Type[5]	5 Year Geomean[6]	Long-term Trend[7]	Short-term Trend[8]	Data References
13-Upper Columbia River Spring-Run															
Wenatchee R			Natural							1958-98	RC	6	0.0	-22.0	BE and LGL 1995, Pevan and Mosey 1996, WDFW 1998c
Entiat R		Sp	Natural				NWD		P	1977-95	TL	89	-18.8	-19.4	BE and LGL 1995, WDFW 1997d
			Natural							1959-98	RC	10	-5.5	-18.4	BE and LGL 1995, WDFW 1998c
Methow R		Sp	Mixed				NCD		P	1977-95	TL	144	+1.1	-15.3	BE and LGL 1995, WDFW 1997d
		Sp	Natural							1959-98	RC	79	-1.3	-11.1	BE and LGL 1995, WDFW 1997c, 1998c
	Twisp	Sp	Natural				NWD		P	1977-95	TL	87	-5.8	-27.4	BE and LGL 1995, WDFW 1997d
Methow R	Twisp		Natural							1959-98	RC	41	-4.2	-21.1	BE and LGL 1995, WDFW 1997c, 1998c
	Chewuch R (Chewack)	Sp	Natural				NWD		P	1977-95	TL	62	-5.1	-28.1	BE and LGL 1995, WDFW 1997d
			Natural							1960-98	RC	33	-1.9	-17.9	BE and LGL 1995, WDFW 1997c, 1998c
	Early Winters Cr	Sp	Natural							1959-98	RC		+0.6		BE and LGL 1995, WDFW 1997d, 1998c
	Lost R	Sp	Natural				NWD		P	1972-94	TL	62	-0.1	-23.2	BE and LGL 1995, WDFW 1997d
			Natural							1959-98	RC	19	-2.8	-20.9	BE and LGL 1995, WDFW 1997c,d
Okanogan R		Sp		X											
Sanpoil R		Sp/Su		X											
Spokane R		Sp/Su		X											
Colville R		Sp/Su		X											
Kettle R		Sp/Su		X											
Pend Oreille R		Sp/Su		X											

NOTES

[1] Run timing designations: Fa -- fall; Sp -- spring; Su -- summer; Wi -- winter (as reported by data reference)

[2] Production: (as reported by data reference)

[3] Status summaries from the following sources:

A--Nehlsen et al. (1991): E, endangered (US); X, extinct; A+, possibly extinct; A, high extinction risk; B, moderate extinction risk; C, special concern.
B--Higgins et al. (1992): A, high risk of extinction; B, moderate risk of extinction; C, stock of concern.
C--Nickelson et al. (1992): H, healthy; D, depressed; S, special concern; U, unknown. 1, May not be a viable population; 2, Hatchery strays; 3, Small, variable run.

Table 4 (cont'd): Summary of chinook salmon data available to the BRT for risk evaluations. Data include information by ESU and River/Stock.

D–WDF et al. (1993): Three characters represent stock origin, production type, and status, in that order.
Origin: N, native; M, mixed; X, non-native; U, unknown; -, unresolved by state and tribes
Production: W, wild; C, composite; A, cultured; U, unknown; -, unresolved
Status: H, healthy; D, depressed; C, critical; U, unknown.

E–Huntington et al. (1996):
H-I, healthy Level I (abundance at least two-thirds as great as would be found in the absense of human impacts).
H-II, healthy Level II (abundance between one-third and two thirds as great as expected without human impacts).

[1] Petition status [P?]: Indicates (by 'P') stocks included in the ONRC and Nawa petition dated 31 January 1995. All petitioned stocks are listed in appendix even if no data are available. Paratheses indicate stock is included as part of a larger unit in the petition.

[3] Data Type Codes: CS, carcass; DC, dam count; FM, fish per mile; IT, index total; PI, peak or index live fish; PR, peak redd count; RC, redd count; TC, trap count; TL, total live fish count.

[4] Most recent 5 years of data used to calculate spawning escapement geometric mean.

[7] Trend (Long-term): Calculated for all data collected after 1950.

[8] Short-term Trend: Calculated for most recent 7-10 years during the period 1987-97, except as noted.

Table 5. Summary of BRT conclusions for extinction risk categories for the chinook salmon ESUs. Numbers in each cell denote the number of BRT members voting for a particular risk level for each risk category. The five-point scale used is described in Myers et al. (1998, Appendix E).

Puget Sound ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution		3	10	6		3.1
Trends/Productivity			5	13	1	3.7
Genetic Integrity		6	5	8		3.1

Lower Columbia River ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution		2	7	7	1	3.4
Trends/Productivity		1	9	7		3.4
Genetic Integrity		2	5	9	1	3.5

Upper Willamette River ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution			3	9	5	4.1
Trends/Productivity		2	7	6	2	3.5
Genetic Integrity		1	11	4	1	3.3

Table 5, continued.

Upper Columbia River Spring-Run ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution				4	15	4.8
Trends/Productivity				6	13	4.7
Genetic Integrity		3	8	7	1	3.4