NOAA Fisheries Report to the Board of Forestry
on
Salmonid Enumeration

May, 2003

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

APR 2 3 2003

Mr. Stan Dixon, Chairman
California Board of Forestry and Fire Protection
1416 9th Street
Sacramento, California 94244-2460

Dear Chairman Dixon:

The Board of Forestry and Fire Protection has requested a joint presentation by the National Marine Fisheries Service (NOAA Fisheries) and the California Department of Fish and Game on fish counting methodologies. We were scheduled to make a presentation to the Joint Meeting of the Board and the Fish and Game Commission at the upcoming May meeting in Riverside, California. The Board, in response to the Governor's request to reduce travel has relocated your meeting to Sacramento, while the Commission has maintained its Riverside location.

Recognizing that delaying the presentation to a later meeting may cause the Board Agenda problems of your own, we are providing you a document (enclosure) that addresses the fish counting methodology question. I hope this is responsive to your needs. We would be pleased to address technical questions at a future meeting; perhaps if the Board/Commission Joint Meeting is rescheduled that would be an appropriate time to address questions.

Under the Federal Endangered Species Act of 1973 as amended our obligation, when determining whether an Evolutionarily Significant Unit (ESU/species) warrants listing, is to use the "best scientific and commercial data" available to us. The enclosed report details the best available data as of April 2003.

Also, as a part of the enclosed Report I have included a Report from the March 2002 meeting of the Salmon Recovery Science Review Panel. NOAA Fisheries established this Panel "to help guide the scientific and technical aspects of recovery planning for listed salmon species throughout the West Coast. The panel consists of six highly qualified, independent scientists…." Three of the Panelists are located in California. The Report focuses on the problems associated with salmonid data in California. As you will see when you review the enclosed Report, California is data poor when it comes to salmon population enumeration; however, what we have represents the best available data and we are obligated to use it in our decision making. You and the Commission have been made aware that all our methodologies have been a part of all our Status Report Reviews and all documents associated with our listing process under the ESA. All of our "listing packages" undergo extensive public review prior to becoming final. Our in-house Biological Review Teams share their draft documents with co-managers, including DFG and the recognized treaty tribes in California. I hope you find our report useful in your deliberations.

If you have any questions please contact Joe Blum at (916) 930-3621.

Sincerely,

Rodney R McInnis

Rodney R. McInnis
Acting Regional Administrator

Enclosures

cc: Joseph R. Blum
Robert Hight
Charlotte A. Ambrose
James F. Bond
Robert Treanor
Michael Flores
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Pete Adams

SALMON RECOVERY SCIENCE REVIEW PANEL
Report for the meeting held
March 18-19, 2002
Southwest Fisheries Science Center, Santa Cruz Lab
National Marine Fisheries Service
Santa Cruz, CA

This introductory material (pp. i-iii) is available on the RSRP web site. As an aid to the reader, we are now including it with individual reports.

Recovery Science Review Panel

Robert T. Paine	**University of Washington, Chair**
Ted Case	**University of California – San Diego**
Frances James	**Florida State University**
Russell Lande	**University of California – San Diego**
Simon Levin	**Princeton University**
William Murdoch	**University of California – Santa Barbara**

The Recovery Science Review Panel (RSRP) was convened by the National Marine Fisheries Service (NMFS) to help guide the scientific and technical aspects of recovery planning for listed salmon and steelhead species throughout the West Coast. The panel consists of six highly qualified, independent scientists who perform the following functions:

1. Review core principles and elements of the recovery planning process being developed by NMFS.
2. Ensure that well accepted and consistent ecological and evolutionary principles form the basis for all recovery efforts.
3. Review the processes and products of all the Technical Recovery Teams (TRTs) for scientific credibility and ensure consistent application of core principles across Evolutionarily Significant Units (ESUs) and recovery domains.
4. Oversee peer review for all recovery plans and appropriate substantial intermediate products.

The panel meets 3-4 times annually, and submits a written review of the issues and documents discussed at each meeting.

Expertise of the Panel Members

Dr. Robert Paine (Chair), University of Washington

- **Field of expertise:** marine community ecology, complex ecological interactions, natural history;
- **Research:** About 100 scientific publications.
- **Awards and Scientific Leadership:** member, National Academy of Sciences; Robert H. MacArthur award, Ecological Society of America; Tansley award, British Ecological Society; Sewall Wright award, American Society of Naturalists; Eminent Ecologist ward, Ecological Society of America; past president of the Ecological Society of America; member of National Research Council committees; member of editorial boards

Dr. Ted Case, University of California-San Diego

- **Field of expertise:** evolutionary ecology, biogeography and conservation biology;
- **Research:** More than 130 scientific articles published, including papers in *Science*, *Nature*, *American Scientist*; featured in *Discover* magazine and on public television and radio.
- **Awards and Scientific Leadership:** Board member for National Center for Ecological Analysis and Synthesis; former Chair of the Department of Biology at UCSD; author of leading textbook on theoretical ecology

Dr. Frances C. James, Florida State University

- **Field of expertise:** conservation biology, population ecology, systematics, ornithology;
- **Research:** More than 105 scientific articles published.
- **Awards and Scientific Leadership:** Eminent Ecologist award, Ecological Society of America; past president of the American Institute of Biological Sciences and the American Ornithologists' Union; member of National Research Council committees; service on editorial boards; Board of Governors for The Nature Conservancy, member of the National Academy of Arts and Sciences

Dr. Russell Lande, University of California-San Diego

- **Field of expertise:** evolution and population genetics, management and preservation of endangered species, conservation and theoretical ecology;
- **Research:** More than 116 scientific publications.
- **Awards and Scientific Leadership:** Sewall Wright award, American Society of Naturalists; John Simon Guggenheim Memorial Foundation Fellow, MacArthur Foundation Fellow, Member American Academy of Arts and Sciences; Past President of the Society for the Study of Evolution; developed criteria for classifying endangered

species adopted by the International Union for Conservation of Nature and Natural Resources (IUCN)

Dr. Simon Levin, Princeton University

- **Field of expertise:** theoretical/mathematical ecologist;
- **Research:** More than 300 technical publications.
- **Awards and Scientific Leadership:** member, National Academy of Sciences; member, American Academy of Arts and Sciences; Robert H. MacArthur award recipient from the Ecological Society of America; Statistical Ecologist award from the International Association for Ecology; Distinguished Service Award from the Ecological Society of America; Okubo award, Society for Mathematical Biology; member of many National Research Council committees; member of the Science Board, Santa Fe Institute; former Board Chair, Beijer International Institute of Ecological Economics; Board of the Committee of Concerned Scientists; past President, Ecological Society of America; past President, Society of Mathematical Biology; and Guggenheim Fellowship

Dr. William Murdoch, University of California-Santa Barbara

- **Field of expertise:** theoretical and experimental ecology, population ecology;
- **Research:** More than 120 scientific publications.
- **Awards and Scientific Leadership:** Robert H. MacArthur award, Ecological Society of America; President's award, American Society of Naturalists; Guggenheim Fellow; member, American Academy of Arts and Sciences; Founder, National Center for Ecological Analysis and Synthesis; Director of California Coastal Commission 10-year study of a coastal nuclear power plant; Board of Governors, the Nature Conservancy

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Dr. Beth Sanderson

- National Marine Fisheries Service liaison to the Recovery Science Review Panel
- Recovery Science Review Panel report coordinator

Dr. Richard Farr

- Science Writer, Northwest Fisheries Science Center

RECOVERY SCIENCE REVIEW PANEL (RSRP)
Southwest Fisheries Science Center, Santa Cruz Lab
March 18-19, 2002

I. INTRODUCTION

A partial panel (Case, James, Lande, Murdoch and Paine) met at the Southwest Fisheries Science Center. In addition to our usual mission—offering independent advice to NMFS on recovery of endangered salmonids and offering advice to the Technical Recovery Teams (TRTs)—this meeting was intended to familiarize the panel with the challenges facing salmon recovery in California.

The information presented to the Panel in Santa Cruz was appropriate, especially given the limited timeframe. These are some of the facts that we learned:

- There are only minimal stock-specific data on coastal chinook, steelhead and coho;
- More than 90% of steelhead in the Central Valley are hatchery fish, and there have been no new data on them since 1993;
- There has been very little coded-wire tagging of hatchery fish in California;
- The enormous success of the hatchery-based Sacramento fall chinook run has disguised a precipitous decline in the spring run, from 600,000 to perhaps 300 fish in recent years (with subsequent increases to 9000-18,000 fish).

We mention these facts at the outset because they identify a fundamental quandary facing the California TRTs, and thus the challenge posed to the RSRP: *What kind of advice can be given when crucial data are missing or limited?*

The sections that follow summarize our impressions.

II. NATURE AND LIMITATIONS OF THE AVAILABLE DATA

We learned that, compared to TRTs in the Northwest, California has limited data in many areas, including population sizes and long-term trends in escapement (numbers of adult fish returning to fresh water) and estimates of the fitness of hatchery fish (from coded wire tags or adipose fin tagging). Even so, the available data for Central Valley stocks is significantly better than for coastal stocks and steelhead. The data on spring and winter Chinook may even be adequate for the types of analyses outlined in the VSP document produced for the Pacific Northwest (McElhany et al 2000).

We were told that three quarters of the chinook caught along the Pacific Coast outside Alaska are in the California commercial fishery. Most of these are hatchery fish; their straying rates are believed to be high, but are largely unknown because hatcheries are still doing very little marking (less than 10% according to Yoshiyama et al 2000).

The California environment differs in significant ways from that of the Pacific Northwest:

- California's coast includes at least two marine biogeographical provinces. River systems inhabitable by salmon and steelhead span climates varying from the relatively wet Pacific Northwest to arid landscapes around San Diego. The implication is that one standardized recovery protocol cannot be fit to all salmon ESUs.

- Terrestrial disturbance regimes in California generate an environment for salmonids during their freshwater phase that is substantially different from and more varied than they experience to the north. California rivers and streams are susceptible to prolonged droughts and catastrophic turbidity associated with extreme weather events. The latter reflects in part a negative and indirect impact of forestry practices. In particular, predicting stock robustness and managing stocks is rendered difficult by the interplay between frequency of fire in watersheds containing salmon habitat, high spatial variation in rainfall, and the resultant production of average stream water temperatures in excess of salmon thermal tolerances.

- A substantial fraction of watershed areas is privately held. The problem was identified and coarsely quantified, but not discussed.

- Some of the coastal streams may be occluded by sand bars, which form and disappear at intervals ranging from months to years. The process emphasizes the management necessity of having accurate stock [ESU] identification and a quantitative grasp of the frequency of straying and identity of the founder stock.

III. RESPONSE OF THE SANTA CRUZ SALMON GROUP TO DATA LIMITATIONS

One component of defining ESUs is adequate genetic information. The Panel heard a report on mitochondrial DNA and nuclear microsatellite diversity in hatchery and wild steelhead (*O. mykiss*) in S. California. Our impression is that such information is limited for all California salmonids. Further, we heard very little about the extensive database associated with the conservation hatchery at the Bodega marine lab. In the absence of data known to be directly relevant to delisting criteria, there is a danger that focusing on the available data will actually lead to incorrect delisting criteria. We saw in the salmon group's presentations at Santa Cruz some reason to be concerned about this possibility. The group has responded to the underlying paucity of data with some imaginative analyses of data that do exist. The question is whether these analyses are the best way to do TRT work in a data-poor environment; on the whole, we think not.

For example, we were presented with a metapopulation patch-occupancy model for coho; this may not be very useful from a management point of view in any case, but especially not when based on presence/absence data that offers too much opportunity for false negatives and at a small spatial scale where individual fish movements can produce pseudo turnover. Another example is dealing with the absence of adequate time series data by trying to develop recovery criteria by studying disturbance regimes. This could be useful in a PVA model for identifying likely spatial patterns of catastrophes (due to floods) and in accounting for missing year classes (as with coho along the central California coast).

A third TRT member recommended doing watershed-level analyses at different spatial scales, and emphasized understanding sediment yield along the northern California coast—a top-down approach. This is OK for descriptive work, but unlikely to help TRTs with their assignment because there is presently no way to connect the timing and amount of sediment disruption with the recruitment success of individual subpopulations. If this relationship could be firmed up, then sedimentation, since it can be readily measured over wide areas, could prove useful.

Spatial analyses of flood events may also provide insight into the "coherence scale" of this particular type of physical disturbance. Two problems with this analysis may be mentioned. Again, it is not clear how reliably measures of flood disturbance translate into population/ demographic disturbance, especially over more than the short term. Second, there are many other potential sources of "disturbance," each with presumably its own spatial coherence scale. Some of these, such as declines in prey species in streams, may not be correlated easily with measured physical factors. Thus, the emphasis on physical measures that are available may focus attention on the wrong variables for determining possible metapopulation structure.

For extinction / colonization estimates, the typical area sampled at each site is probably too small to give insight into colonization and extinction rates of subpopulations that might collectively make up a metapopulation. It might be better to analyze the data in a geographically explicit context by lumping the data within basins or other natural units. The data may then define the spatial distribution of fish among natural units, and perhaps indicate trends in occupancy rate within at least some of these spatial units. Spatial and temporal autocorrelation analysis of the small-scale occupancy data might be informative as to the natural units of population structure. It would also be important to use the existing data to test whether the probability of resampling a site is independent of past occupancy. The best use of this data in recovery planning might be simply to indicate recent trends in populations among drainages or other larger spatial units.

The geographic extinction / colonization analyses could be used to create highly precautionary delisting criteria, with the explicit recommendation that these could be modified in the light of new data. The analyses could also be used to develop a sampling scheme to provide relevant data (e.g. distribution and size of populations in major watersheds along the coast).

In closing this section, the Panel would like to reiterate that the California TRTs find themselves in an inherently difficult situation. While we are critical of many approaches being tried, we do not pretend to have provided a superior strategy. Instead, the next section offers some questions that may provide a context in which one can be developed.

IV. CRITICAL QUESTIONS FOR THE CALIFORNIA TRTs

Focusing on the following questions may help the California TRTs to forge an effective strategy in these data-poor circumstances:

1. What proportion of spawning Central Valley chinook and steelhead are of hatchery origin? The Pacific Fishery Management Council and NMFS need this answer if they are to use reliable escapement and jeopardy targets when setting ocean harvest regulations.

   We note that the data will have to come from a marking program for hatchery fish. Until there is far more consistency in tagging hatchery fish, it will not be possible to make reliable estimates of populations of naturally-spawning salmon or the effects of harvest upon them. We also need tagging of wild fish to obtain better estimates of straying rates.

2. Can habitat improvements and/or water flow regulation in streams and rivers allow salmon populations to increase? We think the costly efforts supported by the Central Valley Project Improvement Act (CVPIA) with its multi-agency CALFED program ($195 million in 2001) and the California state program, could design its projects to allow comparisons in an experimental framework, thereby allowing better inferences about the value of the projects. Spring Chinook escapement was up after controlling for diversions at Butte Creek, Deer Creek and Mill Creek in the Central Valley, so there is a need to sample unscreened diversions and estimate the magnitude of this problem generally. The recovery plans could make explicit recommendations along these lines.

3. The Central Valley fall chinook show a dramatic increase in escapement from about 1995 (slide 34 of Steve Lindley's talk). This coincides with stricter harvest limits but also with better ocean conditions, and presumably increased off-site hatchery releases (although the data shown by Lindley on this point stop at 1995). Is it possible to assign relative strengths to these factors in accounting for recent escapement trends and if so how?

More general issues, of concern to California TRTs because they are of concern to all salmon restoration efforts, include the following:

- Are ocean conditions the primary limiting factor for salmon, as opposed to harvest or in-river management? (Extensions of recent studies, e.g. Roemmich and McGowan 1995; Boydstun 2001; Hare et al. 1999, expect a big return this year because ocean conditions are favorable.)
- To what extent is there loss of genetic diversity in listed ESUs (see Levin and Schiewe 2001)?
- Is supplementation of breeding stock with conservation hatchery fish really beneficial? (Cf. for example Ford 2002, Waples et al 2002.)

- Given the high hatchery production for fall chinook, is it worthwhile to try to assess impacts to wild populations, both in terms of genetic introgression and competitive effects by hatchery fish?

V. CONCLUSION AND RECOMMENDATIONS

To complete their work in the next two years, the California TRTs will have to be very explicit about their level of uncertainty, and will have to include in their plans the development of a new research and monitoring program and a clear indication of what steps are being taken to assure continuing progress.

Part of the RSRP's role is to encourage methodological consistency across the TRTs, and we believe that the California TRTs should continue to attend the NW TRT meetings and study how the NW teams work. The NWFSC produced an excellent document on research needs (the "Salmon Research Plan," Vols 1 & II); their colleagues in California should look closely at it.

California TRTs need not be intimidated by the head start made by the larger group in the Pacific Northwest, which has also complained about data gaps. In fact, we think the California TRTs can set an example by developing priorities for an efficient new sampling program and working to get it implemented during the next two-year period, a project that will probably take collaboration with the California Department of Fish and Game and probably the Pacific Fishery Management Council.

For delisting criteria, California TRTs need to summarize the geographic distribution of each ESU along with whatever information is available on within and between population genetic variation and demography. We did not hear any details about the ongoing genetics work at the Santa Cruz laboratory or recent PVAs for winter Chinook (Botsford and Brittnacher (1998); Lindley et al. 2000, Lindley and Mohr (in press).)

California can begin with the listing criteria and then state what information is most needed. Likewise, TRTs should try to rank the most probable threats for each ESU based on current information, even though it is incomplete.

The current paucity of population data, and consequent high uncertainty in population status and trends in several stocks outlined in the presentations, implies that the initial recovery plans and delisting criteria should apply the precautionary principle (O'Riordan et al. 2001, IUCN 2001), which would call for exceptionally high protection until new evidence shows that it is not necessary. As part of the recovery plans serious effort should also be put into outlining a long-term program for collecting salmonid population data for California patterned on existing practices in Oregon and Washington. This might encourage concerned state agencies to begin collecting the relevant data in order to refine the recovery goals and delisting criteria, because with better data in the future these might not have to be as precautionary as initially dictated by the current high uncertainty.

The lack of extensive quantitative population data on most salmonid stocks in California suggests that initial precautionary recovery goals and delisting criteria might be based on general criteria outlined in the NMFS Viable Salmonid Populations document (NMFS 2000), combined with objective, population-based criteria (for listing and delisting) such as those currently used by IUCN (IUCN 2001). A previous RSRP report (RSRP 2001) outlined the need for such an approach in practice, even in Oregon and Washington, with specific population viability criteria determined insofar as possible by stochastic population models based on available data. This RSRP report also included detailed suggestions concerning population viability analysis, particularly on dealing with uncertainties in population data and dynamics.

The RSRP cannot too strongly emphasize that the California TRTs' task of formulating effective salmonid recovery plans depends on an increased level of cooperation among state and federal agencies, especially with respect to sharing data in a common repository. It will be impossible to measure wild fish recruitment rates and determine possible hatchery impacts on wild fish without better data being available.

We urge the California TRTs and the Santa Cruz Lab to make a list of the important questions, estimate what actions and time commitments will be required to answer them, and then set clear priorities in the light of that knowledge.

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Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

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February 2003

Co-manager review draft

[This is a draft document being provided to state, tribal, and federal comanagers for technical review.]

EXECUTIVE SUMMARY

This draft report summarizes preliminary scientific conclusions of the NMFS Biological Review Team (BRT) regarding the updated status of 26 ESA-listed Evolutionarily Significant Units (ESUs) of salmon and steelhead (and one candidate species ESU) from Washington, Oregon, Idaho, and California. These ESUs were listed following a series of status reviews conducted during the decade of the 1990s. The status review updates were undertaken to allow consideration of new data that have accumulated over the various time periods since the last updates and to address issues raised in recent court cases regarding the ESA status of hatchery fish and resident (nonanadromous) populations. The draft BRT conclusions in this report should be considered preliminary for two reasons. First, the BRT will not finalize its conclusions until state, tribal, and other federal comanagers have had an opportunity to review and comment on the draft report. Second, some policy issues regarding the treatment of hatchery fish and resident fish in ESU determinations and risk analyses are not resolved at this time.

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

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

For the following ESUs, the majority BRT conclusion was "in danger of extinction:" Upper Columbia spring-run chinook, Sacramento River winter-run chinook, Upper Columbia steelhead, Southern California steelhead, California Central Valley steelhead, Central California Coast coho, Lower Columbia River coho, Snake River sockeye. For the following ESUs, the majority BRT conclusion was "likely to become endangered in the foreseeable future:" Snake River fall-run chinook, Snake River spring/summer-run chinook, Puget Sound chinook, Lower Columbia River chinook, Upper Willamette River chinook, California Coastal chinook, Central Valley spring-run chinook, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Northern California steelhead, Central California Coast steelhead, South-Central California Coast steelhead, Oregon Coast coho, S. Oregon/N. California Coast coho, Lake Ozette sockeye, Hood Canal summer-run chum, and Lower Columbia River chum. In a number of ESUs, adult returns over the last 1-3 years have been significantly higher than have been observed in the recent past, at least in some populations. The BRT found these results, which affected the overall BRT conclusions for some ESUs, to be encouraging. For example, the majority BRT conclusion for Snake River fall chinook salmon was "likely to become endangered," whereas the BRT concluded at the time of the original status review that this ESU was "in danger of extinction." This change reflects the larger adult returns over the past several years, which nevertheless remain well below preliminary targets for ESA recovery. In the Upper Columbia River, the majority BRT conclusions for spring chinook salmon and steelhead were still "in danger of extinction," but a substantial minority of the votes fell in the "likely to become endangered" category. The votes favoring the less severe risk category reflect the fact that recent increases in escapement have at least temporarily somewhat alleviated the immediate concerns for persistence of individual populations, many of which fell to critically low levels in the mid 1990s. Overall, although recent increases in escapement were considered a favorable sign by the BRT, the response was uneven across ESUs and, in some cases, across populations within ESUs. Furthermore, in most instances in which recent increases have occurred, they have not yet been sustained for even a full salmon/steelhead generation. The causes for the increases are not well understood, and in many (perhaps most) cases may be due primarily to unusually favorable conditions in the marine environment rather than more permanent alleviations in the factors that led to widespread declines in abundance over the past century. In general, the BRT felt that ESUs and populations would have to maintain themselves for a longer period of time at levels considered viable before it could be concluded that they are not at significant continuing risk.

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INTRODUCTION

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

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

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

Recently, several factors led NMFS to conclude that the ESA status of listed salmon and steelhead ESUs should be reviewed at this time. First, a September 2001 ruling in a lawsuit called into question the NMFS decision to not list several hatchery populations considered to be part of the Oregon Coast coho salmon ESU (Alsea Valley Alliance v. Evans (161 F. Supp. 2d 1154, D. Oreg. 2001; Alsea decision). That ruling held that the ESA does not allow listing of any unit smaller than a DPS (or ESU), and that NMFS had violated that provision of the act by listing only part of an ESU. Although this legal case applied directly only to the Oregon Coast coho salmon ESU, the same factual situation (hatchery populations considered part of listed ESUs but not listed) also applied to most of the other listed ESUs of salmon and steelhead. Second, another lawsuit currently pending that involves the Southern California ESU of steelhead (EDC v. Evans, SACV-00-1212-AHS (EEA), United States District Court, C.D. California) raised a similar issue—NMFS concluded that resident fish were part of the ESU but only the anadromous steelhead were listed. Again, this same factual situation is found in most, if not all, listed steelhead ESUs. Finally, at least several years of new data are available even for the most recently listed ESUs, and up to a decade has passed since the first populations were listed in the Sacramento and Snake Rivers. Furthermore, in some areas, adult returns in the last few years have been considerably higher than have been seen for several decades.

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

ESU determinations

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

Geographic boundaries

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

Artificial propagation

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

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

Category 1—The hatchery population was derived from a native, local population; is released within the range of the natural population from which it was derived; and has experienced only relatively minor genetic changes from causes such as founder effects, domestication or non-local introgression. Examples of populations that fall into this category include:

a) A hatchery population that has been recently founded (e.g., within one or two generations) from a representative sample of a native, natural population.

b) A hatchery population that was founded some time in the past (e.g., more than two generations ago) as a representative sample from a native, natural population, and has received regular, substantial, and representative infusions of natural fish from the original founding population into the broodstock since that time.

Category 2—The hatchery population was derived from a local natural population, and is released within the range of the natural population from which it was derived, but is known or suspected to have experienced a moderate level of genetic change from causes such as founder effects, domestication or non-native introgression. Examples of populations that fall into this category include:

a) A hatchery population for which there is direct evidence (e.g., from molecular genetic data or breeding studies) of moderate genetic divergence between the hatchery population and the natural population from which it was derived. In this context, "moderate divergence" would be a level of divergence typical of that observed among natural populations within the same ESU.

b) A hatchery population that was founded from a native, natural population, but 1) the sample was not representative; or 2) the broodstock has received few or no reintroductions of native, natural fish since the time of founding; or 3) the hatchery population is believed to have experienced moderate genetic change (e.g., from domestication or non-local introgression) since the time of founding.

c) A hatchery population that was founded predominantly from a local natural population but has also had a greater level of introgression from non-local stocks than would be expected from natural straying rates.

Category 3—The hatchery population was derived predominantly from other populations that are in the same ESU, but is substantially diverged from the local, natural population(s) in the watershed in which it is released. Examples include:

a) A hatchery population that has been deliberately artificially selected, has experienced substantial unintentional domestication, or both.

b) A hatchery population that was founded in a substantially non-representative way or was founded long ago (many salmon generations) and has received few or no infusions of wild fish into the broodstock since the time of founding.

c) A hatchery population that was founded from a mixture of several natural or hatchery populations from within the ESU, or has experienced substantial introgression from non-local populations (much higher than would be expected from natural straying).

d) A hatchery population that was founded from within the ESU, but is released outside of the historical range of the natural population from which it was founded (but still within the historical range of the ESU).

Category 4—The hatchery population was predominantly derived from populations that are not part of the ESU in question; or there is substantial uncertainty about the origin and history of the hatchery population.

Resident fish

In addition to the anadromous life history, sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*) have nonanadromous or resident forms, generally referred to as kokanee and rainbow trout, respectively. As is the case with hatchery fish, it is important to determine the relationship of these resident fish to anadromous populations in listed ESUs. This issue is complicated by the complexity of jurisdictional responsibilities—NMFS has ESA responsibility for anadromous Pacific salmonids, but the U.S. Fish and Wildlife Service (USFWS) has jurisdiction for resident fish. At the time this report was prepared, the two agencies had not reached agreement on how to determine the ESU/DPS status of resident fish or how to make the listing determinations for the overall ESU/DPSs.

For the purposes of this status review update, the BRT adopted a provisional working framework for determining the ESU/DPS status of resident *O. mykiss* geographically associated with listed steelhead ESUs. These evaluations were guided by the same biological principles used to define ESUs of natural fish and determine ESU membership of hatchery fish: the extent of reproductive isolation from, and evidence of biological divergence from, other populations within the ESU. Ideally, each resident population would be evaluated individually on a case-by-case basis, using all available biological information. In practice, little or no information is available for most resident salmonid populations. To facilitate provisional conclusions about the ESU/DPS status of resident fish, NMFS and USFWS have identified three different cases, reflecting the range of geographic relationships between resident and anadromous forms within different watersheds:

Case 1: no obvious physical barriers to interbreeding between resident and anadromous forms;
Case 2: long-standing natural barriers (e.g., a waterfall) separate resident and anadromous forms;
Case 3: relatively recent (e.g., within last 100 years) human actions (e.g., construction of a dam without provision for upstream fish passage) separate resident and anadromous forms.

As a provisional framework, NMFS has adopted the following working assumptions about ESU membership of resident fish falling in each of these categories:

Case 1: Resident fish assumed provisionally to be part of the ESU. Rationale: Empirical studies show that resident and anadromous *O. mykiss* are typically very similar genetically when they co-occur in sympatry with no physical barriers to migration or interbreeding (Chilcote 1976, Currens et al. 1987, Leider et al. 1995, Pearsons et al. 1998). Note: this assumption is not necessarily applicable to *O. nerka*, because sockeye and kokanee can show substantial divergence even in sympatry.

Case 2: resident fish assumed provisionally not to be part of the ESU. Rationale: Many populations in this category have been isolated from contact with anadromous populations for thousands of years. Empirical studies (Chilcote 1976, Currens et al. 1990) show that in these cases the resident fish typically show substantial genetic and life history divergence from the nearest downstream anadromous populations.

Case 3: resident fish assumed provisionally to be part of the ESU. Rationale: Case 3 populations were, most likely, Case 1 populations (and hence part of the ESU) prior to construction of the artificial barrier.

These default assumptions about ESU membership can be overridden by specific information for individual populations. For example, as noted above, anadromous and resident *O. nerka* can diverge substantially in sympatry, and it is possible the same may be true for some *O. mykiss* populations. In addition, some Case 3 populations that historically were part of the ESU may no longer be, as a result of rapid divergence in a novel environment, or displacement by or introgression from non-native hatchery rainbow trout. The BRT reviewed available information about individual resident populations of *O. mykiss* and *O. nerka* to determine which Case each population fits into and whether any information exists to override the default assumption about ESU membership.

Risk Assessments

ESA definitions

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

A variety of information is considered in evaluating the level of risk faced by an ESU. According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific information available regarding its current status, after taking into consideration conservation measures that are proposed or are in place. In its biological status reviews, the BRT does not evaluate likely or possible effects of conservation measures except to the extent they are reflected in metrics of population or ESU viability; these measures are taken into account in a separate process by the NMFS regional offices prior to making listing determinations. Therefore, the BRT does not make recommendations as to whether identified ESUs should be listed as threatened or endangered species, because that determination requires evaluation of factors not considered by the team. Rather, the BRT draws scientific conclusions about the risk of extinction faced by identified ESUs under the assumption that present conditions will continue into the future (recognizing, of course, that existing trends in factors affecting populations and natural demographic and environmental variability are inherent features of "present conditions").

Artificial propagation

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

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

1. Identify which hatchery populations are part of the ESU (see previous section)
2. Review the status of the ESU
3. Evaluate existing protective efforts and make a listing determination

This document is concerned with Step 2—the risk analysis for listed salmon and steelhead ESUs.

The draft revised hatchery policy reaffirms the interpretation that the purpose of the ESA is to conserve threatened and endangered species in their natural habitats. In its risk evaluations, the BRT therefore used the approach it has in the past—focusing on whether populations and ESUs are self-sustaining in their natural habitat. The draft policy also indicates that the potential conservation benefits of artificial propagation should be considered before a listing determination is made. The potential conservation benefits of artificial propagation, together with other conservation measures, will be considered by NMFS Regional Office and Headquarters staff in developing a listing proposal.

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

Resident fish

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

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

Factors Considered in Status Assessments

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

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

The Risk Matrix

In previous status reviews, the BRTs have used a simple "risk matrix" for quantifying ESU-scale risks according to major risk factors. The revised matrix (see Appendix 1) integrates the four major VSP criteria (abundance, productivity, spatial structure, diversity) directly into the risk assessment process. After reviewing all relevant biological information for a particular ESU, each BRT member assigns a risk score (see below) to each of the four VSP criteria. Use of the risk matrix makes it easier to compare risk factors within and across ESUs. The scores are tallied and reviewed by the BRT before making its overall risk assessment (see FEMAT method, below). Although this process helps to integrate and quantify a large amount of diverse information, there is not a simple way to translate the risk matrix scores directly into an assessment of overall risk. For example, simply averaging the values of the various risk factors would not be appropriate; an ESU at high risk for low abundance would be at high risk even if there were no concerns for any other risk factor.

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

1) *Very Low Risk*. Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.

2) *Low Risk*. Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may, in combination with other factors.

3) *Moderate Risk*. This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

4) *Increasing Risk*. Present risk is Low or Moderate, but is likely to increase to high risk in the foreseeable future if present conditions continue.

5) *High Risk*. This factor by itself indicates danger of extinction in the near future.

Recent Events. The "Recent Events" category considers events that have predictable consequences for ESU status in the future but have occurred too recently to be reflected in the population data. Examples include a flood that decimated most eggs or juveniles in a recent broodyear, or large jack returns that generally anticipate strong adult returns in subsequent year(s). This category is scored as follows: "++" - expect a strong improvement in status of the ESU; "+" - expect some improvement in status; "0" - neutral effect on status; "-" - expect some decline in status; "--" - expect strong decline in status.

Overall risk assessment

The BRT analysis of overall risk to the ESU uses categories that correspond to definitions in the ESA: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (As discussed above, these evaluations do not consider conservation measures and therefore are not recommendations regarding listing status). The overall risk assessment reflects

Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead

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Co-manager review draft

[This is a draft document being provided to state, tribal, and federal comanagers for technical review.]

EXECUTIVE SUMMARY

This draft report summarizes preliminary scientific conclusions of the NMFS Biological Review Team (BRT) regarding the updated status of 26 ESA-listed Evolutionarily Significant Units (ESUs) of salmon and steelhead (and one candidate species ESU) from Washington, Oregon, Idaho, and California. These ESUs were listed following a series of status reviews conducted during the decade of the 1990s. The status review updates were undertaken to allow consideration of new data that have accumulated over the various time periods since the last updates and to address issues raised in recent court cases regarding the ESA status of hatchery fish and resident (nonanadromous) populations. The draft BRT conclusions in this report should be considered preliminary for two reasons. First, the BRT will not finalize its conclusions until state, tribal, and other federal comanagers have had an opportunity to review and comment on the draft report. Second, some policy issues regarding the treatment of hatchery fish and resident fish in ESU determinations and risk analyses are not resolved at this time.

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

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

For the following ESUs, the majority BRT conclusion was "in danger of extinction:" Upper Columbia spring-run chinook, Sacramento River winter-run chinook, Upper Columbia steelhead, Southern California steelhead, California Central Valley steelhead, Central California Coast coho, Lower Columbia River coho, Snake River sockeye. For the following ESUs, the majority BRT conclusion was "likely to become endangered in the foreseeable future:" Snake River fall-run chinook, Snake River spring/summer-run chinook, Puget Sound chinook, Lower Columbia River chinook, Upper Willamette River chinook, California Coastal chinook, Central Valley spring-run chinook, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Northern California steelhead, Central California Coast steelhead, South-Central California Coast steelhead, Oregon Coast coho, S. Oregon/N. California Coast coho, Lake Ozette sockeye, Hood Canal summer-run chum, and Lower Columbia River chum. In a number of ESUs, adult returns over the last 1-3 years have been significantly higher than have been observed in the recent past, at least in some populations. The BRT found these results, which affected the overall BRT conclusions for some ESUs, to be encouraging. For example, the majority BRT conclusion for Snake River fall chinook salmon was "likely to become endangered," whereas the BRT concluded at the time of the original status review that this ESU was "in danger of extinction." This change reflects the larger adult returns over the past several years, which nevertheless remain well below preliminary targets for ESA recovery. In the Upper Columbia River, the majority BRT conclusions for spring chinook salmon and steelhead were still "in danger of extinction," but a substantial minority of the votes fell in the "likely to become endangered" category. The votes favoring the less severe risk category reflect the fact that recent increases in escapement have at least temporarily somewhat alleviated the immediate concerns for persistence of individual populations, many of which fell to critically low levels in the mid 1990s. Overall, although recent increases in escapement were considered a favorable sign by the BRT, the response was uneven across ESUs and, in some cases, across populations within ESUs. Furthermore, in most instances in which recent increases have occurred, they have not yet been sustained for even a full salmon/steelhead generation. The causes for the increases are not well understood, and in many (perhaps most) cases may be due primarily to unusually favorable conditions in the marine environment rather than more permanent alleviations in the factors that led to widespread declines in abundance over the past century. In general, the BRT felt that ESUs and populations would have to maintain themselves for a longer period of time at levels considered viable before it could be concluded that they are not at significant continuing risk.

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INTRODUCTION

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

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

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

Recently, several factors led NMFS to conclude that the ESA status of listed salmon and steelhead ESUs should be reviewed at this time. First, a September 2001 ruling in a lawsuit called into question the NMFS decision to not list several hatchery populations considered to be part of the Oregon Coast coho salmon ESU (Alsea Valley Alliance v. Evans (161 F. Supp. 2d 1154, D. Oreg. 2001; Alsea decision). That ruling held that the ESA does not allow listing of any unit smaller than a DPS (or ESU), and that NMFS had violated that provision of the act by listing only part of an ESU. Although this legal case applied directly only to the Oregon Coast coho salmon ESU, the same factual situation (hatchery populations considered part of listed ESUs but not listed) also applied to most of the other listed ESUs of salmon and steelhead. Second, another lawsuit currently pending that involves the Southern California ESU of steelhead (EDC v. Evans, SACV-00-1212-AHS (EEA), United States District Court, C.D. California) raised a similar issue—NMFS concluded that resident fish were part of the ESU but only the anadromous steelhead were listed. Again, this same factual situation is found in most, if not all, listed steelhead ESUs. Finally, at least several years of new data are available even for the most recently listed ESUs, and up to a decade has passed since the first populations were listed in the Sacramento and Snake Rivers. Furthermore, in some areas, adult returns in the last few years have been considerably higher than have been seen for several decades.

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

ESU determinations

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

Geographic boundaries

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

Artificial propagation

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

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

Category 1—The hatchery population was derived from a native, local population; is released within the range of the natural population from which it was derived; and has experienced only relatively minor genetic changes from causes such as founder effects, domestication or non-local introgression. Examples of populations that fall into this category include:

a) A hatchery population that has been recently founded (e.g., within one or two generations) from a representative sample of a native, natural population.

b) A hatchery population that was founded some time in the past (e.g., more than two generations ago) as a representative sample from a native, natural population, and has received regular, substantial, and representative infusions of natural fish from the original founding population into the broodstock since that time.

Category 2—The hatchery population was derived from a local natural population, and is released within the range of the natural population from which it was derived, but is known or suspected to have experienced a moderate level of genetic change from causes such as founder effects, domestication or non-native introgression. Examples of populations that fall into this category include:

a) A hatchery population for which there is direct evidence (e.g., from molecular genetic data or breeding studies) of moderate genetic divergence between the hatchery population and the natural population from which it was derived. In this context, "moderate divergence" would be a level of divergence typical of that observed among natural populations within the same ESU.

b) A hatchery population that was founded from a native, natural population, but 1) the sample was not representative; or 2) the broodstock has received few or no reintroductions of native, natural fish since the time of founding; or 3) the hatchery population is believed to have experienced moderate genetic change (e.g., from domestication or non-local introgression) since the time of founding.

c) A hatchery population that was founded predominantly from a local natural population but has also had a greater level of introgression from non-local stocks than would be expected from natural straying rates.

Category 3—The hatchery population was derived predominantly from other populations that are in the same ESU, but is substantially diverged from the local, natural population(s) in the watershed in which it is released. Examples include:

a) A hatchery population that has been deliberately artificially selected, has experienced substantial unintentional domestication, or both.

b) A hatchery population that was founded in a substantially non-representative way or was founded long ago (many salmon generations) and has received few or no infusions of wild fish into the broodstock since the time of founding;

c) A hatchery population that was founded from a mixture of several natural or hatchery populations from within the ESU, or has experienced substantial introgression from non-local populations (much higher than would be expected from natural straying).

d) A hatchery population that was founded from within the ESU, but is released outside of the historical range of the natural population from which it was founded (but still within the historical range of the ESU).

Category 4—The hatchery population was predominantly derived from populations that are not part of the ESU in question; or there is substantial uncertainty about the origin and history of the hatchery population.

Resident fish

In addition to the anadromous life history, sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*) have nonanadromous or resident forms, generally referred to as kokanee and rainbow trout, respectively. As is the case with hatchery fish, it is important to determine the relationship of these resident fish to anadromous populations in listed ESUs. This issue is complicated by the complexity of jurisdictional responsibilities—NMFS has ESA responsibility for anadromous Pacific salmonids, but the U.S. Fish and Wildlife Service (USFWS) has jurisdiction for resident fish. At the time this report was prepared, the two agencies had not reached agreement on how to determine the ESU/DPS status of resident fish or how to make the listing determinations for the overall ESU/DPSs.

For the purposes of this status review update, the BRT adopted a provisional working framework for determining the ESU/DPS status of resident *O. mykiss* geographically associated with listed steelhead ESUs. These evaluations were guided by the same biological principles used to define ESUs of natural fish and determine ESU membership of hatchery fish: the extent of reproductive isolation from, and evidence of biological divergence from, other populations within the ESU. Ideally, each resident population would be evaluated individually on a case-by-case basis, using all available biological information. In practice, little or no information is available for most resident salmonid populations. To facilitate provisional conclusions about the ESU/DPS status of resident fish, NMFS and USFWS have identified three different cases, reflecting the range of geographic relationships between resident and anadromous forms within different watersheds:

Case 1: no obvious physical barriers to interbreeding between resident and anadromous forms;
Case 2: long-standing natural barriers (e.g., a waterfall) separate resident and anadromous forms;
Case 3: relatively recent (e.g., within last 100 years) human actions (e.g., construction of a dam without provision for upstream fish passage) separate resident and anadromous forms.

As a provisional framework, NMFS has adopted the following working assumptions about ESU membership of resident fish falling in each of these categories:

Case 1: Resident fish assumed provisionally to be part of the ESU. Rationale: Empirical studies show that resident and anadromous *O. mykiss* are typically very similar genetically when they co-occur in sympatry with no physical barriers to migration or interbreeding (Chilcote 1976, Currens et al. 1987, Leider et al. 1995, Pearsons et al. 1998). Note: this assumption is not necessarily applicable to *O. nerka*, because sockeye and kokanee can show substantial divergence even in sympatry.

Case 2: resident fish assumed provisionally not to be part of the ESU. Rationale: Many populations in this category have been isolated from contact with anadromous populations for thousands of years. Empirical studies (Chilcote 1976, Currens et al. 1990) show that in these cases the resident fish typically show substantial genetic and life history divergence from the nearest downstream anadromous populations.

Case 3: resident fish assumed provisionally to be part of the ESU. Rationale: Case 3 populations were, most likely, Case 1 populations (and hence part of the ESU) prior to construction of the artificial barrier.

These default assumptions about ESU membership can be overridden by specific information for individual populations. For example, as noted above, anadromous and resident *O. nerka* can diverge substantially in sympatry, and it is possible the same may be true for some *O. mykiss* populations. In addition, some Case 3 populations that historically were part of the ESU may no longer be, as a result of rapid divergence in a novel environment, or displacement by or introgression from non-native hatchery rainbow trout. The BRT reviewed available information about individual resident populations of *O. mykiss* and *O. nerka* to determine which Case each population fits into and whether any information exists to override the default assumption about ESU membership.

Risk Assessments

ESA definitions

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

A variety of information is considered in evaluating the level of risk faced by an ESU. According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific information available regarding its current status, after taking into consideration conservation measures that are proposed or are in place. In its biological status reviews, the BRT does not evaluate likely or possible effects of conservation measures except to the extent they are reflected in metrics of population or ESU viability; these measures are taken into account in a separate process by the NMFS regional offices prior to making listing determinations. Therefore, the BRT does not make recommendations as to whether identified ESUs should be listed as threatened or endangered species, because that determination requires evaluation of factors not considered by the team. Rather, the BRT draws scientific conclusions about the risk of extinction faced by identified ESUs under the assumption that present conditions will continue into the future (recognizing, of course, that existing trends in factors affecting populations and natural demographic and environmental variability are inherent features of "present conditions").

Artificial propagation

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

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

1. Identify which hatchery populations are part of the ESU (see previous section)
2. Review the status of the ESU
3. Evaluate existing protective efforts and make a listing determination

This document is concerned with Step 2—the risk analysis for listed salmon and steelhead ESUs.

The draft revised hatchery policy reaffirms the interpretation that the purpose of the ESA is to conserve threatened and endangered species in their natural habitats. In its risk evaluations, the BRT therefore used the approach it has in the past—focusing on whether populations and ESUs are self-sustaining in their natural habitat. The draft policy also indicates that the potential conservation benefits of artificial propagation should be considered before a listing determination is made. The potential conservation benefits of artificial propagation, together with other conservation measures, will be considered by NMFS Regional Office and Headquarters staff in developing a listing proposal.

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

Resident fish

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

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

Factors Considered in Status Assessments

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

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

The Risk Matrix

In previous status reviews, the BRTs have used a simple "risk matrix" for quantifying ESU-scale risks according to major risk factors. The revised matrix (see Appendix 1) integrates the four major VSP criteria (abundance, productivity, spatial structure, diversity) directly into the risk assessment process. After reviewing all relevant biological information for a particular ESU, each BRT member assigns a risk score (see below) to each of the four VSP criteria. Use of the risk matrix makes it easier to compare risk factors within and across ESUs. The scores are tallied and reviewed by the BRT before making its overall risk assessment (see FEMAT method, below). Although this process helps to integrate and quantify a large amount of diverse information, there is not a simple way to translate the risk matrix scores directly into an assessment of overall risk. For example, simply averaging the values of the various risk factors would not be appropriate; an ESU at high risk for low abundance would be at high risk even if there were no concerns for any other risk factor.

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

1) *Very Low Risk.* Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.

2) *Low Risk.* Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may, in combination with other factors.

3) *Moderate Risk.* This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

4) *Increasing Risk.* Present risk is Low or Moderate, but is likely to increase to high risk in the foreseeable future if present conditions continue.

5) *High Risk.* This factor by itself indicates danger of extinction in the near future.

Recent Events. The "Recent Events" category considers events that have predictable consequences for ESU status in the future but have occurred too recently to be reflected in the population data. Examples include a flood that decimated most eggs or juveniles in a recent broodyear, or large jack returns that generally anticipate strong adult returns in subsequent year(s). This category is scored as follows: "++" - expect a strong improvement in status of the ESU; "+" - expect some improvement in status; "0" - neutral effect on status; "-" - expect some decline in status; "--" - expect strong decline in status.

Overall risk assessment

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

To allow for uncertainty in judging the actual risk facing an ESU, the BRTs have adopted a "likelihood point" method. This method, also referred to as the FEMAT method because it was used by scientific teams evaluating options under President Clinton's Forest Plan (Forest Ecosystem Management: An Ecological, Economic, and Social Assessment Report of the Forest Ecosystem Management Assessment Team (FEMAT; http://www.or.blm.gov/ForestPlan/NWFPTitl.htm), allows each reviewer to distribute 10 likelihood points among the three ESU risk categories, reflecting their opinion of the likelihood that that category correctly reflects the true ESU status. Thus, if a reviewer were certain that the ESU was in the "not at risk" category; then s/he could assign all 10 points to that category. A reviewer with less certainty about ESU status could split the points among two or even three categories. The FEMAT method has been used in all status review updates for anadromous Pacific salmonids since 1999.

METHODS

Data on adult returns were obtained from a variety of sources, including time series of freshwater spawner surveys, redd counts, and counts of adults migrating past dams/weirs. Time series were assembled at the scale of population where these have been identified by TRTs or quasi-population where population identification is ongoing.

Calculating recruits

Recruits from a give brood year are calculated as

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

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

$$C(preHarvest)_t = \sum_{i=1}^{MaxAge} P_{t+i} A(i)_{t+i} \, , \qquad \text{(Eq. 2)}$$

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

Mean abundance

Recent average abundance of natural-origin spawners is reported as the geometric mean of the most recent data. Five-year geometric means were calculated to represent the recent abundance of natural-origin spawners for each population or quasi-population within an ESU. Five-year geometric means for the most recent 5 years of available data were calculated, as well as the minimum and maximum 5-year geometric means for the entire time series. The equation for a 5-year geometric mean is

$$GM_{N_t} = \sqrt[5]{N_t N_{t-1} N_{t-2} N_{t-3} N_{t-4}}\,, \qquad \text{(Eq. 3)}$$

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

Zero values in the data set were replaced with a value of one, and missing data values within a 5-year range were excluded from geometric mean calculations. For example, if data were available from 1997–2001, with no data for 1998, the geometric mean was calculated as

$$GM_{N_{1997}} = \sqrt[4]{N_{1997} N_{1999} N_{2000} N_{2001}}\,. \qquad \text{(Eq. 4)}$$

Trends in abundance

Short-term and long-term trends were calculated from time series of adult spawners. Short-term was defined as that resulting from data from 1990 to the most recent year of data, with a minimum of 10 data points in the 13-year span. Long-term trend was defined as that resulting from all data in a time series.

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

$$\ln(N+1) = \beta_0 + \beta_1 X + \varepsilon\,, \qquad \text{(Eq. 5)}$$

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

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

$$\exp(\ln(b_1) - t_{0.05(2),df}\, s_{b_1}) \le \beta_1 \le \exp(\ln(b_1) + t_{0.05(2),df}\, s_{b_1})\,, \qquad \text{(Eq. 6)}$$

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

Lambda calculations

The median growth rate (λ) of natural-origin spawners was calculated in two ways for each population over both short-term and long-term time frames as above (short-term = 1990-most recent year and long-term = all data). The first (λ) assumed that hatchery-origin spawners had zero reproductive success, while the second (λ_h) assumed that hatchery-origin spawners had reproductive success equivalent to that of natural-origin spawners. These extreme assumptions bracket the range likely to occur in nature. Empirical studies indicate that hatchery-origin spawning fish generally have lower (and perhaps much lower) reproductive success than natural-origin spawners. However, this parameter can vary considerably across species and populations, and it is very rare that data are available for a particular population of interest.

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

$$R_t = \sum_{i=1}^{4} N_{t-i+1} \; , \qquad \text{(Eq. 7)}$$

where N_t is the number of natural-origin spawners in year t.

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

$$\hat{\mu} = mean\left(\ln\left(\frac{R_{t+1}}{R_t} \right) \right) \qquad \text{(Eq. 8)}$$

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

$$\hat{\lambda} = e^{\hat{\mu}} \; . \qquad \text{(Eq. 9)}$$

Confidence intervals (95%) were calculated for $\hat{\lambda}$ to provide a measure of the uncertainty associated with the growth rate point estimate. First, an estimate of variability was determined by calculating an estimate for σ^2 using the slope method (Holmes 2001). An estimate for σ^2, $\hat{\sigma}^2_{slp}$ was calculated for each population in an ESU, after which an arithmetic average of populations was calculated. This average was used as the measurement of variability for calculating confidence intervals for both short-term and long-term time series for all populations in an ESU.

We determined the degrees of freedom for the appropriate t-value for use in confidence interval calculations based on the method for adjusting degrees of freedom when variance is calculated using the slope method (Holmes and Fagan 2002). The adjusted degrees of freedom were then summed over all populations in an ESU to obtain the df to determine t. The degrees of freedom for each population was calculated as

$$df = 0.333 + 0.212n - L, \qquad \text{(Eq. 10)}$$

where n is the length of the time series and L is the number of counts summed to calculate R_t ($L = 4$ in these analyses). Confidence intervals were calculated as

$$\exp\left(\hat{\mu} \pm t_{.05(2),df}\sqrt{\hat{\sigma}_{slp}{}^{2} / \gamma(n-4)}\right), \qquad \text{(Eq. 11)}$$

where $\gamma \cong 1$. In addition, the probability that trend was less than one was calculated utilizing the fact that $\ln(\lambda)$ follows a t-distribution. The probability that λ is less than one is calculated by finding the probability that the natural log of the calculated lambda divided by its standard error is less than one, given the degrees of freedom, which is the number of data points used to calculate lambda minus two.

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

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

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

$$(RH)_t = \sum_{i=1}^{4} H_{t-i+1}\,, \qquad \text{(Eq. 13)}$$

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

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

$$\psi_t = \frac{(RN)_t + (RH)_t}{(RN)_t}. \qquad \text{(Eq. 14)}$$

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

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

$$A_j = \sum_{j=1}^{\max age} \sum_{all\, t} a_j (N+H)_t . \qquad \text{(Eq. 15)}$$

2. Calculate the total number of spawners (*G*)

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

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

$$T = \sum_{j=1}^{\max age} \frac{j \times A_j}{G} . \qquad \text{(Eq. 17)}$$

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

$$\hat{\mu} = mean\left(\ln\left(\frac{(RN)_{t+1}}{(RN)_t} \right) - \frac{1}{T} \ln(\psi_t) \right). \qquad \text{(Eq. 18)}$$

The point estimate for λ_h was then calculated as the median annual population growth rate,

$$\hat{\lambda}_h = e^{\hat{\mu}} . \qquad \text{(Eq. 19)}$$

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

$$\hat{\sigma}^2 = \text{slope of var}\left(\ln\left(\frac{(RN)_{t+\tau}}{(RN)_t} \right) - \frac{1}{T} \ln\left(\prod_{i=0}^{\tau-1} \psi_{t+i} \right) \right) \text{vs. } \tau. \qquad \text{(Eq. 20)}$$

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Appendix 1. A template for the risk matrix used in BRT deliberations. The matrix is divided into five sections: corresponding to the four VSP "parameters" (McElhany et al. 2000) plus a "recent events" category.

[ESU Template]

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

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

B. STEELHEAD

B.1. BACKGROUND AND HISTORY OF LISTINGS

Background

Steelhead is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss*. The present distribution of steelhead extends from Kamchatka in Asia, east to Alaska, and down to southern California (NMFS 1999), although the historic range of *O. mykiss* extended at least to the Mexico border (Busby et al. 1996). *O. mykiss* exhibit perhaps the most complex suite of life history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident (and under some circumstances, apparently yield offspring of the opposite form). Those that are anadromous can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. The half-pounder life-history type in Southern Oregon and Northern California spends only 2 to 4 months in salt water after smoltification, then returns to fresh water and outmigrates to sea again the following spring without spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus* except *O. clarki* spawn once and then die (semelparous). The anadromous form is under the jurisdiction of the National Marine Fisheries Service (NMFS), while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of U. S. Fish and Wildlife Service (FWS).

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these *runs* are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer, or fall steelhead. For example, large rivers, such as the Columbia, Rogue, and Klamath rivers, have migrating adult steelhead at all times of the year. There are local variations in the names used to identify the seasonal runs of steelhead; in Northern California, some biologists have retained the use of the terms spring and fall steelhead to describe what others would call summer steelhead.

Steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry, and duration of spawning migration (Burgner et al. 1992). The *stream-maturing* type (summer steelhead in the Pacific Northwest and Northern California) enters fresh water in a sexually immature condition between May and October and requires several months to mature and spawn. The *ocean-maturing* type (winter steelhead in the Pacific Northwest and Northern California) enters fresh water between November and April with well-developed gonads and spawns shortly thereafter. In basins with both summer and winter steelhead runs, it appears that the summer run occurs where habitat is not fully utilized by the winter run or a seasonal hydrologic barrier, such as a waterfall, separates them. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966, Roelofs 1983, Behnke 1992). Coastal streams are dominated by winter steelhead, whereas inland steelhead of the Columbia River Basin are almost exclusively summer steelhead. Winter steelhead may have been excluded from inland areas of the Columbia River Basin by Celilo Falls or by the considerable migration distance from the ocean. The Sacramento-San Joaquin River Basin may have historically had multiple runs of steelhead that probably included both ocean-maturing and stream-maturing stocks (CDFG 1995, McEwan and Jackson 1996). These steelhead are referred to as winter steelhead by the California Department of Fish and Game (CDFG); however, some biologists call them fall steelhead (Cramer et. al 1995). It is thought that hatchery practices and modifications in the hydrology of the basin caused by large-scale water diversions may have altered the migration timing of steelhead in this basin (D. McEwan, pers. commun.).

Inland steelhead of the Columbia River Basin, especially the Snake River Subbasin, are commonly referred to as either *A-run* or *B-run*. These designations are based on a bimodal migration of adult steelhead at Bonneville Dam (235 km from the mouth of the Columbia River) and differences in age (1- versus 2-ocean) and adult size observed among Snake River steelhead. It is unclear, however, if the life history and body size differences observed upstream are correlated back to the groups forming the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas throughout the Snake River Basin is not well understood. A-run steelhead are believed to occur throughout the steelhead-bearing streams of the Snake River Basin and the inland Columbia River; B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon Rivers (IDFG 1994).

The *half-pounder* is an immature steelhead that returns to fresh water after only 2 to 4 months in the ocean, generally overwinters in fresh water, and then outmigrates again the following spring. Half-pounders are generally less than 400 mm and are reported only from the Rogue, Klamath, Mad, and Eel Rivers of Southern Oregon and Northern California (Snyder 1925, Kesner and Barnhart 1972, Everest 1973, Barnhart 1986); however, it has been suggested that as mature steelhead, these fish may only spawn in the Rogue and Klamath River Basins (Cramer et al. 1995). Various explanations for this unusual life history have been proposed, but there is still no consensus as to what, if any, advantage it affords to the steelhead of these rivers.

As mentioned earlier, *O. mykiss* exhibits varying degrees of anadromy. Non-anadromous forms are usually called rainbow trout; however, nonanadromous *O. mykiss* of the inland type are often called Columbia River redband trout. Another form occurs in the upper Sacramento River and is called Sacramento redband trout. Although the anadromous and nonanadromous forms have long been taxonomically classified within the same species, the exact relationship between the forms in any given area is not well understood. In coastal populations, it is unusual for the two forms to co-occur; they are usually separated by a migration barrier, be it natural or manmade. In inland populations, co-occurrence of the two forms appears to be more frequent. Where the two forms co-occur, "it is possible that offspring of resident fish may migrate to the sea, and offspring of steelhead may remain in streams as resident fish" (Burgner et al. 1992, p. 6; see also Shapovalov and Taft 1954, p. 18). Mullan et al. (1992) found evidence that in very cold streams, juvenile steelhead had difficulty attaining mean threshold size for smoltification and concluded that most fish in the Methow River in Washington that did not emigrate downstream early in life were thermally-fated to a resident life history regardless of whether they were the progeny of anadromous or resident parents. Additionally, Shapovalov and Taft (1954) reported evidence of *O. mykiss* maturing in fresh water and spawning prior to their first ocean migration; this life-history variation has also been found in cutthroat trout (*O. clarki*) and some male chinook salmon (*O. tshawytscha*).

In May 1992, NMFS was petitioned by the Oregon Natural Resources Council (ONRC) and 10 co-petitioners to list Oregon's Illinois River winter steelhead (ONRC et al. 1992). NMFS concluded that Illinois River winter steelhead by themselves did not constitute an ESA "species" (Busby et al. 1993, NMFS 1993a). In February 1994, NMFS received a petition seeking protection under the Endangered Species Act (ESA) for 178 populations of steelhead (anadromous *O. mykiss*) in Washington, Idaho, Oregon, and California. At the time, NMFS was conducting a status review of coastal steelhead populations (*O. m. irideus*) in Washington, Oregon, and California. In response to the broader petition, NMFS expanded the ongoing status review to include inland steelhead (*O. m. gairdneri*) occurring east of the Cascade Mountains in Washington, Idaho, and Oregon.

In 1995, the steelhead Biological Review Team (BRT) met to review the biology and ecology of West Coast steelhead. After considering available information on steelhead genetics, phylogeny, and life history, freshwater ichthyogeography, and environmental features that may affect steelhead, the BRT identified 15 ESUs—12 coastal forms and three inland forms. After considering available information on population abundance and other risk factors, the BRT concluded that five steelhead ESUs (Central California Coast, South-Central California Coast, Southern California, Central Valley, and Upper Columbia River) were presently in danger of extinction, five steelhead ESUs (Lower Columbia River, Oregon Coast, Klamath Mountains Province, Northern California, and Snake River Basin) were likely to become endangered in the foreseeable future, four steelhead ESUs (Puget Sound, Olympic Peninsula, Southwest Washington, and Upper Willamette River) were not presently in significant danger of becoming extinct or endangered, although individual stocks within these ESUs may be at risk, and one steelhead ESU (Middle Columbia River) was not presently in danger of extinction but the BRT was unable to reach a conclusion as to its risk of becoming endangered in the foreseeable future.

Of the 15 steelhead ESUs identified by NMFS, five are not listed under the ESA: Southwest Washington, Olympic Peninsula, and Puget Sound (Federal Register, Vol. 61, No. 155, August 9, 1996, p. 41558), Oregon Coast (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), and Klamath Mountain Province (Federal Register, Vol. 66, No. 65, April 4, 2001, p. 17845); eight are listed as threatened: Snake River Basin, Central California Coast and South-Central California Coast (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937), Lower Columbia River, California Central Valley (Federal Register, Vol. 63, No. 53, March 19, 1998, p. 13347), Upper Willamette River, Middle Columbia River (Federal Register, Vol. 64, No. 57, March 25, 1999, p. 14517), and Northern California (Federal Register, Vol. 65, No. 110, June 7, 2000, p.36074), and two are listed as endangered: Upper Columbia River and Southern California (Federal Register, Vol. 62, No. 159, August 18, 1997, p. 43937).

The West Coast steelhead BRT[1] met in January 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original

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[1] The biological review team (BRT) for the updated status review for West Coast steelhead included, from the NMFS Northwest Fisheries Science Center: Thomas Cooney, Dr. Robert Iwamoto, Gene Matthews, Dr. Paul McElhany, Dr. James Myers, Dr. Mary Ruckelshaus, Dr. Thomas Wainwright, Dr. Robin Waples, and Dr. John Williams; from NMFS Southwest Fisheries Science Center: Dr. Peter Adams, Dr. Eric Bjorkstedt, Dr. David Boughton, Dr. John Carlos Garza, Dr. Steve Lindley, and Dr. Brian Spence; from the U.S. Fish and Wildlife Service, Abernathy, WA: Dr. Donald Campton; and from the USGS Biological Resources Division, Seattle: Dr. Reginald Reisenbichler.

BRTs. This report summarizes new information and the preliminary BRT conclusions on the following ESUs: Snake River Basin, Upper Columbia River, Middle Columbia River, Lower Columbia River, Upper Willamette River, Northern California, Central California Coast, South-Central California Coast, Southern California, and California Central Valley.

Resident fish

As part of this status review update process, a concerted effort was made to collect biological information for resident populations of *O. mykiss.* Information from listed ESUs in Washington, Oregon, and Idaho is contained in a draft report by Kostow (2003), and the sections below summarize relevant information from that report for specific ESUs. A table (Appendix B.5.1) summarizes information about resident *O. mykiss* populations in California.

The BRT had to consider in more general terms how to conduct an overall risk assessment for an ESU that includes both resident and anadromous populations, particularly when the resident individuals may outnumber the anadromous ones but their biological relationship was unclear or unknown. Some guidance is found in Waples (1991), which outlines the scientific basis for the NMFS ESU policy. That paper suggested that an ESU that contains both forms could be listed based on a threat to only one of the life history traits "if the trait were genetically based and loss of the trait would compromise the 'distinctiveness' of the population" (p. 16). That is, if anadromy were considered important in defining the distinctiveness of the ESU, loss of that trait would be a serious ESA concern. In discussing this issue, the NMFS ESU policy (FR notice citation) affirmed the importance of considering the genetic basis of life history traits such as anadromy, and recognized the relevance of a question posed by one commenter: "What is the likelihood of the nonanadromous form giving rise to the anadromous form after the latter has gone locally extinct?".

The BRT also discussed another important consideration, which is the role anadromous populations play in providing connectivity and linkages among different spawning populations within an ESU. An ESU in which all anadromous populations had been lost and the remaining resident populations were fragmented and isolated would have a very different future evolutionary trajectory than one in which all populations remained linked genetically and ecologically by anadromous forms.

In spite of concerted efforts to collect and synthesize available information on resident forms of *O. mykiss*, existing data are very sparse, particularly regarding interactions between resident and anadromous forms (Kostow 2003). The BRT was frustrated by the difficulties of considering complex questions involving the relationship between resident and anadromous forms, given this paucity of key information. To help focus this issue, the BRT considered a hypothetical scenario that has varying degrees of relevance to individual steelhead ESUs. In this scenario, the once-abundant and widespread anadromous life history is extinct or nearly so, but relatively healthy native populations of resident fish remain in many geographic areas. The question considered by the BRT was the following: Under what circumstances would you conclude that such an ESU was not in danger of extinction or likely to become endangered? The BRT identified the required conditions as:

1) The resident forms are capable of maintaining connectivity among populations to the extent that historic evolutionary processes of the ESU are not seriously disrupted;
2) The anadromous life history is not permanently lost from the ESU but can be regenerated from the resident forms.

Regarding the first criterion, although some resident forms of salmonids are known to migrate considerable distances in freshwater, extensive river migrations have not been demonstrated to be an important behavior for resident *O. mykiss*, except in rather specialized circumstances (e.g., forms that migrate from a stream to a large lake or reservoir as a surrogate for the ocean). Therefore, the BRT felt that loss of the anadromous form would, in most cases, substantially change the character and future evolutionary potential of steelhead ESUs. Regarding the second criterion, it is well established that resident forms of *O. mykiss* can occasionally produce anadromous migrants, and vice versa (Mullan et al. 1992, Zimmerman and Reeves 2000, Kostow 2003), just as has been shown for other salmonid species (e. g., *O. nerka,* Foerster 1947, Fulton and Pearson 1981, Kaeriyama et al. 1992; coastal cutthroat trout *O. clarki clarki,* Griswold 1996, Johnson et al. 1999; brown trout *Salmo trutta,* Jonsson 1985; and Arctic char *Salvelinus alpinus*, Nordeng 1983). However, available information indicates that the incidence of these occurrences is relatively rare, and there is even less empirical evidence that, once lost, a self-sustaining anadromous run can be regenerated from a resident salmonid population. Although this must have occurred during the evolutionary history of *O. mykiss,* the BRT found no reason to believe that such an event would occur with any frequency or within a specified time period. This would be particularly true if the conditions that promote and support the anadromous life history continue to deteriorate. In this case, the expectation would be that natural selection would gradually eliminate the migratory or anadromous trait from the population, as individuals inheriting a tendency for anadromy migrate out of the population but do not survive to return as adults and pass on their genes to subsequent generations.

Given the above considerations, the BRT focused primarily on information for anadromous populations in the risk assessments for steelhead ESUs. However, as discussed below in the "BRT Conclusions" section, the presence of relatively numerous, native resident fish was considered to be a mitigating risk factor for some ESUs.

B.2.6 NORTHERN CALIFORNIA STEELHEAD ESU

B.2.6.1 Previous BRT Conclusions

The Northern California ESU includes coastal basins from Redwood Creek (Humboldt County) southward to the Gualala River (Mendocino County), inclusive (Busby et al. 1996). Within this ESU, both summer run[2], winter run, and half-pounders[3] are found. Summer steelhead are found in the Mad, Eel, and Redwood rivers; the Middle Fork Eel River population is their southern-most occurrence. Half-pounders are found in the Mad and Eel rivers. Busby et al. (1996) argued that when summer and winter steelhead co-occur within a basin, they were more similar to each other than either is to the corresponding run-type in other basins. Thus Busby et al. (1996) considered summer and winter steelhead to jointly comprise a single ESU.

Summary of major risks and status indicators

Risks and limiting factors—The previous status review (Busby et al. 1996) identified two major barriers to fish passage: Mathews Dam on the Mad River and Scott Dam on the Eel River. Numerous other blockages on tributaries were also thought to occur. Poor forest practices and poor land use practices, combined with catastrophic flooding in 1964, were thought to have caused significant declines in habitat quality that then persisted up to the date of the status review. These effects include sedimentation and loss of spawning gravels. Non-native Sacramento pikeminnow (*Ptychocheilus grandis*) had been observed in the Eel River Basin and could potentially be acting as predators on juvenile steelhead.

Status indicators—Historical estimates (pre-1960s) of steelhead in this ESU are few (Table B.2.6.1). The only time-series data are dam counts of winter steelhead in the upper Eel River (Cape Horn Dam, 1933-present), winter steelhead in the Mad River (Sweasey Dam, 1938-1963), and combined counts of summer and winter steelhead in the South Fork Eel River (Benbow Dam, 1938-75; see Figure B.2.6.1A). More recent data are snorkel counts of summer steelhead that were made in the middle fork of the Eel since 1966 (with some gaps in the time-series) (Scott Harris and Wendy Jones, CDFG, personal communication). Some "point" estimates of mean abundance exist—in 1963, the California Department of Fish and Game made estimates of steelhead abundance for many rivers in the ESU (Table B.2.6.2). An attempt was made to estimate a mean count over the interval 1959 to 1963, but in most cases 5 years of data were not available and estimates were based on fewer years (CDFG 1965); the authors state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource" (CDFG 1965).

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[2] Some consider summer-run steelhead and fall-run steelhead to be separate runs within a river while others do not consider these groups to be different. For purposes of this review, summer run and fall run are considered stream-maturing steelhead and will be referred to as summer steelhead (see McEwan 2001 for additional details).

[3] A half pounder is a sexually immature steelhead, usually small, that returns to freshwater after spending less than a year in the ocean (Kesner and Barnhart 1972, Everest 1973).

Table B.2.6.1. Summary of historical abundance (average counts) for steelhead in the Northern California evolutionarily significant unit (see also Figure 1).

		Average count						
Basin	Site	1930s	1940s	1950s	1960s	1970s	1980s	Reference
Eel River	Cape Horn Dam	4,390	4,320	3,597	917	721	1,287	Grass 1995
Eel River	Benbow Dam	13,736	18,285	12,802	6,676	3,355	-	
Mad River	Sweasey Dam	3,167	4,720	2,894	1,985	-	-	

Although the data were relatively few, the data that did exist suggested the following to the BRT: 1) Population abundances were low relative to historical estimates (1930s dam counts; see Table B.2.6.1 and Figure B.2.6.1). 2) Recent trends were downward (except for a few small summer stocks; see Figures B.2.6.1 and B.2.6.2). 3) Summer steelhead abundance was "very low." The BRT was also concerned about negative influences of hatchery stocks, especially in the Mad River (Busby et al. 1996). Finally, the BRT noted that the status review included two major sources of uncertainty: lack of data on run sizes throughout the ESU, and uncertainty about the genetic heritage of winter steelhead in Mad River.

Listing status

Status was formally assessed in 1996 (Busby et al. 1996), updated in 1997 (Schiewe 1997) and updated again in 2000 (Adams 2000). Although other steelhead ESUs were listed as threatened or endangered in August 1997, the National Marine Fisheries Service (NMFS) allowed steelhead in the Northern California ESU to remain a candidate species pending an evaluation of state and federal conservation measures. There is a "North Coast Steelhead Memorandum of Agreement" (MOA) with the State of California, which lists a number of proposed actions, including a change in harvest regulations, a review of California hatchery practices, implementation of habitat restoration activities, implementation of a comprehensive monitoring program, and numerous revisions to rules on forest-practices. These revisions would be expected to improve forest condition on non-federal lands. In March 1998 the NMFS announced its intention to reconsider the previous no-listing decision. On 6 October 1999 the California Board of Forestry failed to take action on the forest practice rules, and the NMFS Southwest Region (SWR) regarded this failure as a breach of the MOA. The Northern California ESU was listed as threatened in June 2000.

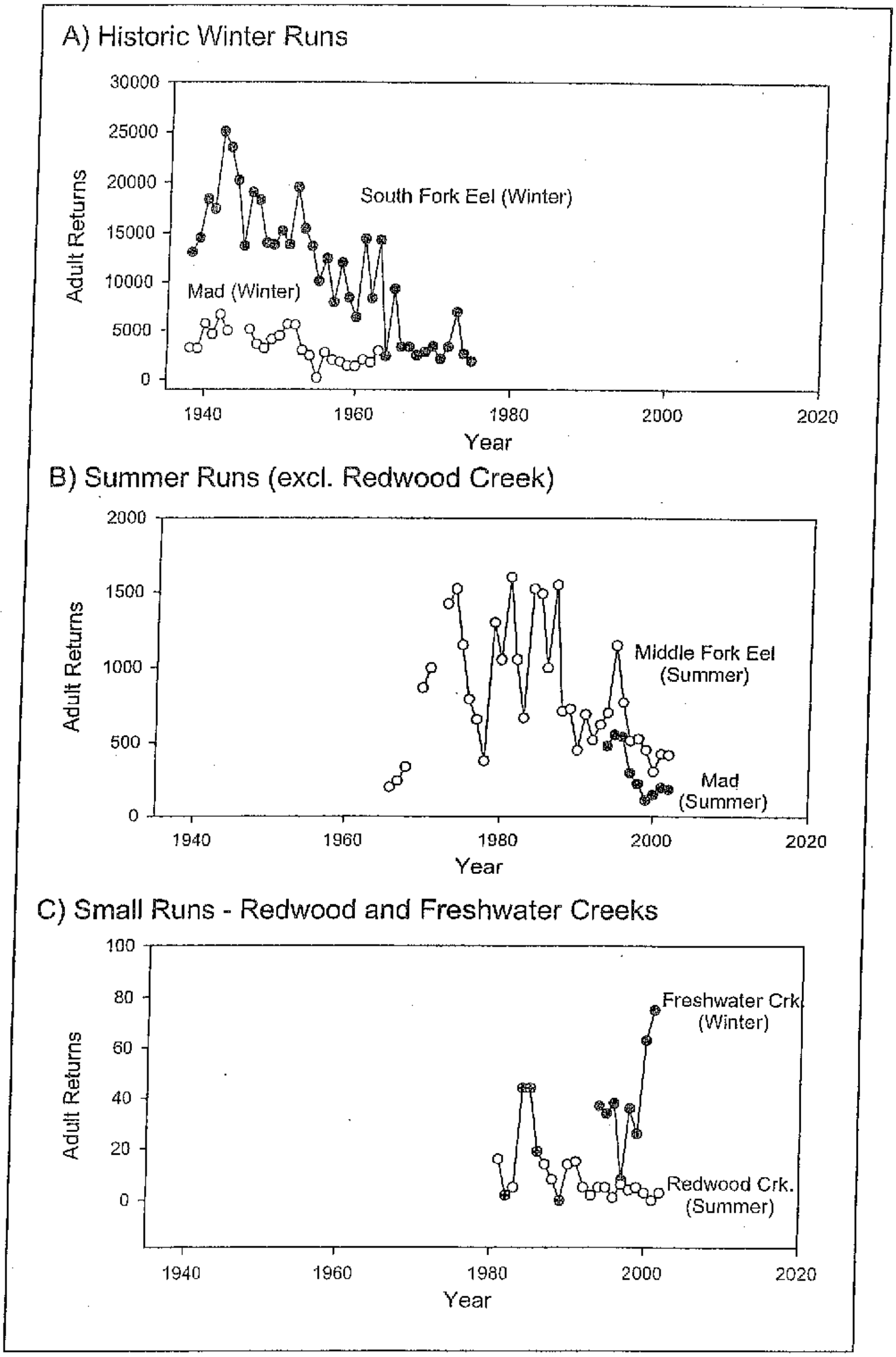

Figure B.2.6.1. Time-series data for the North-Central California Steelhead ESU. A) Historic data from winter runs on the Mad River and South Fork Eel. B) Summer runs on the Middle Fork Eel and Mad River. C) Summer steelhead in Redwood Creek, and winter steelhead in Freshwater Creek, Humboldt County. Symbols with crosses represent minimum estimates. Note the three different scales of the *y*-axis.

Table B.2.6.2. Historical estimates of number of spawning steelhead for California rivers in the Northern California ESU and Central California Coast ESU (data from CDFG 1965). Estimates are considered by CDFG (1965) to be notably uncertain.

ESU	Stream	1963
Northern California		
	Redwood Creek	10,000
	Mad River	6,000
	Eel River (total)	82,000
	Eel River	(10,000)
	Van Duzen River (Eel)	(10,000)
	South Fork Eel River	(34,000)
	North Fork Eel River	(5,000)
	Middle Fork Eel River	(23,000)
	Mattole River	12,000
	Ten Mile River	9,000
	Novo River	8,000
	Big River	12,000
	Navarro River	16,000
	Garcia River	4,000
	Gualala River	16,000
	other Humboldt County stream	3,000
	other Mendocino County streams	20,000
	Total	198,000
Central California Coast		
	Russian River	50,000
	San Lorenzo River	19,000
	other Sonoma County streams	4,000
	other Marin County steams	8,000
	other San Mateo County streams	8,000
	other Santa Cruz County streams	5,000
	Total	94,000

B.2.6.2 New Data

There are three significant sets of new information: (1) updated time-series data exist for the middle fork of the Eel River (summer steelhead; snorkel counts. See Figure B.2.6.1B). (2) There are new data-collection efforts initiated in 1994 in the Mad River (summer steelhead; snorkel counts. Figure B.2.6.1B) and in Freshwater Creek (winter steelhead; weir counts; Freshwater Creek is a small stream emptying into Humboldt Bay. See Figure B.2.6.1C). (3) Numerous reach-scale estimates of juvenile abundance have been made extensively throughout the ESU. Analyses of these data are described below.

B.2.6.3 New and Updated Analyses

Updated Eel River data

The time-series data for the Middle Fork of the Eel River are snorkel counts of summer steelhead, made for fish in the holding pools of the entire mainstem of the middle fork (Scott Harris and Wendy Jones, CDFG, pers. commun.). Most adults in the system are thought to oversummer in these holding pools. An estimate of λ over the interval 1966 to 2002 was made using the method of Lindley (in press; random-walk-with-drift model fitted using Bayesian assumptions). The estimate of λ is 0.98, with a 95% confidence interval of [0.93, 1.04] (see Table B.2.6.3)[4]. The overall trend in the data is downward in both the long- and the short-term (Figure B.2.6.1B).

New time-series

The Mad River time-series consists of snorkel counts for much of the mainstem below Ruth Dam. Some counts include the entire mainstem; other years include only data from land owned by Simpson Timber Company. In the years with data from the entire mainstem, fish from Simpson Timber land make up at least 90% of the total count.. The time-series from Freshwater Creek is composed of weir counts. Estimates of λ were not made for either time-series because there were too few years of data.

Vital statistics for these and other existing time-series are given in Table B.2.6.3; trend versus abundance is plotted in Figure B.2.6.2.

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[4] Note that Lindley (in press) defines $\lambda \approx \exp(\mu + \sigma^2/2)$, whereas Holmes (2001) defines $\lambda \approx \exp(\mu)$; see the Lindley (in press) for meaning of the symbols.

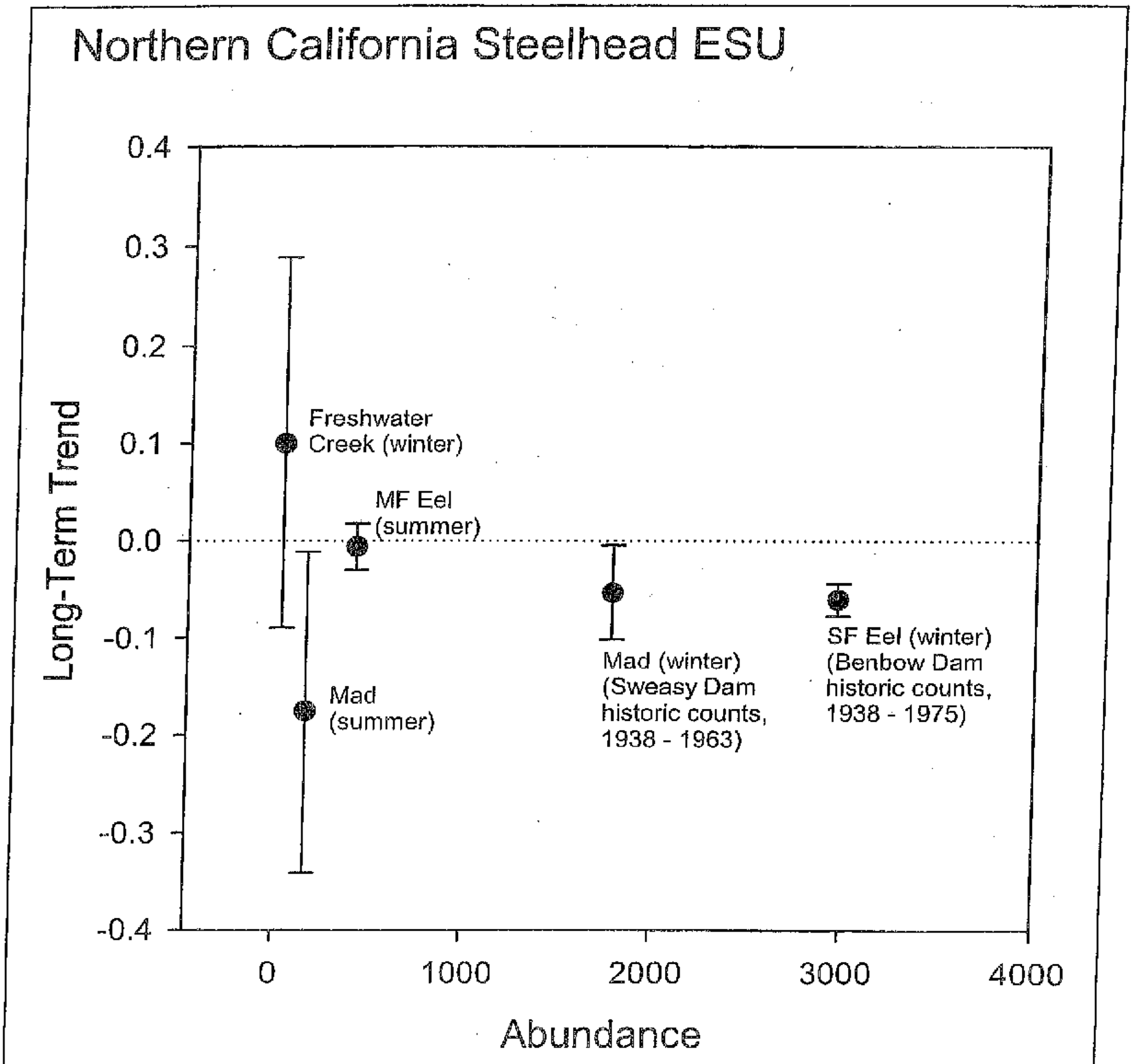

Figure B.2.6.2. Trends versus abundance for the time-series data from Figure 1. Note that neither set of dam counts (Sweasy Dam, Benbow Dam) has any recent data. Vertical bars are 95% confidence intervals.

Table B.2.6.3. Summary of time-series data for listed steelhead ESUs on the California Coast.

Population	Span of time series	5-Year Means[5]			Lambda[6]	Long-term trend (95% conf. int.)	Short-term trend (95% conf. int.)
		Rec.	Min.	Max.			
Northern California ESU (threatened)							
M.Fk. Eel Riv. (summer)	'66-'02	418	384	1,246	0.98 (0.93, 1.04)	-0.00599 (-0.0293, 0.0173)	-0.0668 (-0.158, 0.0243)
Mad River (summer)	'94-'02	162	162	384	Insufficient data	-0.176 (-0.341, -0.0121)	-0.176 (-0.341, -0.121)
Freshwater Crk. (winter)	'94-'01	32	25	32	Insufficient data	0.0999 (-0.289, 0.489)	0.0999 (-0.289, 0.489)
Redwood Crk. (summer)	'81-'02	3	See Fig. 1C[7]		Insufficient data	See Fig. 1C	-0.775 (-1.276, -0.273)
S.Fk. Eel Riv. (winter)[8]	'38-'75	2,971	2,743	20,657	0.98 (0.92, 1.02)	-0.0601 (-0.077, -0.0432)	No recent data
Mad Riv. (winter)[9]	'38-'63	1,786	1,140	5,438	1.00 (0.93, 1.05)	-0.0534 (-0.102, -0.00504)	No recent data
Central California ESU (threatened)							
No data							
South-Central California ESU (threatened)							
Carmel River (winter)[10]	'62-'02	611	1.13	881	Inappropriate data[11]	See Fig. B.2.6.5	See Fig. 5
Southern California ESU (endangered)							
Santa Clara R. (winter)[12]	'94-'97	1.0			Insufficient data		

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[5] Geometric means. The value 0.5 was used for years in which the count was zero.
[6] Lambda calculated using the method of Lindley (In press). Note that a population with lambda greater than 1.0 can nevertheless be declining, due to environmental stochasticity.
[7] Certain years have minimum run sizes, rather than unbiased estimates of run size, rendering the time series unsuitable for some of the estimators.
[8] Historic counts made at Benbow Dam.
[9] Historic counts made at Sweasy Dam.
[10] There is a gap in the time series for 1978 – 87.
[11] Recent restoration work in the Carmel River involves substantial transplanting of juveniles from below to above the dam at which counts were made.
[12] Recent abundance is a 4-year mean.

Juvenile data

The juvenile data were collected at numerous sites using a variety of methods. Many of the methods involve the selection of reaches thought to be "typical" or "representative" steelhead habitat; other reaches were selected because they were thought to be typical coho habitat, and steelhead counts were made incidentally to coho counts. In general, the field crew made electro-fishing counts (usually multiple-pass, depletion estimates) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

We analyze these juvenile data below. However, we note that they have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems; non-random sampling of populations within the ESU; and a general lack of estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.6.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

We calculated trends from the juvenile data. To estimate a trend, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum length of the time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The recent origin of some relevant time-series and the fact that some of the shorter time-series include information for different age-classes prompted us to consider these slightly smaller datasets.

This procedure resulted in 10 independent populations for which a trend was estimated. Both upward and downward trends were observed (Figure B.2.6.3). We tested the null hypothesis that abundances were stable or increasing. It was not rejected (H_o: slope ≥ 0; $p < 0.32$ via one-tailed *t*-test against expected value). However, it is important to note that a significance level of 0.32 implies a probability of 0.32 that the ESU is stable or increasing, and a probability of $1 - 0.32 = 0.68$ that the ESU is declining; thus the odds are more than 2:1 that the ESU has been declining during the past 6 years. This conclusion requires the assumption that the assessed populations 1) are indeed independent populations rather than plausibly independent populations, and 2) were randomly sampled from all populations in the ESU.

Table B.2.6.4. Interpretation of data on juvenile trends.

		Inference made about adult trends		
		Increasing	Level	Decreasing
Observed juvenile trends	Increasing	Possible, if no density-dependence in the smolt/oceanic phase. The most parsimonious inference.	Possible, if density-dependence occurs in the juvenile over-wintering phase, or in the smolt/oceanic phase.	Possible, if oceanic conditions are deteriorating markedly at the same time that reproductive success per female is improving.
	Level	Possible, if oceanic conditions are improving for adults, but juveniles undergo density-dependence.	Possible. The most parsimonious inference.	Possible, if oceanic conditions are deteriorating.
	Decreasing	Unlikely, but could happen over the short term due to scramble competition at the spawning/redd phases.	Possible, if river habitat is deteriorating, and there was strong, pre-existing density dependence in the oceanic phase.	Likely. The most parsimonious inference.

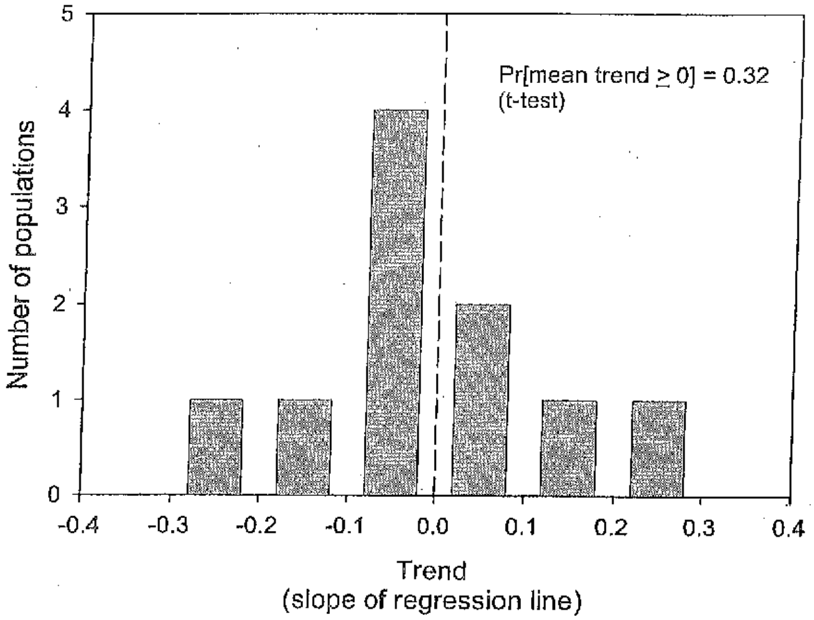

Figure B.2.6.3. Distribution of trends in juvenile density, for 10 "independent" populations within the North Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than zero indicate increase. Assuming that the populations were randomly drawn from the ESU as a whole, the hypothesis that the ESU is stable or increasing cannot be statistically rejected ($p = 0.32$), but is only half as likely as the hypothesis that the ESU is declining ($p = 1 - 0.32 = 0.68$).

Harvest impacts

Sport harvest of steelhead in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. commun.). Freshwater sport fishing probably constitutes a larger impact.

CDFG (2002b) describes the current freshwater sport fishing regulations for steelhead of the northern ESU. All streams are closed to fishing year round except for special listed streams as follows: Catch-and-release angling is allowed year round excluding April and May in the lower mainstem of many coastal streams. Most of these have a bag limit of one hatchery trout or steelhead during the winter months (Albion River, Alder Creek, Big River, Cottoneva Creek, Elk Creek, Elk River, Freshwater Creek, Garcia River, Greenwood Creek, Little River in Humboldt Co., Gualala River, Navarro River, Noyo River, Ten Mile River, and Usal Creek); in a few the ome-fish bag extends to the entire season (Bear River and Redwood Creek, both in Humboldt Co.). The Mattole River has a slightly more restricted catch-and-release season with zero bag limit year round.

The two largest systems are the Mad River and Eel River. The mainstem Mad River is open except for April and May over a very long stretch; bag limit is two hatchery trout or steelhead; other stretches have zero bag limit or are closed to fishing. Above Ruth Dam, an impassable barrier, the bag limit is five trout per day. The Eel River's mainstem and south fork are open to catch-and-release over large stretches, year round in some areas and closed April and May in others. The middle fork is open for catch and release except mid summer and late fall/winter. It is noteworthy that in the upper middle fork and many of its tributaries, there are summer fisheries with bag limits of two or five fish with no stipulated restriction on hatchery or wild. In the Van Duzen, a major tributary of the mainstem Eel, there is a summer fishery with bag limit five above Eaton Falls (CDFG 2002c).

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG (2000) states that "The only mortality expected from a no-harvest fishery is from hooking and handling injury or stress" (p. 16), and estimates this mortality rate to be about 0.25%-1.4%. This estimate is based on angler capture rates measured in other river systems throughout California (range: 5% - 28%) , multiplied by an estimated mortality rate of 5% once a fish is hooked. This estimate may be biased downward because it doesn't account for multiple catch/release events.

Some summer trout fishing is allowed, generally with a two- or five- bag limit. Cutthroat trout have a bag limit of two from a few coastal lagoons or esturaries.

B.2.6.4 New Hatchery/ESU Information

Current California hatchery steelhead stocks being considered in this ESU include the Mad River Hatchery, Yager Creek Hatchery, and the North Fork Gualala River Steelhead Project.

Mad River Hatchery (Mad River Steelhead [CDFG])

The Mad River Hatchery is located 20 km upriver near the town of Blue Lake (CDFG/NMFS 2001). The trap is located at the hatchery.

Broodstock Origin and History—The hatchery was opened in 1970 and steelhead were first released in 1971. The original steelhead releases were from adults taken at Benbow Dam on the South Fork Eel River. Between 1972 and 1974, broodstock at Mad River Hatchery were composed almost exclusively of South Fork Eel River steelhead. After 1974, returns to the hatchery supplied about 90% of the egg take; other eggs originated from Eel River steelhead. In addition, over 500 adult San Lorenzo River steelhead were spawned at Mad River Hatchery in 1972 and progeny of these fish may have been planted in the basin. All subsequent broodyears have come from trapping at the hatchery.

Broodstock size/natural population size—An average of 5,536 adults were trapped from 1991 to 2002 and an average of 178 females were spawned during the broodyears 1991-2002. There are no abundance estimates for the Mad River, but steelhead are widespread and abundance throughout the Basin.

Management—Starting in 1998, steelhead are 100% marked and fish are included in the broodstock in proportion to the numbers returned. The current production goals are 250,000 yearlings raised to 4-8/lb for release in March to May.

Population genetics—Alloyzme data group Mad River samples in with the Mad River Hatchery and then with the Eel River (Busby et al.1996).

Category—Category 3 hatchery. There have been no introductions since 1974, and naturally spawned fish are included in the broodstock. However, there is still an out-of-basin nature to the stock (SSHAG 2003; see Appendix B.5.2).

Yager Creek Hatchery (Yager Creek Steelhead [PalCo])

The Yager Creek trapping and rearing facility is located at the confluence of Yager and Cooper Mill creeks (tributaries of the Van Duzen River, which is a tributary of the Eel River).

Broodstock Origin and History—The project was initiated in 1976. Adult broodstock are taken from Yeager Creek and juveniles are released in the Van Duzen River Basin. As with all Cooperative hatcheries, the fish are all marked and hatchery fish are usually excluded from broodstock (unless wild fish are rare). There are no records of introductions to the broodstock.

Management—About 4,600 Freshwater Creek (a tributary of Humboldt Bay) juvenile steelhead were released in the Yager Creek Basin in 1993 (Busby et al. 1996). The current program goal is the restoration of Van Duzen River Steelhead.

Population genetics—There are no genetic data for this hatchery.

Category—Category 1 hatchery. The broodstock has had no out-of-basin introductions and hatchery fish are excluded from the broodstock (SSHAG 2003; see Appendix B.5.2).

North Fork Gualala River Hatchery (Gualala River Steelhead Project [CDFG/Gualala River Steelhead Project])

This project rears juvenile steelhead rescued from tributaries of the North Fork Gualala River. Rearing facilities are located on Doty Creek, a tributary of the Gualala River 12 miles from the mouth. Steelhead smolts resulting from this program are released in Doty Creek.

Broodstock Origin and History—The project was started in 1981 and has operated sporadically since then. Juvenile steelhead are rescued from the North Fork of the Gualala River and reared at Doty Creek.

Management—The current program goal is restoration of Gualala River steelhead.

Population genetics—There are no genetic data for this hatchery.
Category—Category 1 hatchery. Usually only naturally spawned juveniles are reared at this facility (SSHAG 2003; see Appendix B.5.2).

B.2.7 CENTRAL CALIFORNIA COAST STEELHEAD

B.2.7.1 Previous BRT Conclusions

The Central California Coast ESU inhabits coastal basins from the Russian River (Sonoma County), to Soquel Creek (Santa Cruz County) inclusive (Busby et al. 1996). Also included in this ESU are populations inhabiting tributaries of San Francisco and San Pablo bays. The ESU is composed only of winter-run fish.

Summary of major risks and status indicators

Risks and limiting factors—Two significant habitat blockages are the Coyote and Warm Springs Dams in the Russian River watershed; data indicated that other smaller fish passage problems were widespread in the geographic range of the ESU. Other impacts noted in the status report were: urbanization and poor land-use practices; catastrophic flooding in 1964 causing habitat degradation; and dewatering due to irrigation and diversion. Principal hatchery production in the region comes from the Warm Springs Hatchery on the Russian River, and the Monterey Bay Salmon and Trout Project on a tributary of Scott Creek. At the time of the status review there were other small private programs producing steelhead in the range of the ESU, reported by Bryant (1994) to be using stocks indigeneous to the ESU, but not necessarily to the particular basin in which the program was located. There was no information on the actual contribution of hatchery fish to naturally spawning populations.

Status indicators—One estimate of historical (pre-1960s) abundance was reported by Busby et al. (1996): Shapovalov and Taft (1954) described an average of about 500 adults in Waddell Creek (Santa Cruz County) for the 1930s and early 1940s. A bit more recently, Johnson (1964) estimated a run size of 20,000 steelhead in the San Lorenzo River before 1965, and CDFG (1965) estimated an average run size of 94,000 steelhead for the entire ESU, for the period 1959-1963 (see Table B.2.7.5 for a breakdown of numbers by basin). The analysis by CDFG (1965) was compromised by the fact that for many basins, the data did not exist for the full 5-year period. The authors of CDFG (1965) state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource."

Recent data for the Russian and San Lorenzo Rivers (CDFG 1994, Reavis 1991, Shuman 1994[13]; see Table B.2.7.5) suggested that these basins had populations smaller than 15% of the size that they had had 30 years previously. These two basins were thought to have originally contained the two largest steelhead populations in the ESU.

A status review update conducted in 1997 (Schiewe 1997) concluded that slight increases in abundance occurred in the 3 years following the status review, but the analyses on which these conclusions were based had various problems, including inability to distinguish hatchery and wild fish, unjustified expansion factors, variance in sampling efficiency on the San Lorenzo River. Presence/absence data compiled by P. Adams (SWFSC, personal communication)

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[13] The basis for the estimates provided by Shuman (1994) appears to be questionable.

Table B.2.7.5. Summary of estimated runs sizes for the Central Coast steelhead ESU, reproduced from Busby et al. (1996), Tables 19 & 20.

River basin	Estimate of Run Size	Year	Reference
Russian River	65,000	1970	CACSS (1988)
	1750 – 7000	1994	McEwan and Jackson (1996), CDFG (1994)
Lagunitas Creek	500		CDFG (1994)
	400 – 500	1990s	McEwan and Jackson (1996)
San Gregorio	1,000	1973	Coots (1973)
Waddell Creek	481	1933–1942	Shapovolov and Taft (1954)
	250	1982	Shuman (1994)[14]
	150	1994	Shuman (1994)[14]
Scott Creek	400	1991	Nelson (1994)
	<100	1991	Reavis (1991)
	300	1994	Titus et al. (MS)
San Vicente Creek	150	1982	Shuman (1994)[14]
	50	1994	Shuman (1994)[14]
San Lorenzo River	20,000	Pre-1965	Johnson (1964), SWRCB (1982)
	1,614	1977	CDFG (1982)
	>3,000	1978	Ricker and Butler (1979)
	600	1979	CDFG (1982)
	3,000	1982	Shuman (1994)[14]
	"few"	1991	Reavis (1991)
	<150	1994	Shuman (1994)[14]
Soquel Creek	500 – 800	1982	Shuman (1994)[14]
	<100	1991	Reavis (1991)
	50 – 100	1994	Shuman (1994)[14]
Aptos Creek	200	1982	Shuman (1994)[14]
	<100	1991	Reavis (1991)
	50 – 75	1994	Shuman (1994)[14]

[14] The basis for the estimates provided by Shuman (1994) appears to be questionable.

indicated that most (82%) of sampled streams (a subset of all historical steelhead streams) had extant populations of juvenile *O. mykiss*.

Previous BRT conclusions

The original BRT concluded that the ESU was in danger of extinction (Busby et al. 1996). Extirpation was considered especially likely in Santa Cruz County and in the tributaries of San Pablo and San Francisco Bays. The BRT suggested that abundance in the Russian River (the largest system inhabited by the ESU) has declined seven-fold since the mid-1960s, but abundance appeared to be stable in smaller systems. Two major sources of uncertainty were: 1) few data on run sizes, which necessitated that the listing be based on indirect evidence, such as habitat degradation; and 2) genetic heritage of populations in tributaries to San Francisco and San Pablo Bays was uncertain, causing the delineaton of the geographic boundaries of the ESU to be uncertain. A status review update (Schiewe 1997) concluded that conditions had improved slightly, and that the ESU was not presently in danger of extinction, but was likely to become so in the foreseeable future (Minorities supported both more and less extreme views on extinction risk.). Uncertainties in the update mainly revolved around inadequate sampling methods for estimating adult and juvenile numbers in various basins.

Listing status

The status of steelhead was formally assessed in 1996 (Busby et al. 1996). The original status review was updated in 1997 (Schiewe 1997), and the Central California Coast ESU was listed as threatened in August 1997.

B.2.7.2 New Updated Analyses

Juvenile data—The juvenile data were collected at numerous sites using a variety of methods. Many of the methods involved the selection of reaches thought to be "typical" or "representative" steelhead habitat; other reaches were selected because they were thought to be typical coho habitat, and steelhead counts were made incidentally to coho counts. In general, the field crew made electro-fishing counts (usually single-pass) of the young-of-the-year and 1+ age classes. Most of the target reaches got sampled several years in a row; thus there are a large number of short time-series. Although methods were always consistent within a time-series, they were not necessarily consistent across time-series.

We analyze these data below. However, we note that these data have limited usefulness for understanding the status of the adult population, due to non-random sampling of reaches within stream systems, non-random sampling of populations within the ESU, and a general lack of estimators shown to be robust for estimating fish density within a reach. In addition, even if more rigorous methods had been used, there is no simple relationship between juvenile numbers and adult numbers (Shea and Mangel 2001), the latter being the usual currency for status reviews. Table B.2.7.4 describes the various possible ways that one might translate juvenile trends into inferences about adult trends.

We calculated trends from the juvenile data. To estimate a trend, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum length of the time series is 6 years (Other assessments in this status review place the cut-off at 10 yrs.). The recent origin of some relevant time-series and the fact that some of the shorter time-series include information for different age-classes prompted us to consider these slightly smaller datasets.

Table B.2.8.1. Estimates of historic run sizes from the previous status review (Busby 1996).

River basin	Run size estimate	Year	Reference
Pajaro R.	1,500	1964	McEwan and Jackson 1996
	1,000	1965	McEwan and Jackson 1996
	2,000	1966	McEwan and Jackson 1996
Carmel R.	20,000	1928	CACSS (1988)
	3,177	1964 – 1975	Snider (1983)
	2,000	1988	CACSS (1988)
	<4,000	1988	Meyer Resources (1988)

Current distribution vs. historical distribution—In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages between the northern and southern geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in stream reaches that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 37 drainages in which steelhead were known to have occurred historically, between 86% and 95% were currently occupied by *O. mykiss*. The range in the estimate of occupancy occurs because three basins could not be assessed due to restricted access. Of the vacant basins, two were considered to be vacant because they were dry in 2002, and one was found to be watered but a snorkel survey revealed no *O. mykiss*. One of the "dry" basins—Old Creek—is dry because no releases were made from Whale Rock Reservoir; however, a land-locked population of steelhead is known to occur in the reservoir above the dam.

Occupancy was also determined for 18 basins with no historical record of steelhead occurrence. Three of these basins—Los Osos, Vicente, and Villa Creeks—were found to be occupied by *O. mykiss*. It is somewhat surprising that no previous record of steelhead seems to exist for Los Osos Creek, near Morro Bay and San Luis Obispo.

The current distribution of steelhead among the basins of the region is not much less than what occurred historically. This conclusion rests on the assumption that juveniles inhabiting stream reaches with access to the ocean will undergo smoltification and thus are truly steelhead.

B.2.8.3 New Updated Analyses

Two significant analyses exist: 1) A critical review of the historical run sizes cited in the previous status review, and 2) an assessment of recent trends observed in the adult counts being made on the Carmel River.

Review of historic run sizes—Estimates of historic sizes for a few runs were described in the previous status review (Busby et al. 1996), and are here reproduced in Table B.2.8.1.

The recent estimates for the Pajaro River (1,500, 1,000, 2,000) were reported in McEwan and Jackson (1996), but the methodology and dataset used to produce the estimates were not described.

CACCS (1988) suggested an annual run size of 20,000 adults in the Carmel River of the 1920s, but gave no supporting evidence for the estimate. Their 1988 estimate of 2,000 adults also lacked supporting evidence. Meyer Resources (1988) provides an estimate of run size, but was not available for review at the time of this writing. Snider (1983) examined the Carmel River, and in the abstract of his report gave an estimate of 3,177 fish as the mean annual smolt production for 1964 through 1975; Busby et al. (1996) mistakenly cited this estimate as an estimate of run size. Moreover, Snider's "3,177" figure may itself be a mistake, as it disagrees with the information in the body of Snider's (1983) report, which estimates annual smolt production in the year 1973 as 2,708 smolts, and in the year 1974 as 2,043 smolts. Snider (1983) also gives adult counts for fish migrating upstream through the fish ladder at San Clemente Dam, for the years 1964 through 1975 (data not reported in Busby et al. 1996. See Figure B.2.8.1 for counts.). The mean run size from these data is 821 adults. To make these estimates, visual counts were made twice a day by reducing the flow through the ladder and counting the fish in each step; thus they may underestimate the run size by some unknown amount if fish moved completely through the ladder between counts (an electronic counter was used in 1974 and 1975 and presumably is more accurate). In addition, San Clemente Dam occurs 19.2 miles from the mouth of the river and a small fraction of the run probably spawns below the dam.

Thus, much of the historical data used in the previous status review are highly uncertain or mistaken. The most reliable data are the Carmel River dam counts, which were not reported in the previous status review. Further analysis of these data are described below.

Abundance in the Carmel River—The Carmel River data are the only time-series for this ESU. These data suggest that the abundance of adult spawners in the Carmel River has increased since the last status review (Figure B.2.8.1). A continuous series of data exists for 1964 through 1977. A regression line drawn through these data indicates a downward trend, but the trend is not statistically significant (slope = -28.45; $R^2 = 0.075$; $F = 1.137$; $p = 0.304$;). Continuous data have also been collected for the period 1988 through 2002. The beginning of this time series has counts of zero adults for three consecutive years, then shows a rapid increase in abundance. The regression line has a positive slope that is statistically significant (slope = 61.30; $R^2 = 0.735$; $F = 36.00$; $p < 0.0001$). However, due to the initial zeros the data do not meet an assumption of the significance test (constant variance). A regression that omits the zeros also gives a positive slope that is statistically significant (slope = 66.56; $R^2 = 0.634$; $F = 17.33$; $p = 0.0019$) and that appears to meet the assumption of constant variance (see also Table B.2.8.3).

The time series is too short to infer anything about the underlying dynamical cause of the positive trend. In particular, a positive trend in a short time series may be due either to improved conditions (i.e. mean lambda greater than one), or to transient effects of age structure. It is also possible that the trend arises from immigration of adults (or the planting of juveniles) from other areas; in particular, from the lower reaches of the Carmel River below San Clemente dam. The rapid increase in adult abundance from 1991 (one adult) to 1997 (775 adults) seems great enough to require substantial immigration or transplantation as an explanation.

According to the Monterey Peninsula Water Management District, the entity responsible for managing the basin and the fishery, the likely reasons for the positive trend are:

> "Improvements in streamflow patterns, due to favorable natural fluctuations...since 1995; ...actively manag[ing] the rate and distribution of groundwater extractions and direct surface diversions within the basin; changes to Cal-Am's [dam] operations ... providing increased streamflow below San Clemente Dam; improved conditions for fish passage at Los Padres and San Clemente Dams ...; recovery of riparian habitats, tree cover along the stream, and increases in woody debris...; extensive rescues ... of juvenile steelhead over the last ten years ... ; transplantation of the younger juveniles to viable habitat upstream and of older smolts to the lagoon or ocean; and implementation of a captive broodstock program by Carmel River Steelhead Association and California Department of Fish & Game (CDFG), [including] planting ... from 1991 to1994." (MPWMD 2001)

Harvest impacts

Harvest of steelhead in West Coast ocean fisheries is a rare event (M. Mohr, NMFS, personal communication). Freshwater sport fishing probably constitutes a larger impact.

CDFG (2002) describes the current freshwater sport fishing regulations for steelhead of the south-central ESU. CDFG (2000) describes the basis for these regulations in terms of management objectives. The regulations allow catch-and-release winter steelhead angling in many of the river basins occupied by the ESU, specifiying that all wild steelhead must be released unharmed. There are significant restrictions on timing, location, and gear used for angling. The CDFG (2000) states that, "The only mortality expected from a no-harvest fishery is from hooking and handling injury or stress" (p. 16), and estimates this mortality rate to be about 0.25% - 1.4%. This estimate is based on angler capture rates measured in other river systems throughout California (range: 5% - 28%), multiplied by an estimated mortality rate of 5% once a fish is hooked. This estimate may be biased downward because it doesn't account for multiple catch/release events.

Summer trout fishing is allowed in some systems, often with a two- or five-bag limit. These include significant parts of the Salinas system (upper Arroyo Seco and Nacimiento above barriers; the upper Salinas; Salmon Creek; and the San Benito River in the Pajaro system (All: bag limit five trout). Also included in the summer fisheries is the Carmel River above Los Padres Dam (bag limit two trout, between 10" and 16"). A few other creeks have summer catch-and-release regulations. It is worth noting that the draft of the Fishery Management and Evaluation Plan (CDFG 2000) recommended complete closure of the Salinas system to protect the steelhead there, but the final regulations did not implement this recommendation, allowing both summer trout angling and winter catch-and-release steelhead angling in selected parts of the system (CDFG 2002).

B.2.8.4. New Hatchery/ESU Information

Current California hatchery steelhead stocks being considered in this ESU include:

Whale Rock Hatchery (Whale Rock Steelhead [CDFG])

Whale Rock Reservoir was created in 1961 by placing a dam on Old Creek (and Cottontail Creek), 2 km northwest of Cayucos. Old Creek had supported a large steelhead run previous to construction of the dam and these fish were presumably trapped behind the dam. Whale Rock Hatchery was established in 1992 as an effort to improve the sport fishery in the reservoir after anglers reported a decline in fishing success. The original Whale Rock broodstock (40 fish) were collected at a temporary weir placed in the reservoir at the mouth of Old Creek Cove (Nielsen et al. 1997). Adult fish are trapped in the shallows of the reservoir using nets that are set during late winter and spring as the fish begin their migration upstream from the reservoir into Old Creek. The fish are held in an enclosure while they are monitored for ripeness. Eggs and sperm are collected from fish using non-lethal techniques, and then the adult fish are returned to the reservoir. Fish were originally hatched and raised at the Whale Rock Hatchery located below the dam at the maintenance facility, but are now raised at the Fillmore Hatchery in Ventura County. The fry are cared for until September or November at which time they are released back into the reservoir as 3-5" fingerling trout.

Broodstock Origin and History—Hatchery operations began in 1992 and have been sporadic since. The project began as a cooperative venture, but has been taken over by CDFG. Fish were raised in 1992, 1994, 2000, and 2002 (John Bell, personal communication). All broodstock are taken from the reservoir.

Broodstock size/natural population size—An average of 121 fish were spawned. Spawning success was poor. There are no population estimates for the reservoir and the hatchery fish are not marked.

Management—The current program goal is to increase angling success in Whale Rock Reservoir.

Population genetics—Neilsen et al. (1997) found significant genetic identity remains between the Whale Rock Hatchery stock and wild steelhead in the Santa Ynez River and Malibu creeks, despite a loss of an overall genetic diversity within the hatchery stock.

Category—Category 2 hatchery (SSHAG 2003; Appendix B.5.2). Broodstock are taken from the source population, but the small, restricted population could easily lead to significant genetic bottlenecks.

B.2.9 SOUTHERN CALIFORNIA STEELHEAD

B.2.9.1 Previous BRT Conclusions

The geographic range of the ESU extends from the the Santa Maria River Basin near the town of Santa Maria, south to the United States border with Mexico. There is a report of *O. mykiss* populations in Baja California del Norte (Ruiz-Campos and Pister 1995); these populations are thought to be resident trout, but may be part of the ESU if found to be anadromous (note that they do not lie within the jurisdiction of the Endangered Species Act). Schiewe (1997) cites reports of several other steelhead populations south of the border. The southern California ESU is the extreme southern limit of the anadromous form of *O. mykiss*. It was separated from steelhead populations to the north on the basis of a general faunal transition (in the fauna of both freshwater and marine systems) in the vicinity of Point Concepcion. The genetic differentiation of steelhead populations within the ESU, and from other ESUs in northern California or the Pacific Northwest appears to be great; however the conclusion is based on genetic data from a small number of populations.

Summary of major risks and status indicators

Risks and limiting factors—There has been extensive loss of populations, especially south of Malibu Creek, due to urbanization, dewatering, channelization of creeks, human-made barriers to migration, and the introduction of exotic fish and riparian plants. Many of these southern-most populations may have originally been marginal or intermittent (i.e. exhibiting repeated local extinctions and recolonizations in bad and good years respectively). No hatchery production exists for the ESU. The relationship between anadromous and resident *O. mykiss* is poorly understood in this region, but likely plays an important role in population dynamics and evolutionary potential of the fish.

Status indicators—Historical data on the ESU are sparse. The historic run size for the ESU was estimated to be at least 32,000-46,000 (estimates for the four systems comprising the Santa Ynez, Ventura, Santa Clara Rivers, and Malibu Creek; this omits the Santa Maria system and points south of Malibu Creek). Recent run sizes for the same four systems were estimated to be less than 500 adults total. No time series data were found for any populations.

BRT conclusions

The original BRT concluded that that ESU was in danger of extinction, noting that populations were extirpated from much of their historical range (Busby et al. 1996). There was strong concern about widespread degradation, destruction, and blockage of freshwater habitats, and concern about stocking of rainbow trout. The two major areas of uncertainty were 1) lack of data on run sizes, past and present; and 2) the relationship between resident and anadromous forms of the species in this region. A second BRT convened for an update (Schiewe 1997) found that the small amount of new data did not suggest that the situation had improved, and the majority view was that the ESU was still in danger of extinction.

Listing status

The ESU was listed as endangered in 1997.

B.2.9.2 New Data

There are three new significant pieces of information: 1) Four years of adult counts in the Santa Clara River; 2) observed recolonizations of vacant watersheds, notably Topanga Creek in Los Angeles county, and San Mateo Creek in Orange county; and 3) a comprehensive assessment of the current distribution of *O. mykiss* within the historic range of the ESU (Boughton and Fish MS). Items (1) and (2) are described further in the analyses section below; item (3) is described here:

Current distribution vs. historical distribution

In 2002, an extensive study was made of steelhead occurrence in most of the coastal drainages within the geographic boundaries of the ESU (Boughton and Fish MS). Steelhead were considered to be present in a basin if adult or juvenile *O. mykiss* were observed in stream reaches that had access to the ocean (i.e. no impassable barriers between the ocean and the survey site), in any of the years 2000-2002 (i.e. within one steelhead generation). Of 65 drainages in which steelhead were known to have occurred historically, between 26% and 52% were still occupied by *O. mykiss*. The range in the estimate of occupancy occurs because 17 basins could not be surveyed, due to logistical problems, pollution, or lack of permission to survey on private land (most are probably vacant, based on a subjective assessment of habitat degradation). Four basins were considered vacant because they were dry, 18 were considered vacant due to impassable barriers below all spawning habitat; and eight were considered vacant because a snorkel survey found no evidence of *O. mykiss*. One of the "dry" basins—San Diego River—may have water in some tributaries—it was difficult to establish that the entire basin below the dam was completely dry. Numerous anecdotal accounts suggest that several of the basins that had complete barriers to anadromy may have landlocked populations of native steelhead/rainbow trout in the upper tributaries. These basins include the San Diego, Otay, San Gabriel, Santa Ana, and San Luis Rey Rivers. Occupancy was also determined for 17 basins with no historical record of steelhead occurrence; none were found to be currently occupied.

Nehlsen et al. (1991) listed the following Southern California stocks as extinct: Gaviota Creek, Rincon Creek, Los Angeles River, San Gabriel River, Santa Ana River, San Diego River, San Luis Rey River, San Mateo Creek, Santa Margarita River, Sweetwater River, and Maria Ygnacio River. The distributional study of 2002 determined that steelhead were present in two of these systems, namely Gaviota Creek (Stoecker and CCP 2002) and San Mateo Creek (a recent colonization; see below). Nevertheless, the current distribution of steelhead among the basins of the region appears to be substantially less than what occurred historically. Except for the small population in San Mateo Creek in northern San Diego County, the anadromous form of the species appears to be completely extirpated from all systems between the Santa Monica Mountains and the Mexican border.

Table B.2.9.1. Estimates from Busby et al. (1996), for run sizes in the major river systems of the southern steelhead ESU.

River basin	Run size estimate	Year	Reference
Santa Ynez	20,000 – 30,000	Historic	Reavis (1991)
	12,995 – 25,032	1940s	Shapovalov & Taft (1954)
	20,000	Historic	Titus et al (MS)
	20,000	1952	CDFG (1982)
Ventura	4,000-6,000	Historic	AFS (1991)
	4,000-6,000	Historic	Hunt et al. (1992)
	4,000-6,000	Historic	Henke (1994)
	4,000-6,000	Historic	Titus et al. (MS)
Matilija Cr.	2,000 – 2,500	Historic	Clanton & Jarvis (1946)
Santa Clara	7,000 – 9,000	Historic	Moore (1980)
	9,000	Historic	Comstock (1992)
	9,000	Historic	Henke (1994)

Recent colonization events

Several colonization events were reported during the interval 1996-2002. Steelhead colonized Topanga Creek in 1998 and San Mateo Creek in 1997 (R. Dagit, T. Hovey, pers. commun.). As of this writing (October 2002) both colonizations persist although the San Mateo Creek colonization appears to be declining. T. Hovey (CDFG, pers. commun.) used genetic analyses to establish that the colonization in San Mateo Creek was made by two spawning pairs in 1997. In the summer of 2002 a dead mature female was found in the channelized portion of the San Gabriel River in the Los Angeles area (M. Larsen, CDFG, pers. commun.). A single live adult was found trapped and over-summering in a small watered stretch of Arroyo Sequit in the Santa Monica Mountains (K. Pipal and D. Boughton, UCSC and NMFS, pers. commun.). The "run sizes" of these colonization attempts are of the same order as recent "run sizes" in the Santa Clara system—namely, less than five adults per year.

B.2.9.3 New and Updated Analyses

Two significant analyses exist: 1) A critical review of the historical run sizes cited in the previous status review, and 2) A few new data on run size and population distribution in three of the larger basins.

Review of historic run sizes

Few data exist on historic run sizes of southern steelhead. Based on the few data available, the previous status review made rough estimates for three of the large river systems (Table B.2.9.1), and a few of the smaller ones (Busby et al. 1996). The run size in the Santa Ynez system—probably the largest run historically—was estimated to originally lie between 20,000 and 30,000 spawners (Busby et al. 1996). This estimate was based primarily on four references cited in the status review: Reavis (1991) (20,000-30,000 spawners), Titus et al. (MS) (20,000 spawners), Shapovalov and Taft (1954) (12,995-25,032 spawners), and CDFG (1982) (20,000 spawners). Examination of these references revealed the following: Reavis (1991) asserted a run size of 20,000-30,000, but provided no supporting evidence. Titus et al. (MS) reviewed evidence described by Shapovalov (1944), to be described below. Shapovalov and Taft (1954) did not address run sizes in this geographic region; the citation is probably a mis-citation for Shapovalov (1944). CDFG (1982) was not obtained in time to review it for this writing.

Entrix (1995) argued that the above estimates are too large. They argue that the only original data on run sizes are from Shapovalov (1944), and are based on a CDFG employee's visual estimate that the 1944 run was "at least as large" as runs in the Eel River (northern California), which the employee had observed in previous years. Estimated run sizes for the Eel River ranged between 12,995 and 25,032 during the years 1939 to 1944 (Shapovalov 1944), and this has been reported as the estimated run size of the Santa Ynez. Entrix (1995) observed, however, that the employee who made the comparison was only present at the Eel River during two seasons, 1938-39 and 1939-40. The estimates for run sizes in those years were 12,995 and 14,476 respectively, which implies that a more realistic estimate for the Santa Ynez run size is 13,000-14,500.

This revised range of estimates may itself be a maximum, because the year 1944 occurred toward the end of a wet period that may have provided especially favorable spawning and rearing conditions for steelhead (Entrix 1995). In additon, the year 1944 seems to have occurred toward the end of a period in which extensive rescues of juvenile steelhead had been made during low-flow years (Shapovalov 1944, Titus et al. MS). During the interval 1939-1946, a total of 4.3 million juveniles were rescued from drying portions of the mainstem, and usually replanted elsewhere in the system (no rescues were made in 1941, due to sufficient flow). This averages to about 61,400 juveniles rescued per year. Assuming that rescue operations lowered the mean mortality rate as intended, during the 1939-1946 interval, the Santa Ynez population may have increased somewhat (or failed to undergo a decline) due to the rescue operations. These data also suggest that even in wet years, high mortality of juveniles during the summer months was a common occurrence.

On the other hand, the revised range of estimates (13,000-14,500) may be somewhat low, because it was not made until well after a significant proportion of spawning habitat had been lost. The Santa Ynez system currently has two major dams on the mainstem that block portions of spawning and rearing habitat. The upper dam (Gibralter) was built in 1920. At that time, no estimates of run size had been made for the Santa Ynez, but it was widely known that important spawning areas had become landlocked above Gilbralter dam (Titus et al. MS). The lower dam (Cachuma or Bradbury) was completed in 1953. It is also worth noting that due to the flashy nature of the Santa Ynez mainstem, and the propensity of the region for drought, the annual run sizes may have been zero in some years.

According to Titus et al. (MS), the Ventura River was estimated to have a run size of 4,000-5,000 adults during a normal water year. This estimate was made in 1946, after several years of planting juveniles from the Santa Ynez (27,200 in 1943, 20,800 in 1944, and 45,440 in 1945, as well as 40,000 in 1930, 34,000 in 1931, and 15,000 in 1938). Like the estimates for the Santa Clara, this estimate was made toward the end of a wet period, in a system that had received numerous plantings of juveniles. As in the Santa Ynez, anecdotal accounts suggest that run sizes declined precipitously during the late 1940s and 1950s, due possibly to both drought and to anthropogenic changes to the river system. Similar considerations apply to the estimate made by Clanton and Jarvis (1946), of 2,000-2,500 adults in the Matilija basin, a major tributary of the Ventura River.

Moore's (1980) estimate of 9,000 spawners for the Santa Clara basin is based on the estimate of Clanton and Jarvis (1946) for Matilija Creek. Moore (1980) assumed similar levels of production per stream mile in the two systems, and noted that at least five-times more spawning and rearing habitat exists in the Santa Clara. Moore (1980) regarded his estimate as conservative, because although it included the major spawning areas (Santa Paula, Sespe, and Piru creeks), it omitted numerous small side-tributaries. On the other hand, his estimates also may be biased upwards for the same reasons as the estimates for the Ventura and Santa Ynez basins.

Ed Henke (cited in Schiewe 1997) stated that abundance of steelhead in the Southern California ESU was probably about 250,000 adults prior to European settlement of the region. His argument is based on historical methods of research involving interviews of older residents of the area as well as written records. The original analysis of data producing the estimate was not obtained in time for the current update.

In summary, the estimates of historic run sizes for this steelhead ESU are based on very sparse data and long chains of assumptions that are plausible but not exactly supportable. The existing estimates may be biased upwards, due to the fact that they were all made in the mid-1940s; or they may be biased downwards due to the omission of portions of spawning habitat. The authors of these estimates widely acknowledge both the uncertainty of the estimates, and the fact that average run sizes may not be terribly meaningful for this ESU, due to high year-to-year variability in the amount of water running through the systems.

Recent run sizes of large river systems

It seems likely that the larger river systems were originally the mainstay of the ESU. Large river systems, which probably harbored steelhead populations in the past are (from north to south) the Santa Maria, the Santa Ynez, the Santa Clara, the Los Angeles, the San Gabriel, the Santa Ana, and possibly the San Diego. Of these seven systems, the data suggest that steelhead currently occur in only three—the Santa Maria, Santa Ynez, and Santa Clara.

The Santa Maria—There do not appear to be any estimates for recent run sizes in the Santa Maria system. Twitchell Dam blocks access to a significant proportion of historical spawning habitat, the Cuyama River, one of the two major branches of the Santa Maria. The other major branch, the Sisquoc River, appears to still have substantial spawning and rearing habitat that is accessible from the ocean; juvenile steelhead have recently been observed in these areas (Cardenas 1996, Kevin Cooper, Los Padres NF, pers. commun.).

The Santa Ynez—Most historic spawning habitat is blocked by Cachuma and Gibralter Dams. However, extensive documentation exists for steelhead/rainbow trout populations in a number of ocean-accessible sites below Cachuma dam (Table B.2.9.2). These are Salsipuedes/El

Jaro Creeks, Hilton Creek, Alisal Creek, Quiota Creek, San Miguelito Creek, and three reaches in the mainstem (Hanson 1996, Engblom 1997, 1999, 2001). Various life stages of steelhead, including upstream migrants and smolts, have been consistently observed at some of these sites (see Table B.2.9.2). Run sizes are unknown, but likely small (<100 adults total).

The Santa Clara—A few estimates of recent run sizes exist for the Santa Clara system, due to the presence of a fish ladder and counting trap at the Vern Freeman Diversion Dam on the mainstem. This diversion dam lies between the ocean and what is widely believed to be one of the largest extant populations of steelhead in the ESU (the Sespe Canyon population). The run size of upstream migrants was one adult in each of 1994 and 1995, two adults in 1996, and no adults in 1997. The operation of the counting trap (but not the fish ladder) was discontinued in 1998 at the request of NMFS (the fish ladder itself is currently dysfunctional due to changes in flow patterns of the river).

Harvest impacts

Harvest of steelhead in West Coast ocean fisheries is a rare event (M. Mohr, NMFS, pers. commun.). Freshwater sport fishing probably constitutes a larger impact.

CDFG (2002) describes the current freshwater sport fishing regulations for steelhead of the southern ESU. The regulations specify that all wild steelhead must be released unharmed. Summer-fall catch-and-release angling is allowed in Piru Creek below the dam; San Juan Creek (Orange County); San Mateo Creek (one section); Santa Margarita River and tributaries; and Topanga Creek. Year-round catch and release is allowed in the San Gabriel River (below Cogswell Dam); and Sespe Creek and tributaries (all of the above are historical steelhead streams). Year-round trout fisheries are allowed in Calleguas Creek and tributaries (limit 5); Piru Creek above the dam (limit 2); San Luis Rey River (limit 5); Santa Paula Creek above the falls (limit 5); the Santa Ynez River above Gibralter Dam (limit 2); Sisquoc River (limit 5); and Sweetwater River (limit 5). With the possible exception of the Sisquoc River, these take-fisheries appear to be isolated from the ocean by natural or human-made barriers. Except for Calleguas Creek and possibly the Sweetwater, the above drainages are listed as historic steelhead streams by Titus et al. (MS). It is certainly possible that some currently harbor native trout with the potential to exhibit anadromy.

Table B.2.9.2. Presence of steelhead in the lower Santa Ynez River system (*caught in upstream migrant trap).

Tributary	Redds	<6"	>6"	Smolts	Adults	Unspec	Year (spr.)	Source
Salsipuedes/El Jaro		Y	Y	Y	Y*		1994	Hanson 1996
				Y	Y*		1995	Hanson 1996
	Y	Y	Y	Y	Y*		1996	Hanson 1996, Engblom 1997
	Y	Y	Y	Y	Y*		1997	Engblom 1997
	Y	Y	Y		Y*		1998	Engblom 1999
	Y	Y	Y		Y*		1999	Engblom 1999
					Y*		2000	Engblom 2001
		Y	Y	Y	Y*		2001	Engblom 2001
Hilton Creek		N	N		Y*		1994	Hanson 1996
		Y	Y†	Y	Y*		1995	Hanson 1996
				N	Y*		1996	Hanson 1996, Engblom 1997
	N	Y	Y	N	Y*		1997	Engblom 1997
	Y	Y			Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
		Y	Y		Y*		2001	Engblom 2001
Alisal Creek		Y	Y		Y*		1995	Hanson 1996
Nojoqui Creek		N	N		N*		1994	Hanson 1996
				N	N*		1995	Hanson 1996
				N			1997	Engblom 1997
		N	Y		Y*		1998	Engblom 1999
					N*		1999	Engblom 1999
Quiota Creek (& trib)	Y		Y		N*		1995	Hanson 1996
		Y	Y				1994	Hanson 1996
		Y					1998	Engblom 1999
		Y	Y				2001	Engblom 2001
San Miguelito Creek		Y	Y				1996	Hanson 1996
	Y			Y			1997	Engblom 1997
		Y		N	N*		1998	Engblom 1999
	Y			N	N*		1999	Engblom 1999
Mainstem/Hwy 154		Y	Y				1995	Hanson 1996
		Y	Y				1996	Hanson 1996
					Y		1994	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y						1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Refugio		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
	Y	N	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Alisal reach		Y	Y				1995	Hanson 1996
		N	Y				1996	Hanson 1996
		Y	Y				1998	Engblom 1999
		Y	Y				1999	Engblom 1999
		Y	Y				2001	Engblom 2001
Mainstem/Cargasachi		N	N				1995	Hanson 1996
		N	N				1996	Hanson 1996

B.2.10 CALIFORNIA CENTRAL VALLEY STEELHEAD

B.2.10.1 Previous BRT Conclusions

Summary of major risk factors and status indicators

Steelhead were once abundant and widespread throughout the Central Valley (CV), from tributaries to the upper Sacramento in the north to perhaps the Kern River in the southern San Joaquin Valley. Steelhead require cool water in which to oversummer, and much of this habitat is now above impassable dams. Where steelhead are still extant, natural populations are apparently small and subject to habitat degradation, including various effects of water development and land use practices. Concerns included extirpation from most of historic range, a monotonic decline in the single available time series of abundance (Table B.2.10.1; Figure B.2.10.1), declining proportion of wild fish in spawning runs, substantial opportunity for deleterious interactions with hatchery fish (including out-of-basin origin stocks), various habitat problems, and no ongoing population assessments. Compared to most chinook salmon populations in the Central Valley, steelhead spawning above Red Bluff Diversion Dam (RBDD) have a fairly strong negative population growth rate and small population size (Figure B.2.10.2).

Table B.2.10.1. Summary statistics for Central Valley steelhead trend analyses. Numbers in parentheses are 0.90 confidence intervals. Threatened and endangered chinook salmon populations are shown for comparison.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sac. R. steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	-0.06 (-0.26, 0.15)
Sac. R. winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Cr. spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Cr. spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Cr. spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

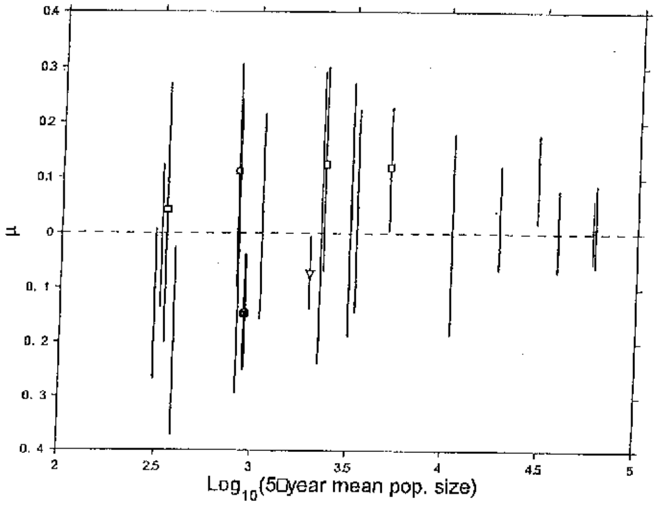

Figure B.2.10.1. Abundance and growth rate of Central Valley salmonid populations. Large filled circle- steelhead; open squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, μ ≈log [λ].)

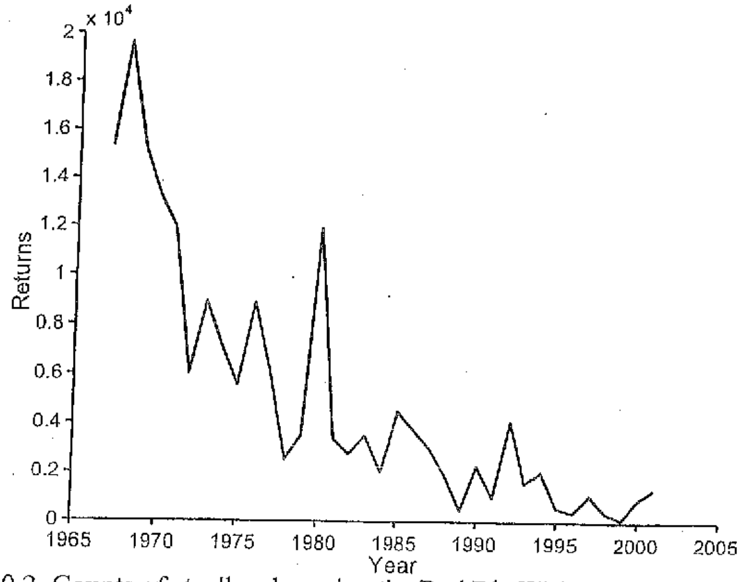

Figure B.2.10.2. Counts of steelhead passing the Red Bluff Diversion Dam fish ladders. These fish include hatchery fish from Coleman NFH.

BRT Conclusions

The BRT previously concluded that the Central Valley ESU was in danger of extinction (Busby et al. 1996), and this opinion did not change in two status review updates (NMFS 1997; NMFS 1998a). The Nimbus Hatchery and Mokelumne River Hatchery steelhead stocks were excluded from the Central Valley ESU (NMFS 1998b).

Listing status

The Central Valley steelhead ESU was listed as Threatened on March 19, 1998.

B.2.10.2 New Data

Historic distribution and abundance

McEwan (2001) reviewed the status of Central Valley steelhead. Steelhead probably occurred from the McCloud River and other northern tributaries to Tulare Lake and the Kings River in the southern San Joaquin Valley. McEwan also guessed that more than 95% of historic spawning habitat is now inaccessible. He did not hazard a guess about current abundance. He guessed, on the basis of the fairly uncertain historical abundance estimates of Central Valley chinook reported by Yoshiyama et al. (1998), that between 1 million and 2 million steelhead may have once spawned in the Central Valley. McEwan's estimate is based on the observation that presently, steelhead are found in almost all systems where spring-run chinook salmon occur and can utilize elevations and gradients even more extreme than those used by spring chinook. Steelhead should therefore have had more freshwater habitat than spring chinook, and the sizes of steelhead populations should therefore have been roughly as big as those of spring chinook.

Current abundance

The only significant new abundance information since the last status review comes from midwater trawling below the confluence of the Sacramento and San Joaquin Rivers at Chipps Island. This trawling targets juvenile chinook; catches of steelhead are incidental. In a trawling season, over 2,000 20-minute tows are made. Trawling occurred from the beginning of August through the end of June in 1997/98 and 1998/99, after which trawling has occurred year-round. Usually, 10 tows are made per day, and trawling occurs several days per week.

Since the 1998 broodyear, all hatchery steelhead have been ad-clipped. Trawl catches of steelhead provide an estimate of the proportion of wild to hatchery fish, which, combined with estimates of basin-wide hatchery releases, provide an estimator for wild steelhead production:

$$N_w = \frac{C_w}{C_h} N_h \tag{1}$$

where N_w is the number of wild steelhead, C_w and C_h are the total catches of wild and hatchery steelhead, and N_h is the number of hatchery fish released.

Catches of steelhead are sporadic—most sets catch no steelhead, but a few sets catch up to four steelhead. To estimate the mean and variance of C_w / C_h, I resampled (with replacement) the trawl data sets 1,000 times. The mean C_w / C_h ranged from 0.06 to 0.30, and coefficients of variation ranged from 16% to 37% of the means.

From such calculations, it appears that about 100,000-300,000 steelhead juveniles (roughly, smolts) are produced naturally each year in the Central Valley (Table B.2.10.2). If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1% of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1million-2 million spawners before 1850, and 40,000 spawners in the 1960s. Table B.2.10.2 shows the effects of different assumptions about survival on estimates of female spawner abundance.

Current distribution

Recent surveys of small Sacramento River tributaries (Mill, Deer, Antelope, Clear, and Beegum creeks) and incidental captures of steelhead during chinook monitoring (Cosumnes, Stanislaus, Tuolumne, and Merced rivers) have confirmed that steelhead are widespread, if not abundant, throughout accessible streams and rivers. Figure B.2.10.3 summarizes the distribution of steelhead in Central Valley streams.

Harvest impacts

Steelhead are caught in freshwater recreational fisheries, and CDFG estimates the number of fish caught. Because the sizes of Central Valley steelhead populations are unknown, however, harvest *rates* are unknown. According to CDFG creel census, the great majority (93%) of steelhead catches occur on the American and Feather rivers, sites of the two largest steelhead hatcheries. In 2000, 1,800 steelhead were retained and 14,300 were caught and released. The total number of steelhead contacted is on the order of basin-wide escapement, so even low catch-and-release mortality may pose a problem for wild populations. Additionally, steelhead juveniles are presumably affected by trout fisheries on tributaries and the mainstem Sacramento.

Table B.2.10..2. Estimated natural production of steelhead juveniles from the Central Valley. C_w/C_h = ratio of unclipped to clipped steelhead; N_r = total hatchery releases; N_w = estimated natural production; ESS = egg-to-smolt survival.

				wild female spawners		
Year	C_w/C_h	N_r (millions)	N_w (thousands)	ESS=1%	ESS=5%	ESS=10%
1998	0.300	1.12	336	6,720	1,344	672
1999	0.062	1.51	93.6	1,872	374	187
2000	0.083	1.38	115	2,291	458	229
average	0.148	1.34	181	3,628	726	363

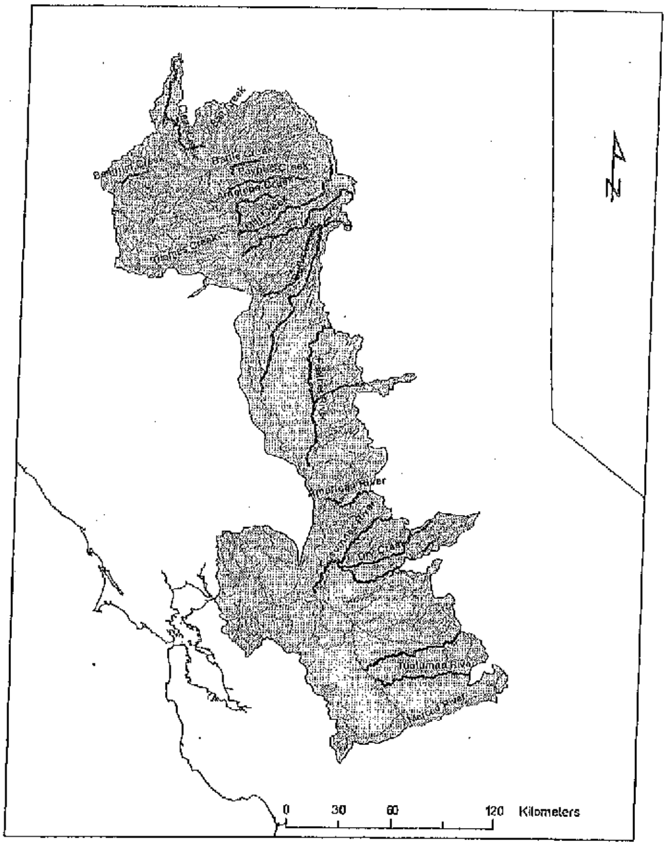

Figure B.2.10.3. Central Valley tributaries known (red lines; bold font) or suspected (orange lines; normal font) to be used by steelhead adults. Kerrie Pipal (NMFS Santa Cruz Lab) assembled this information from agency and consultant reports and discussions with CDFG field biologists.

The State of California's proposed Fishery Management and Evaluation Plan (part of the requirements to obtain ESA coverage for in-river sport fisheries) was recently rejected by NMFS mostly because of the inadequacy of existing and proposed monitoring of fisheries impacts.

B.2.10.3 New Comments

The San Joaquin Tributaries Association proposes that the California Central Valley ESU be delisted. They argue that the basis of the listing was that there are no self-sustaining populations of steelhead in the San Joaquin Valley, and that this argument is flawed because there never have been steelhead in the San Joaquin Valley. Any steelhead observed in San Joaquin tributaries are strays from the Mokelumne River Hatchery. They further argue that exclusion of resident trout populations from the ESU is arbitrary and capricious.

B.2.10.4 New Updated Analyses

Based on the provisional framework discussed in Previous BRT Conclusions, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the California Central Valley Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including Shasta Dam on the Upper Sacramento River; Whiskeytown Dam on Clear Creek; Black Butte Dam on Stony Creek; Oroville Dam on the Feather River; Englebright Dam on the Yuba River; Camp Far West Dam on the Bear River; Nimbus Dam on the American River; Commanche Dam on the Mokelumne River; New Hogan Dam on the Calaveras River; Goodwin Dam on the Stanislaus River; La Grange Dam on the Tuolumne River; and Crocker Diversion Dam on the Merced River; but below natural barriers, provisionally would be part of the ESU.

Coastal *O. mykiss* is widely distributed in the Central Valley basin (Figure B.2.10.6). Roughly half of the trout habitat (by area) in the Central Valley is above dams that are impassable to fish. Higher elevation habitats appear to support quite high densities of trout, ranging from a few hundred to a few thousand 4"-6" fish per km (Table B.2.10.3).

There are several areas of substantial uncertainty that make interpreting this information difficult. First, it is not clear how anadromous and non-anadromous coastal *O. mykiss* interacted in the Central Valley before the era of dam building. In other systems, anadromous and non-anadromous *O. mykiss* forms can exist within populations, while in other systems, these groups can be reproductively isolated despite nearly sympatric distributions within rivers. Second, hatchery produced *O. mykiss* have been widely stocked throughout the Central Valley, Sierra Nevada and southern Cascades. It is possible that this stocking has had deleterious effects on native wild trout populations.

Table B.2.10..3. Estimates of *O. mykiss* density above impassable dams in Central Valley rivers and streams.

Basin	River/stream	Density (fish(km)	Size class	Reference
Upper Sacramento	Sacramento R	420-1670	>4"	CDFG 2000
	McCloud R	2361	>5"	pers. comm.[1]
	Fall R	2541	>6"	Rode and Weidlein 1986
	Hat Cr	159-2539	>8"	Deinstadt and Berry 1999
		32-1335	>12"	Deinstadt and Berry 1999
Lower Sacramento	Nelson Cr	155-621	>6"	CDFG 1979
San Joaquin	Clavey R	1317		Robertson 1985
	San Joaquin R (Upper Main Fk)	119-695	>6"	Deinstadt et al. 1995
	Kern R	43-620		Stephens et al. 1995

[1] CDFG Region 1 biologists: Mike Dean , Mike Berry, Randy Benthin, Bob McAllister, Bill, Jong, Phil Bairrington

In the absence of information on these issues, we presume that coastal *O. mykiss* that are above man-made barriers are part of the Central Valley ESU, because these populations were probably exhibiting some degree of anadromy and interacting with each other on evolutionary time scales prior to barrier construction. Clearly, the Central Valley ESU is severely fragmented by the abundant man-made barriers throughout the basin, and population processes (exchange of migrants, recolonization) that were likely once important have been greatly altered as a result.

B.2.10.5 New Hatchery Information

There is little new information pertaining to hatchery stocks of steelhead in the Central Valley. Figures B.2.10.4 and B.2.10.5 show the releases and returns of steelhead to and from Central Valley hatcheries. As discussed above in the section on new abundance information, hatchery steelhead juveniles dominate catches in the Chipps Island trawl, suggesting that hatchery production is large relative to natural production. Note that Mokelumne River Hatchery and Nimbus Hatchery stocks are not part of the CV ESU due to broodstock source and genetic, behavioral, and morphological similarity to Eel River stocks. Categorization of Central Valley steelhead hatchery stocks (SSHAG 2003) can be found in Appendix B.5.2.

B.2.10.6 Comparison with Previous Data

The few new pieces of information do not indicate a dramatic change in the status of the Central Valley ESU. The Chipps Island trawl data suggest that the population decline evident in the RBDD counts and the previously-noted decline in the proportion of wild fish is continuing. The fundamental habitat problems are little changed, with the exception of some significant restoration actions on Butte Creek. There is still a nearly complete lack of steelhead monitoring in the Central Valley.

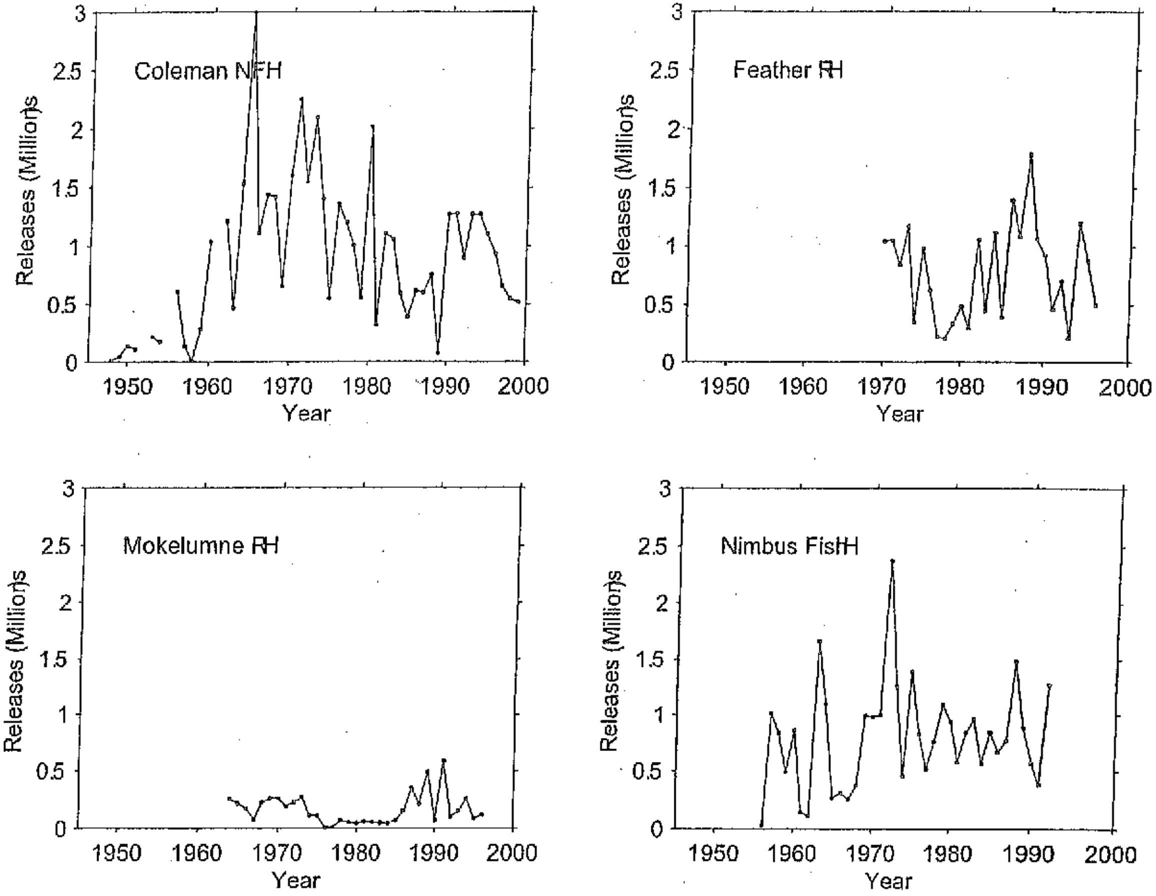

Figure B.2.10.4. Releases of steelhead from Central Valley hatcheries.

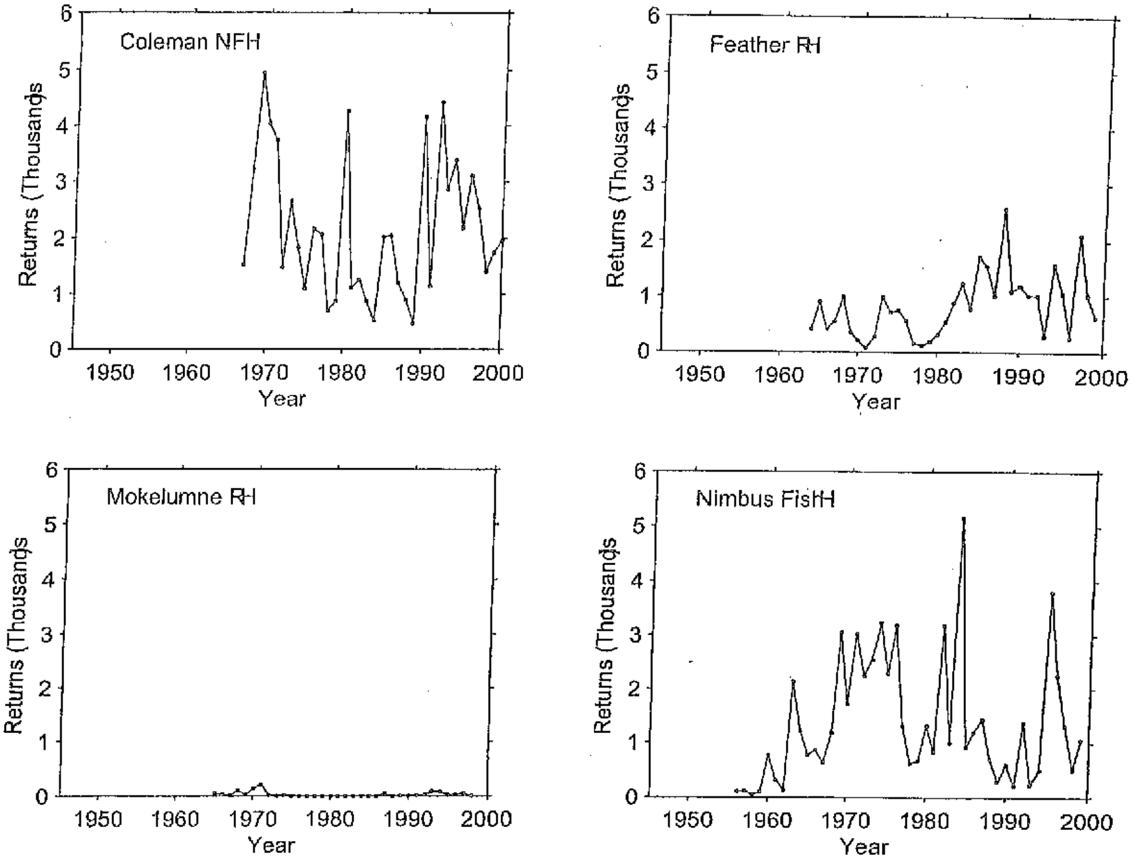

Figure B.2.10.5. Returns of steelhead to Central Valley hatcheries.

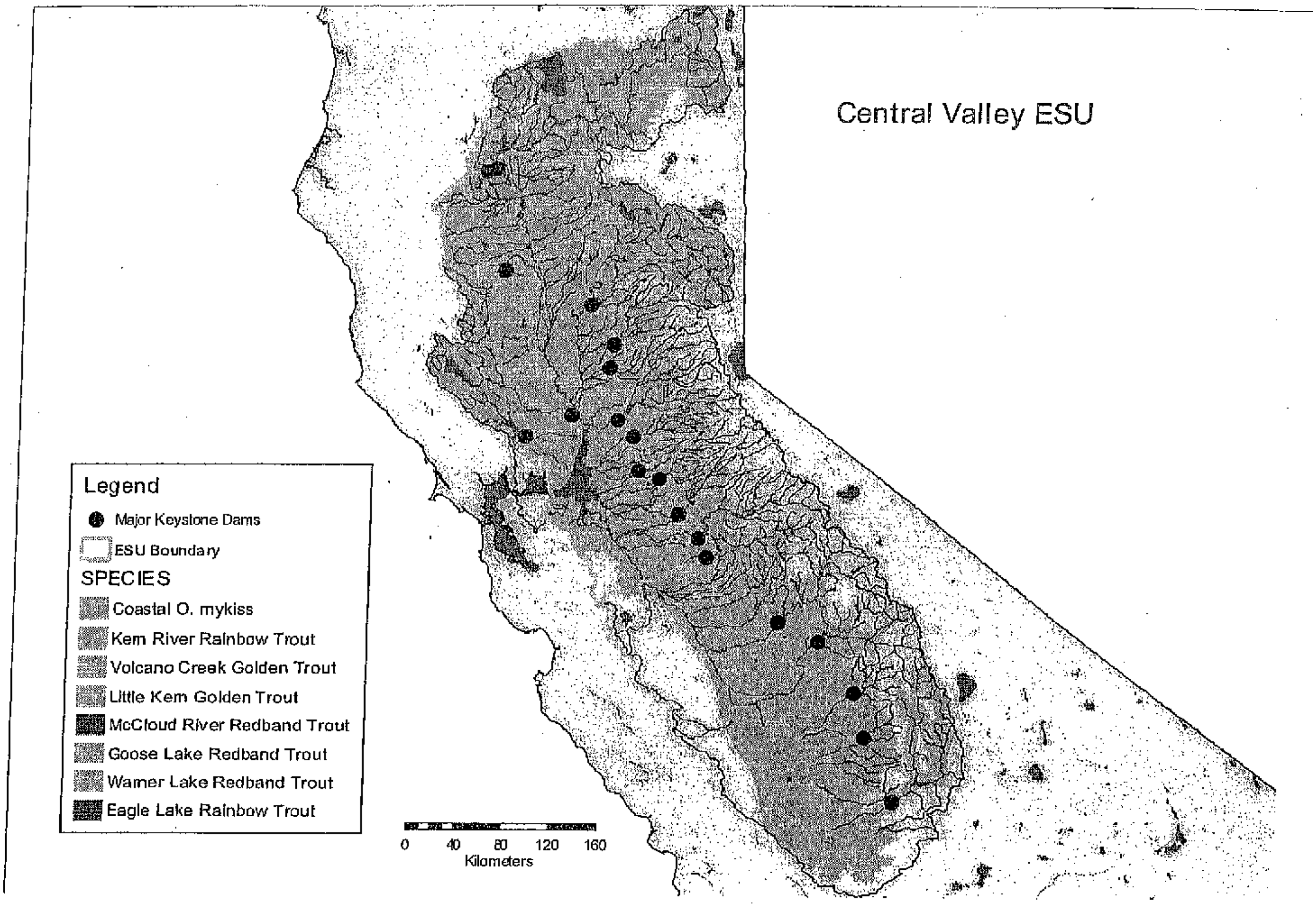

Figure B.2.10.6. Distribution of coastal *O. mykiss* and various *O. mykiss* subspecies in the Central Valley.

B.3 PRELIMINARY STEELHEAD BRT CONCLUSIONS

Snake River steelhead

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction," and "not likely to become endangered" categories. The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for spatial structure to 3.2 for growth rate/productivity) (Table B.3.1). The continuing depressed status of B-run populations was a particular concern. Paucity of information on adult spawning escapements makes a quantitative assessment of viability for this ESU difficult. As indicated in previous status reviews, the BRT remained concerned about the replacement of naturally produced fish by hatchery fish in this ESU; naturally produced fish now make up only a small fraction of the total adult run. Again, lack of key information considerably complicates the risk analysis. Although several large production hatcheries for steelhead occur throughout this ESU, relatively few data exist regarding the number of hatchery fish that spawn naturally, or the consequences of such spawnings when they do occur.

On a more positive note, sharp upturns in 2000 and 2001 in adult returns in some populations and evidence for high smolt-adult survival indicate that populations in this ESU are still capable of responding to favorable environmental conditions. In spite of the recent increases, however, abundance in most populations for which there are adequate data are well below interim recovery targets (NMFS 2002).

The BRT did not attempt to resolve the ESU status of resident fish residing above the Hell's Canyon Dam complex, as little new information is available relevant to this issue. However, Kostow (2003) suggested that, based on substantial ecological differences in habitat, the anadromous *O. mykiss* that historically occupied basins upstream of Hell's Canyon (e.g., Powder, Burnt, Malheur, Owhyee rivers) may have been in a separate ESU.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Palouse and Malad rivers) are not. Recent genetic data suggest that native resident *O. mykiss* above Dworshak Dam on the North Fork Clearwater River should be considered part of this ESU, but hatchery rainbow trout that have been introduced to that and other areas would not.

Upper Columbia River steelhead

A slight majority of the BRT votes for this ESU fell in the "danger of extinction" category, with most of the rest falling in the "likely to become endangered" category. The most serious risk identified for this ESU was growth rate/productivity (mean score 4.3); scores for the other VSP factors were also relatively high, ranging from 3.1 (spatial structure) to 3.6 (diversity) (Table B.3.1). The last 2-3 years have seen an encouraging increase in the number of naturally produced fish in this ESU. However, the recent mean abundance in the major basins is still only a fraction of interim recovery targets (NMFS 2002). Furthermore, overall adult returns are still dominated by hatchery fish, and detailed information is lacking regarding productivity of natural populations. The BRT did not find data to suggest that the extremely low replacement rate of naturally spawning fish (estimated adult:adult ratio was only 0.25-0.3 at the time of the last status review update) has improved substantially.

The BRT did not attempt to resolve the ESU status of resident fish residing above Grand Coulee Dam as little new information is available relevant to this issue. Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Entiat, Methow, and perhaps, Okanogan basins) are not. Resident fish potentially occur in all areas in the ESU used by steelhead. According to this framework, native resident fish above Conconully Dam would provisionally be part of the ESU.

Middle Columbia River steelhead

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with a minority falling in the "not likely to become endangered" category. The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for spatial structure to 2.8 for abundance) (Table B.3.1).

This ESU proved difficult to evaluate for two reasons. First, the status of different populations within the ESU varies greatly. On the one hand, the abundance in two major basins, the Deschutes and John Day, is relatively high, and over the last 5 years, is close to or slightly over the interim recovery targets (NMFS 2002). On the other hand, steelhead in the Yakima basin, once a large producer of steelhead, remain severely depressed (10% of the interim recovery target), in spite of increases in the last 2 years. Furthermore, in recent years, escapement to spawning grounds in the Deschutes River has been dominated by stray, out-of-basin (and largely out-of-ESU) fish—which raises substantial questions about genetic integrity and productivity of the Deschutes population. The John Day is the only basin of substantial size in which production is clearly driven by natural spawners. The other difficult issue centered on how to evaluate the contribution of resident fish, which according to Kostow (2003) and other sources, are very common in this ESU and may greatly outnumber anadromous fish. The BRT concluded that the relatively abundant and widely distributed resident fish mitigated extinction risk in this ESU somewhat. However, due to significant threats to the anadromous component the majority of BRT members concluded the ESU was likely to become endangered.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of this ESU, while those above long-standing natural barriers (e.g., in Deschutes and John Day basins) are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above Condit Dam in the Little White Salmon; above Pelton and Round Butte dams (but below natural barriers) in the Deschutes; and above irrigation dams in the Umatilla rivers provisionally would be part of the ESU.

Lower Columbia River steelhead

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction," and "not likely to become endangered" categories. The BRT found moderate risks in all the VSP categories, with mean risk matrix scores ranging from 2.7 for spatial structure to 3.3 for both abundance and growth rate/productivity (Table B.3.1). All of the major risk factors identified by previous BRTs still remain. Most populations are at relatively low abundance, although many have shown higher returns in the last 2-3 years, and those with adequate data for modeling are estimated to have a relatively high extinction probability. The Willamette-Lower Columbia River TRT (Myers et al. 2002) has estimated that at least four historic populations are now extinct. The hatchery contribution to natural spawning remains high in many populations.

Based on the provisional framework discussed in the introduction, the BRT assumed as a hypothesis that resident fish below historic barriers are part of this ESU, while those above long-standing natural barriers (e.g., in upper Clackamas, Sandy, and some of the small tributaries of the Columbia River Gorge) are not. According to this framework, native resident fish above dams on the Cowlitz, Lewis, and Sandy rivers provisionally would be part of the ESU.

Upper Willamette River steelhead

A majority of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction," and "not likely to become endangered" categories. The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.6 for diversity to 2.9 for both spatial structure and growth rate/productivity) (Table B.3.1). On a positive note, after a decade in which overall abundance (Willamette Falls count) hovered around the lowest levels on record, adult returns for 2001 and 2002 were up significantly, on par with levels seen in the 1980s. Still, the total abundance is small for an entire ESU, resulting in a number of populations that are each at relatively low abundance. The recent increases are encouraging but it is uncertain whether they can be sustained. The BRT considered it a positive sign that releases of the "early" winter-run hatchery population have been discontinued, but remained concerned that releases of non-native summer steelhead continue.

Because coastal cutthroat trout is a dominant species in the basin, resident *O. mykiss* are not as widespread here as in areas east of the Cascades. Resident fish below barriers are found in the Pudding/Molalla, Lower Santiam, Calapooia, and Tualatin drainages, and these would be considered part of the steelhead ESU based on the provisional framework. According to this framework, native resident fish above Big Cliff and Detroit dams on the North Fork Santiam and above Green Peter Dam on the South Fork Santiam also would be part of the ESU. Although there are no obvious physical barriers separating populations upstream of the Calapooia from those lower in the basin, resident *O. mykiss* in these upper basins are quite distinctive both phenotypically and genetically and are not considered part of the steelhead ESU.

Northern California steelhead

The majority of BRT votes were for "likely to become endangered," with the remaining votes split about equally between "in danger of extinction," and "not warranted." Abundance and productivity were of some concern (scores of 3.7; 3.3 in the risk matrix); spatial structure and diversity were of lower concern (scores of 2.2; 2.5); although at least one BRT member gave scores as high as 4 for each of these risk metrics (Table B.3.1).

The BRT considered the lack of data for this ESU to be a source of risk due to uncertainty. The lack of recent data is particularly acute for winter runs. While there are older data for several of the larger river systems that imply run sizes became much reduced since the early 20th century, there are no recent data suggesting much of an improvement.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the Northern California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including Robert W. Matthews Dam on the Mad River, and Scott Dam on the Eel River, but below natural barriers, provisionally would be part of the ESU. In this ESU, the inclusion of resident fish does not greatly increase the total numbers of fish nor have the resident fish been exposed to large amounts of hatchery stocking.

Central California Coast steelhead

The majority of BRT votes were for "likely to become endangered," and a minority were for "in danger of extinction." Abundance and productivity were of relatively high concern (mean score of 3.9 for each, with a range of 3-5 for each), and spatial structure was also of concern (score 3.6) (Table B.3.1). Predation by pinnipeds at river mouths and during the ocean phase was noted as a recent development posing significant risk.

There were no time-series data for this ESU. A variety of evidence suggested the largest run in the ESU (the Russian River winter steelhead run) has been reduced in size and continues to be reduced in size. Concern was also expressed about the populations in the southern part of the range of the ESU—notably populations in Santa Cruz County and the South Bay area.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including Warm Springs Dam on Dry Creek, Russian River; Coyote Dam on the East Fork Russian River; Seeger Dam on Lagunitas Creek; Peters Dam on Nicasio Creek, Lagunitas Creek; Standish Dam on Coyote Creek; and Dam 1 on Alameda Creek; but below natural barriers, provisionally would be part of the ESU. In this ESU, 22% of habitat is behind recent barriers, but there is no density information.

South-Central California Coast steelhead

The majority of BRT votes were for "likely to become endangered," and the minority were for "in danger of extinction." The strongest concern was for spatial structure (score 3.9; range 3-5), but abundance and productivity were also a concern (Table B.3.1). The cessation of plants to the ESU from the Big Creek Hatchery (Central Coast ESU) was noted as a positive development; whereas continued predation from sport fishers was considered a negative development.

New data exists suggesting that populations of steelhead exist in most of the streams within the geographic boundaries of the ESU; however, the BRT was concerned that the two largest river systems—the Pajaro and Salinas basins—are much degraded and have steelhead runs much reduced in size. Concern was also expressed about the fact that these two large systems are ecologically distinct from the populations in the Big Sur area and San Luis Obispo County, and thus, their degradation affects spatial structure and diversity of the ESU. Much discussion centered on the dataset from the Carmel River, including the effects of the drought in the 1980s, the current dependence of the population on intensive management of the river system, and the vulnerability of the population to future droughts.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the South-Central California Coast steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including San Antonia, Nacimiento, and Salinas dams on the Salinas River; Los Padres Dam on the Carmel River; Whale Rock Dam on Old Creek; and Lopez Dam on Arroyo Grande Creek; but below natural barriers, provisionally would be part of the ESU. In this ESU, little of the ESU is behind recent barriers and most of that is on the Salinas River.

Southern California steelhead

The majority of BRT votes were for "in danger of extinction," with the remaining votes being for "likely to become endangered." Extremely strong concern was expressed for abundance, productivity, and spatial structure (mean scores of 4.8, 4.3, and 4.8, respectively), and diversity was also of concern (mean score of 3.6) (Table B.3.1).

The BRT expressed concern about the lack of data on this ESU, about uncertainty as to the metapopulation dynamics in the southern part of the range of the ESU, and about the fish's nearly complete extirpation from the southern part of the range. Several members were concerned and uncertain about the relationship between the population in Sespe Canyon, which is supposedly a sizeable population, and the small run size passing through the Santa Clara River, which connects the Sespe to the ocean. There was some skepticism that flows in the Santa Maria River were sufficient to allow fish passage from the ocean to the Sisquoc River, another "stronghold" of *O. mykiss* in the ESU.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the Southern California steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including Twitchell Dam on the Cuyama River; Bradbury Dam on the Santa Ynez River; Casitas Dam on Coyote Creek, Ventura River; Matilija Dam on Matilija Creek, Ventura River; Santa Felicia Dam on Piru Creek, Santa Clara River; and Casitac Dam on Casitac Creek, Santa Clara River; but below natural barriers, provisionally would be part of the ESU. In this ESU, a large portion of the original area is behind barriers and the few densities estimates from this ESU indicate that the inclusion of area above recent barriers substantially increases the number of fish in the ESU. Due to the extremely low numbers of anadromous fish in this ESU, it is possible that above-barrier populations contribute a significant number of fish to the below-barrier population by spill over.

California Central Valley steelhead

The majority of BRT votes were for "in danger of extinction," and the remainder was for "likely to become endangered." Abundance, productivity, and spatial structure were of highest concern (4.2-4.4), although diversity considerations were of significant concern (3.6) (Table B.3.1). All categories received a 5 from at least one BRT member.

The BRT was highly concerned by the fact that what little new information was available indicated that the monotonic decline in total abundance and in the proportion of wild fish in the ESU was continuing. Other major concerns included the loss of the vast majority of historic spawning areas above impassable dams, the lack of any steelhead-specific status monitoring, and the significant production of out-of-ESU steelhead by the Nimbus and Mokelumne River fish hatcheries. The BRT was unmoved by the sparse information suggesting widespread and abundant *O. mykiss* populations in areas above impassable dams, viewing the anadromous life-history form as a critical component of diversity within the ESU. Dams both reduce the scope for and expression of the anadromous life-history form, thereby greatly reducing the abundance of anadromous *O. mykiss*, and preventing exchange of migrants among resident populations, a process presumably mediated by anadromous fish.

Based on the provisional framework discussed in the introduction, the BRT assumed as a working hypothesis that resident fish below historic barriers are part of the California Central Valley steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. According to this framework, native resident fish above recent (usually man-made) barriers including Shasta Dam on the Upper Sacramento River; Whiskeytown Dam on Clear Creek; Black Butte Dam on Stony Creek; Oroville Dam on the Feather River; Englebright Dam on the Yuba River; Camp Far West Dam on the Bear River; Nimbus Dam on the American River; Commanche Dam on the Mokelumne River; New Hogan Dam on the Calaveras River; Goodwin Dam on the Stanislaus River; La Grange Dam on the Tuolumne River; and Crocker Diversion Dam on the Merced River; but below natural barriers, provisionally would be part of the ESU.

Table B.3.1. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 10 steelhead ESUs reviewed. Data presented are means (range).

ESU	**Abundance**	**Growth Rate/Productivity**	**Spatial Structure and Connectivity**	**Diversity**
Snake River	3.1 (2-4)	3.2 (2-4)	2.5 (1-4)	3.1 (2-4)
Upper Columbia	3.5 (2-4)	4.3 (3-5)	3.1 (2-4)	3.6 (2-5)
Middle Columbia	2.8 (2-4)	2.6 (2-3)	2.5 (1-4)	2.6 (2-4)
Lower Columbia	3.3 (2-5)	3.3 (3-4)	2.7 (2-4)	3.0 (2-4)
Upper Willamette	2.8 (2-4)	2.9 (2-4)	2.9 (2-4)	2.6 (2-3)
Northern California	3.7 (3-5)	3.3 (2-4)	2.2 (1-4)	2.5 (1-4)
Central California Coast	3.9 (3-5)	3.9 (3-5)	3.6 (2-5)	2.8 (2-4)
South Central California	3.7 (2-5)	3.3 (2-4)	3.9 (3-5)	2.9 (2-4)
Southern California	4.8 (4-5)	4.3 (3-5)	4.8 (4-5)	3.6 (2-5)
Central Valley	4.4 (4-5)	4.3 (4-3)	4.2 (2-5)	3.6 (2-5)

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C. COHO

C.1 BACKGROUND AND HISTORY OF LISTINGS

Coho salmon (*Oncorhynchus kisutch*) is a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay in California north to Point Hope, AK, through the Aleutians, and from Anadyr River south to Korea and northern Hokkaido, Japan (Laufle et al. 1986). From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water (Gilbert 1912, Pritchard 1940, Sandercock 1991). The primary exceptions to this pattern are "jacks," sexually mature males that return to freshwater to spawn after only 5-7 months in the ocean. However, in southeast and central Alaska, the majority of coho salmon adults are 4-year-olds, having spent an additional year in fresh water before going to sea (Godfrey et al. 1975, Crone and Bond 1976). The transition zone between predominantly 3-year-old and 4-year-old adults occurs somewhere between central British Columbia and southeast Alaska.

With the exception of spawning habitat, which consists of small streams with stable gravels, summer and winter freshwater habitats most preferred by coho salmon consist of quiet areas with low flow, such as backwater pools, beaver ponds, dam pools, and side channels (Reeves et al. 1989). Habitats used during winter generally have greater water depth than those used in summer, and also have greater amounts of large woody debris. West Coast coho smolts typically leave freshwater in the spring (April to June) and re-enter freshwater when sexually mature from September to November and spawn from November to December and occasionally into January (Sandercock 1991). Stocks from British Columbia, Washington, and the Columbia River often have very early (entering rivers in July or August) or late (spawning into March) runs in addition to "normally" timed runs.

Status reviews

The status of coho salmon for purposes of ESA listings has been reviewed many times, beginning in 1990. The first two reviews occurred in response to petitions to list coho salmon in the Lower Columbia River and Scott and Waddell creeks (central California) under the ESA. The conclusions of these reviews were that NMFS could not identify any populations that warranted protection under the ESA in the LCR (Johnson et al. 1991, *FR* 56(124):29553), and that Scott and Waddell creeks' populations were part of a larger, undescribed ESU (Bryant 1994, *FR* 59(80):21744).

A review of West Coast (Washington, Oregon, and California) coho salmon populations began in 1993 in response to several petitions to list numerous coho salmon populations and NMFS' own initiative to conduct a coastwide status review of the species. This coastwide review identified six coho salmon ESUs, of which the three southern most were proposed for listing, two were candidates for listing, and one was deemed "not warranted" for listing (Weitkamp et al. 1995, *FR* 60(142): 38011). In October 1996, the BRT updated the status review for the Central California (CC) ESU, and concluded that it was at risk of extinction (NMFS 1996a). In October 1996, NMFS listed this ESU as threatened (*FR* 61(212): 56138).

In December 1996, the BRT updated the status review update for both proposed and candidate coho salmon ESUs (NMFS 1996b). However, because of the scale of the review, comanagers' requests for additional time to comment on the preliminary conclusions, and NMFS' legal obligations, the status review was finalized for proposed coho salmon ESUs in 1997 (NMFS 1997), but not for candidate ESUs. In May 1997, NMFS listed the Southern Oregon/Northern California coasts (SONCC) ESU as threatened, while it announced that listing of the Oregon Coast (OC) ESU was not warranted due to measures in the OCSRI plan (*FR* 62(87): 24588). This finding for OC coho salmon was overturned in August 1998, and the ESU listed as threatened (*FR* 63(153): 42587).

The process of updating the coho salmon status review was begun again in October 1998 for coho salmon in Washington and the lower Columbia River. However, this effort was terminated before the BRT could meet, due to competing activities with higher priorities.

In response to a petition by (Oregon Trout et al. 2000), the status of Lower Columbia River (LCR) coho salmon was revisited in 2000, with BRT meetings held in March and May 2001 (NMFS 2001a). The BRT concluded that splitting the LCR/Southwest Washington coast ESU to form separate LCR and Southwest Washington coast coho salmon ESUs was most consistent with available information and the LCR ESU was at risk of extinction. Like the 1996 status review update, these results were never finalized.

The coho salmon BRT[1] met in January 2003 to discuss new data received and to determine if the new information warranted any modification of the conclusions of the original BRTs. This report summarizes new information and the preliminary BRT conclusions on the following ESUs: Lower Columbia River, Oregon Coast, Southern Oregon/Northern California coasts, and Central California coast.

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[1] The biological review team (BRT) for the updated status review for West Coast coho salmon included: Dr. Robert Iwamoto, Dr. Orlay Johnson, Dr. Pete Lawson, Gene Matthews, Dr. Paul McElhany, Dr. Thomas Wainwright, Dr. Robin Waples, Laurie Weitkamp, and Dr. John Williams, from NMFS Northwest Fisheries Science Center (NWFSC); Dr. Peter Adams, Dr. Eric Bjorkstedt, and Dr. Brian Spence from NMFS Southwest Fisheries Science Center (SWFSC); and Dr. Reginald Reisenbichler from the Northwest Biological Science Center, USGS Biological Resources Division, Seattle.

C.2.2 SOUTHERN OREGON/NORTHERN CALIFORNIA COASTS COHO

C.2.2.1 Previous BRT Conclusions

The Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU) extends from Cape Blanco in southern Oregon to Punta Gorda in northern California (Weitkamp et al. 1995). The status of coho salmon throughout their West Coast Range, including the SONCC ESU, was formally assessed in 1995 (Weitkamp et al. 1995). Two subsequent status review updates have been published by NMFS, one addressing all West Coast coho salmon ESUs (Schiewe 1996b) and a second specifically addressing the Oregon Coast and Southern Oregon-Northern California ESUs (Schiewe 1997). Information from those reviews regarding extinction risk, risk factors, and hatchery influences is summarized in the following sections.

Status indicators and major risk factors

California populations—Data on population abundance and trends were limited for the California portion of the SONCC ESU. The BRT found no regular estimates of natural spawner escapement for coho salmon in the SONCC, and most information used by the BRT came from reviews by CDFG (1994) and Brown et al. (1994). Historical point estimates of coho salmon abundance for the early 1960s and mid 1980s cited in these reviews were taken from CDFG (1965), Wahle and Pearson (1987), and Sheehan (1991)[2]. These estimates suggest that statewide coho spawning escapement in the 1940s ranged between 200,000 and 500,000 fish (E. Gerstung, CDFG pers. commun. cited in Brown et al. 1994). By the early-to-mid 1960s, statewide escapement was estimated to have declined to just under 100,000 fish (CDFG 1965), with approximately 43,000 fish (44%) originating from rivers within the SONCC ESU (Table C.2.2.1). Wahle and Pearson (1987) estimated that statewide coho salmon escapement had declined to approximately 30,000 fish by the mid-1980s, with about 12,400 (41%) originating within the SONCC ESU. For the late 1980s, Brown et al. (1994) estimated wild and naturalized coho salmon populations at 13,240 for the state, and 7,080 (53%) for the California portion of the SONCC ESU. To derive their estimate, they employed a "20-fish rule" in which all streams known to historically support coho salmon, except those for which recent surveys indicated coho salmon no longer persist (19% of the total), were assumed to still support 20 spawners. For streams where a recent estimate of spawner abundance existed, they used either that estimate or 20 fish, whichever was larger. They suggested that application of the "20-fish rule" likely overestimated total abundance. As Brown et al. (1994) point out, all of these historic estimates are "guesses" of fishery managers and biologists generated using a combination of limited catch statistics, hatchery records, and personal observations.

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[2] For mid-1980s estimates, Brown et al. (1994) cite Wahle and Pearson (1987) who estimate 30,480 total spawners in California whereas CDFG (1994) cites Sheehan's (1991) estimate of 33,500 spawners. It is unclear how Sheehan's estimates were derived and no basin-specific estimates are presented; thus, we have included the estimates of Wahle and Pearson (1987) in Table C.2.2.1 rather than the Sheehan (1991) estimates cited by the BRT (Weitkamp 1995).

Table C.2.2.1. Historical estimates of coho salmon spawner abundance for various rivers and regions within the Southern Oregon/Northern California Evolutionarily Significant Unit.

	Estimated Escapement		
	CDFG (1965)[a]	**Wahle & Pearson (1987)[b]**	**Brown et al. (1994)[c]**
River/Region	**1965**	**1984-1985**	**1987-1991**
CA rivers trib. to Oregon Coast streams	1,000		
Smith River	5,000	2,000	820[d]
Other Del Norte County	400		180[d]
Klamath River	15,400	3,400	1,860
Mainstem Klamath River & tributaries	8,00	1,000	
Shasta River	800	300	
Scott River	800	300	
Salmon River	800	300	
Trinity River	5,00	1500	
Redwood Creek	2,000	500	280
Mad River	2,000	500	460
Eel River	14,000	4,400	2,040[d]
Mainstem Eel River	500	200	
Van Duzen River	500	200	
South Fork Eel River	13,0	4,000	
North Fork Eel River	0	0	
Middle Fork Eel River	0	0	
Mattole River	2,000	500	760[d]
Other Humboldt County	1,500	1,130	680[d]
ESU Total	**43,300**	**12,430**	**7,080**
California Statewide Total	**99,400**	**30,480**	**13,240**

[a] Excludes ocean catch.

[b] Estimates are for wild or naturalized fish; hatchery returns excluded

[c] Estimates are for wild or naturalized fish; hatchery returns excluded. For streams without recent spawner estimates (or estimates lower than 20 fish), assumes 20 spawners.

d. Indicates high probability that natural production is by wild fish rather than naturalized hatchery stocks.

Additional information regarding the status of coho salmon in the SONCC ESU was obtained from an analysis of recent (1987-1991) occurrence of coho salmon in streams historically known to support coho populations (Brown et al. 1994). Of 115 historical streams in the SONCC ESU for which recent data were available, 73 (63%) were determined to still support coho salmon, whereas it was believed they had been lost from 42 (37%). Schiewe (1996b) presented more recent data (1995-1996) on presence of coho salmon within the SONCC ESU, which suggested that the percentage of streams still supporting coho salmon was lower than estimated by Brown et al. (1994). Of 176 streams recently surveyed in the SONCC ESU, 92 (52%) were found to still support coho salmon (P. Adams, NMFS Southwest Fisheries Science Center, pers. comm. cited in Schiewe 1996b). The percentage of streams still supporting coho salmon was lower (46%) in Del Norte County than in Humboldt County (55%). It was unclear whether the apparent reduction in percentage of streams occupied by coho salmon was a function of trends in local extinctions or an artifact of sampling error.

Two recent reviews assessing the status of coho salmon stocks in California were also reviewed by the BRT. Nehlsen et al. (1991) identified coastal populations of coho salmon north of San Francisco Bay (includes portions of the SONCC and CCC ESUs) as being at moderate risk of extinction and Klamath River coho salmon as a stock of special concern. The Humboldt Chapter of the American Fisheries Society (Higgins et al. 1992), utilizing more detailed information on individual river basins, considered three stocks of coho salmon in the SONCC ESU as at high risk of extinction (Scott River [Klamath], Mad River, and Mattole River), and eight more stocks as of special concern (Wilson Creek, Lower Klamath River, Trinity River, Redwood Creek, Little River, Humboldt Bay tributaries, Eel River, and Bear River)[3].

Oregon populations—For the 1997 status update (Schiewe 1997), the BRT was asked to evaluate the status of the ESU under two conditions: first, under existing conditions; second, assuming that hatchery and harvest reforms of the Oregon Coastal Salmon Restoration Initiative (OCSRI) were implemented.

Evaluation under existing conditions—In the Rogue River Basin, natural spawner abundance in 1996 was slightly above levels in 1994 and 1995. Abundances in the most recent 3 years were all substantially higher than abundances in 1989-1993, and were comparable to counts at Gold Ray Dam (upper Rogue) in the 1940s. Estimated return ratios for 1996 were the highest on record, but this may have been influenced by an underestimate of parental spawners. The Rogue River run included an estimated 60% hatchery fish in 1996, comparable to previous years. The majority of these hatchery fish returned to Cole Rivers Hatchery, but there was no estimate of the number that strayed into natural habitat.

Evaluation with hatchery and harvest reforms—The BRT considered only two sets of measures from the OCSRI—harvest management reforms and hatchery management reforms. The BRT did not consider the likelihood that these measures will be implemented; rather, it only considered the implications for ESU status if these measures were fully implemented as described. The BRT had several concerns regarding both the harvest and hatchery components of the OCSRI plan. Some members had a strong concern that we do not know enough about the

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[3] Weitkamp et al. (1995), citing Higgins et al. (1992), indicate that the numbers of stocks at "moderate risk of extinction" and "of special concern" in the SONCC are 6 and 10, respectively. These numbers appear to be in error.

causes of declines in run size and recruits per spawner to be able to directly assess the effectiveness of specific management measures. Some felt that the harvest measures were the most encouraging part of the plan, representing a major change from previous management. However, there was concern that the harvest plan might be seriously weakened when it is re-evaluated in the year 2000 and concern about our ability to effectively monitor non-target harvest mortality and to control overall harvest impacts.

Of the proposed hatchery measures, substantial reductions in smolt releases were thought to have the most predictable benefit for natural populations; all else being equal, fewer fish released should result in fewer genetic and ecological interactions with natural fish. Marking all hatchery fish should also help to resolve present uncertainties about the magnitude of these interactions. However, the BRT expressed concerns regarding some aspects of the proposed hatchery measures. The plan was vague on several key areas, including plans for incorporation of wild broodstock and how production would be distributed among facilities after 1997. One concern was that the recent and proposed reductions appear be largely motivated by economic constraints and the present inability to harvest fish if they were produced rather than by recognition of negative effects of stray hatchery fish on wild populations. Other concerns expressed by the BRT included no reductions in fry releases in many basins and no consideration of alternative culture methods that could be used to produce higher-quality hatchery smolts, which may have less impact on wild fish. Another concern was the plan's lack of recognition that hatchery-wild interactions reduce genetic diversity among populations.

Specific risk factors identified by the BRT included low current abundance, severe decline from historical run size, the apparent frequency of local extinctions, long-term trends that are clearly downward, degraded freshwater habitat and associated reduction in carrying capacity, and widespread hatchery production using exotic stocks. Of particular concern to the BRT was evidence that several of the largest river basins in the SONCC—including the Rogue, Klamath, and Trinity rivers—were heavily influenced by hatchery releases of coho salmon. Historical transfer of stocks back and forth between SONCC and CCC streams was common, and SONCC streams have also received plants from stocks from hatcheries in the lower Columbia River/Southwest Washington, Puget Sound/Strait of Georgia, and Oregon Coast ESUs. However, the BRT considered the frequency of out-of-basin plants to be relatively low compared with other coho salmon ESUs. Recent (late 1980s and early 1990s) droughts and unfavorable ocean conditions were identified as further likely causes of decreased abundance.

Previous BRT conclusions

In the 1995 status review, the BRT was unanimous in concluding that coho salmon in the SONCC ESU were not in danger of extinction but were likely to become so in the foreseeable future if present trends continued (Weitkamp 1995). In the 1997 status update, estimates of natural population abundance in this ESU were based on very limited information. Favorable indicators included recent increases in abundance in the Rogue River and the presence of natural populations in both large and small basins, factors that may provide some buffer against extinction of the ESU. However, large hatchery programs in the two major basins (Rogue and Klamath/Trinity) raised serious concerns about effects on, and sustainability of, natural populations. New data on presence/absence in northern California streams that historically supported coho salmon were even more disturbing than earlier results, indicating that a smaller percentage of streams in this ESU contained coho salmon compared to the percentage presence in an earlier study. However, it was unclear whether these new data represented actual trends in local extinctions, or were biased by sampling effort. This new information did not change the BRT's conclusion regarding the status of the SONCC ESU. Although the OCSRI proposals were directed specifically at the Oregon portion of this ESU, the harvest proposal would affect ocean harvest of fish in the California portion as well. The proposed hatchery reforms can be expected to have a positive effect on the status of populations in the Rogue River Basin. However, the BRT concluded that these measures would not be sufficient to alter the previous conclusion that the ESU is likely to become endangered in the foreseeable future.

Listing status

Coho salmon in the SONCC ESU were listed as threatened in May of 1997 (62FR24588). On July 18, 1997, NMFS published an interim rule (62FR38479) that identified several exceptions to the Endangered Species Act's Section 9 take prohibitions.

C.2.2.2 New Data and Analyses

California populations

Since the status review for West Coast coho salmon (Weitkamp 1995) and subsequent updates (Schiewe 1996b, and Schiewe 1997) were completed, new data and analyses related to the status of coho salmon in the California portion of the SONCC ESU have become available. Most data are of two types: 1) compilations of presence-absence information for coho streams from the period 1987 to the present, and 2) new data on densities of juvenile coho salmon in index reaches surveyed by private timber companies. We found no time series of adult counts (excepting those substantially influenced by hatchery production), and only five time series of adult spawner indices (maximum live/dead counts) for tributaries of the Eel River (Sprowl Creek), the Mad River (Canon Creek), and the Smith River (West Branch of Mill Creek [two datasets] and East Branch of Mill Creek) that span a period of 8 years or more. Limitations of these datasets are discussed in detail below.

Two independent analyses of presence-absence and limited time series data for the SONCC have been published recently. CDFG (2002) analyzed coho salmon presence-absence for SONCC streams spanning brood years 1986-2000. Using an independent dataset, NMFS (2001) published an updated status review for coho salmon in the California portion of the SONCC. Since then, scientists at the Southwest Fisheries Science Center have continued compiling data on coho salmon distribution and abundance and re-analyzed the updated data, inclusive of data used in the CDFG (2002) analysis. Thus, results presented in this report supercede those presented in NMFS (2001).

CDFG presence-absence analysis

Methods—Staff at the North Coast Region of the California Department of Fish and Game attempted to gather all published and unpublished data collected for 392 streams identified by

Brown and Moyle (1991) as historical coho salmon streams[4]. Sources of data included field notes, planting records, and fish surveys from federal, state and tribal agencies, private landowners, and academic institutions, as well as summaries contained in several recently published status reviews (Ellis 1997, Brownell et al. 1999, and NMFS 2001). For each stream and year in which surveys were conducted, observations of coho salmon presence or absence were assigned to the appropriate brood year. If more than one life stage was observed during a survey, then presence was assigned to more than one brood year. Streams that were not surveyed during a particular year were assigned a "presence" value if fish were documented in an upstream tributary during that year. Overall, the CDFG dataset encompasses records from brood year 1986 to 2000, or five complete brood cycles. Additionally, CDFG (2002) presented results of an extensive field study conducted in the summer of 2001 in which 287 of the 392 Brown and Moyle (1991) streams were surveyed for juvenile coho salmon presence-absence[5].

For their brood-year analysis, CDFG (2002) compared the percentage of streams for which coho salmon were detected at any time during two time periods: brood years 1986-1991 and 1996-2000. The first period was designed to coincide with the period encompassed by the Brown and Moyle (1991) study. Statistics were generated based on data from all streams within the SONCC on the original Brown and Moyle list as well as the subset of these streams that were sampled at least once during each of the two time periods. CDFG (2002) also calculated the percentage of streams for which coho salmon were detected in the 2001 field survey.

Results—Including only streams on the Brown and Moyle list, CDFG (2002) found that coho salmon were observed in 143 of 235 (61%) streams surveyed during the period covering brood years 1986-1991 (Table C.2.2.2). This number is similar to the value of 63% found by Brown and Moyle (1991) based on information on about half as many streams (115). For brood years 1995-2000, surveys were conducted on 355 of the 392 historical coho salmon streams. Of these, coho salmon were detected in 179 (50%), suggesting a decline in occupancy. However, when the analysis was restricted to only the 223 streams for which data were available from both time periods, the percent of streams in which coho were detected went from 62% in 1986-1991 to 57% in 1995-2000, a change that was not statistically significant (Pearson Chi square test, p =0.228; Yates corrected chi square test, p =0 .334).

For the 2001 field survey, presence was confirmed in only 121 (42%) of the 287 streams surveyed within the SONCC ESU. CDFG (2002) makes two cautions in interpreting their year 2001 results. First, CDFG considered sampling intensity to be sufficient to have a high likelihood of detecting fish for only 110 of the 166 streams where coho salmon were not found. Second, they note that absence of fish in a single year class does not mean that fish have been extirpated from the system.

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[4] Brown and Moyle (1991) identified 396 streams in California as historical coho streams; however, four of those streams were dropped by CDFG either because barriers make historically occupancy highly unlikely, because the record of occurrence likely reflects a hatchery outplanting, or because streams were duplicated in the Brown and Moyle list.

[5] CDFG repeated their survey of Brown and Moyle (1991) streams in the summer of 2002; however, those data were unavailable at the time of their analysis.

Table C.2.2.2. Historical presence of coho salmon in the SONCC ESU, as determined by Brown and Moyle (1991) and the California Department of Fish and Game's presence-by-brood-year investigation (as of February 2002). County classifications are based on the location of the mouth of the river system. Table modified from CDFG (2002).

	Brown and Moyle (1991) Calendar years 1987-1990				CDFG (2002) Brood years 1986-1991				CDFG (2002) Brood years 1995-2000			
County/River Basin	**no. of streams**	**no. of streams w/info.**	**coho present**	**%**	**no. of streams**	**no. of streams w/info.**	**coho present**	**(%)**	**no. of streams**	**no. of streams w/info.**	**coho present**	**%**
Del Norte County												
Coastal	9	1	1		8	5	3		8	8	6	
Smith River	41	2	2		41	21	7		41	39	14	
Klamath River	113	41	21		112	82	48		112	89	55	
Subtotal	163	44	24	54%	161	108	58	53%	161	136	75	55%
Humboldt County												
Coastal	34	7	7		33	16	14		33	32	18	
Redwood Creek	14	3	3		14	12	12		14	14	11	
Mad River	23	2	2		23	10	8		23	22	14	
Eel River	124	56	34		123	80	48		123	116	45	
Mattole River	38	3	3		38	9	3		38	35	16	
Subtotal	233	71	49	69%	231	127	85	67%	231	219	104	47%
ESU Total	**396**	**115**	**73**	**63%**	**392**	**235**	**143**	**61%**	**392**	**355**	**179**	**50%**

NMFS presence-absence analysis

Methods—Scientists at the NMFS Southwest Fisheries Science Center compiled a presence-absence database for the SONCC comparable to that developed by CDFG. This dataset is a composite of information contained in the NMFS (2001) status review update, additional information gathered by NMFS since the 2001 status review was published, and data used in the CDFG (2002) analysis. There are four significant differences between the data and analytical approach used by NMFS as compared with CDFG. First, the NMFS database includes alls stream with some historical record of coho salmon presence, including many not found on the Brown and Moyle (1991) list. Second, the NMFS database spans a slightly different time period: brood years 1987 to 2001 (rather than 1986 to 2000). At the time these data were compiled, data from summer 2002 field surveys were only partially reported; thus, results from brood year 2001 are preliminary. Third, unlike CDFG (2002), we did not infer presence in streams on the basis of occurrence in upstream tributaries. Although there is an intuitive logic to assigning presence to streams en route to a particular location, including these "inferred presence" values in the analysis tends to positively bias the overall estimate of percent occupancy because the same logic cannot be applied in the case of a recorded "absence." And finally, in our analysis, we present summary information both by brood year and by brood cycle (3-year aggregation). In contrast, in their brood year analysis, CDFG (2002) calculated percent occupancy for 6-year time spans (two complete brood cycles); any observation of presence during that 6-year window resulted in a value of presence for the entire period.

Results for the NMFS presence-absence analyses are presented by major watersheds or aggregations of adjacent watersheds (Table C.2.2.3). In general, results from larger watersheds are presented independently, whereas data from smaller coastal streams, where data were relatively sparse, are grouped together. In a few cases, individual smaller coastal streams with only a few observations were aggregated with adjacent larger streams if there was no logical geographic grouping of smaller streams.

Results—On an annual basis, the estimated percentage of streams in the SONCC for which coho salmon presence was detected has generally fluctuated between 38% and 58% between brood years 1986 and 2000 (Figure C.2.2.1). The data suggest an apparent decline in percent of streams containing coho between 1995 and 2000; however, that decline may be due to an increase in the number of streams sampled covering brood years 1999 and 2000. Data that have been reported for the 2002 summer sampling season suggest a strong year class; however, the number of streams for which data have been reported is small compared to previous years. The pattern is similar whether all historical coho streams or just those identified in Brown and Moyle (1991) are considered (Figure C.2.2.1).

Table C.2.2.3. Percent of surveyed streams within the SONCC ESU for which coho salmon were detected for four time intervals: brood years 1987-1989, 1990-1992, 1993-1995, 1996-1998, and 1999-2001. Streams include those for which historical or recent evidence of coho salmon presence exists (based on NMFS and CDFG data combined).

		1987-1989			1990-1992			1993-1995			1996-1998			1999-2001		
County and River Basins	Number of Streams with Historical Presence	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]
Del Norte (includes OR tributaries)																
Illinois River	9	0	0%	100%	2	100%	0%	2	50%	50%	7	100%	0%	4	75%	25%
Smith River-Winchuck River	57	16	19%	81%	18	44%	56%	45	56%	44%	29	34%	66%	44	43%	57%
Klamath River -Trinity River	199	124	65%	35%	118	70%	30%	136	68%	32%	135	63%	37%	129	55%	45%
Humboldt																
Redwood Creek	32	15	80%	20%	18	94%	6%	20	80%	20%	14	86%	14%	21	76%	24%
Stone/Big Lagoons	5	0	0%	100%	1	100%	0%	0	0%	100%	2	50%	50%	5	20%	80%
Litte River - Strawberry Creek	9	8	100%	0%	9	100%	0%	6	100%	0%	5	100%	0%	6	83%	17%
Mad River	25	7	100%	0%	6	83%	17%	7	86%	14%	7	71%	29%	24	67%	33%
Humboldt Bay tributaries	41	17	94%	6%	13	100%	0%	29	100%	0%	16	88%	13%	23	70%	30%
Eel River	224	105	48%	52%	124	58%	42%	130	58%	42%	58	29%	71%	150	30%	70%
Bear River-Guthrie Creek	5	0	0%	100%	0	0%	100%	3	0%	100%	2	0%	100%	4	0%	100%
Mattole River-McNutt Gulch	57	5	60%	40%	11	36%	64%	21	71%	29%	41	80%	20%	41	37%	63%
ESU Total	**663**	**297**	**60%**	**40%**	**320**	**67%**	**33%**	**399**	**66%**	**34%**	**316**	**60%**	**40%**	**451**	**46%**	**54%**

[1] Total number of steams surveyed at least once within the three-year interval

[2] Percentage of surveyed streams where coho were present in one or more years during the inerval

[3] Percentage of surveyed streams where coho were absent in all years of survey during the interval

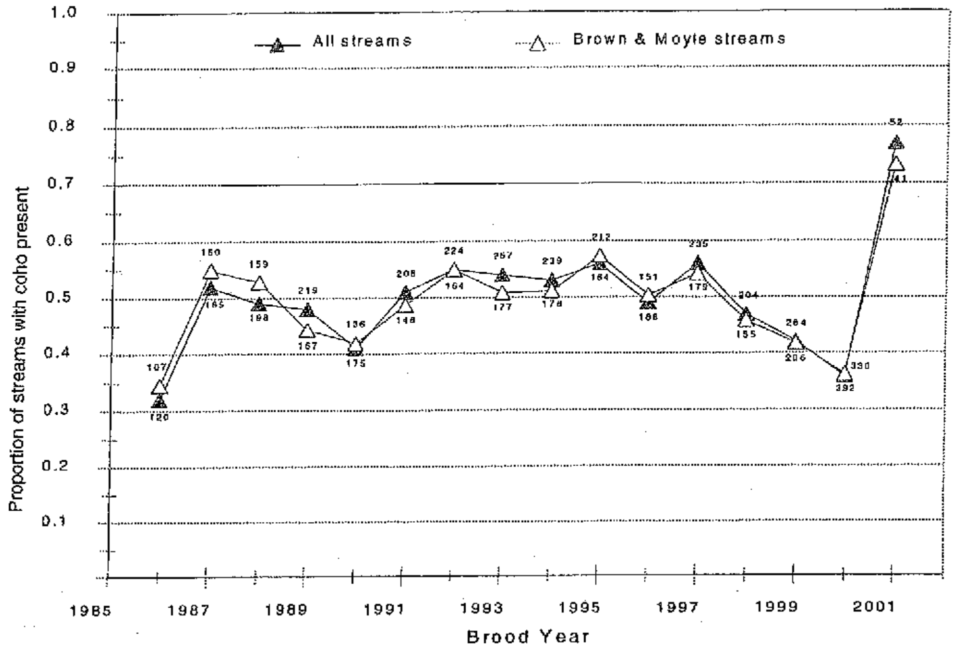

Figure C.2.2.1. Percent of streams surveyed for which coho salmon presence was detected, by brood year, for all historic coho streams (solid triangles) and coho streams identified in Brown and Moyle's (1991) historical list (open triangles) within the SONCC ESU. Sample sizes (i.e. number of streams surveyed) are shown above next to data points. Data are from combined NMFS and CDFG datasets.

When data were aggregated over complete brood cycles (3-year periods), the percentage of streams for which coho salmon presence was detected remained relatively constant (between 60% and 67%) between the 1987-1989 and 1996-1998 brood cycles (Table C.2.2.3). Percent occupancy for the 1999-2001 brood cycle was lower at 46%; however, interpretation of this apparent decline is complicated by two factors. First, the number of streams surveyed was higher than in any other period due to CDFG's intensive survey of the Brown and Moyle streams in the summer of 2001, a drought year. Second, reporting from the 2002 summer season (brood year 2001) remains incomplete, and as noted above, preliminary data indicate that the 2001 brood year was strong. Thus, it is likely that the percent occupancy for this period will increase after all data from CDFG's 2002 survey and other sources are analyzed. When analysis was restricted to streams on the Brown and Moyle (1991) list, the ESU-wide pattern was almost identical, with percent occupancy values being within 1%-2% for all time periods (data not shown). Overall, it appears that there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to the present.

In general, the number of streams sampled within any individual watershed (or grouping of watersheds) was sufficiently small or variable among time periods to make interpretation of local patterns difficult. However, there are a few noteworthy results for watersheds where sampling frequency is higher. Most notable was coho salmon occurrence within the Eel River basin, which appears to have declined from between 48% and 58% in the period between 1987 and 1995 to about 30% in the past two brood cycles. Similarly, the percentage of streams with coho salmon presence in the Klamath-Trinity system appears to have declined over the five brood cycles examined, though the magnitude of the decrease is smaller. In both these cases, anecdotal reports suggest that inclusion of more data from the 2002 sampling year may increase the observed percentages because of the relatively strong adult returns in the winter of 2001-2002. Still, the relatively low percentage of streams that still support coho salmon in the Eel River and the possible downward trend in the Klamath River basin, despite continued heavy hatchery influence, are cause for concern given that these are the largest river basins in the California portion of the SONCC.

The results of NMFS analysis are generally consistent with those of CDFG (2002), but depart from those of NMFS (2001), which suggested a significant decline in percent occupancy in the SONCC from 1989 to 2000. This discrepancy resulted from bias in data used in that analysis towards values of "presence," particularly in the late 1980s to mid 1990s. A more exhaustive examination of stream surveys from the SONCC region compiled by CDFG has substantially increased the total number of observations in the dataset (especially in the earliest years) and those additional observations have been strongly weighted toward "absences."

Adult time series

Spawner surveys have been conducted annually by the California Department of Fish and Game on 4.5 miles of Sprowl Creek, tributary to the Eel River, since 1974 (except in 1976-1977) and on 2 miles of Cannon Creek, tributary to the Mad River, since 1981 (PFMC 2002b). Inconsistent sampling frequency from years—anywhere from one to seven surveys on Sprowl Creek and one to10 surveys on Cannon Creek per year—precludes use of these data for meaningful time series analysis. However, peak live/dead counts for both creeks have generally been low (often 0) during the period of record (Figures C.2.2.2a and C.2.2.2b). Spawner surveys have been conducted by Jim Waldvogel (UC Cooperative Extension) on the West Branch Mill Creek, a tributary to the Smith River, from 1980 to 2001. Peak live/dead counts have fluctuated between two and 28 fish during this period (Figure C.2.2.2c). Surveys have also been conducted on the west branch of Mill Creek, as well as the east branch, by Stimson Timber Company since 1993. Maximum live/dead counts recorded by Stimson on the west branch have been higher than those reported by Waldvogel, but have shown a substantial drop during the 8 years of record (Figure C.2.2.2d). A similar decline has been observed on the east branch of Mill Creek (Figure C.2.2.2e).

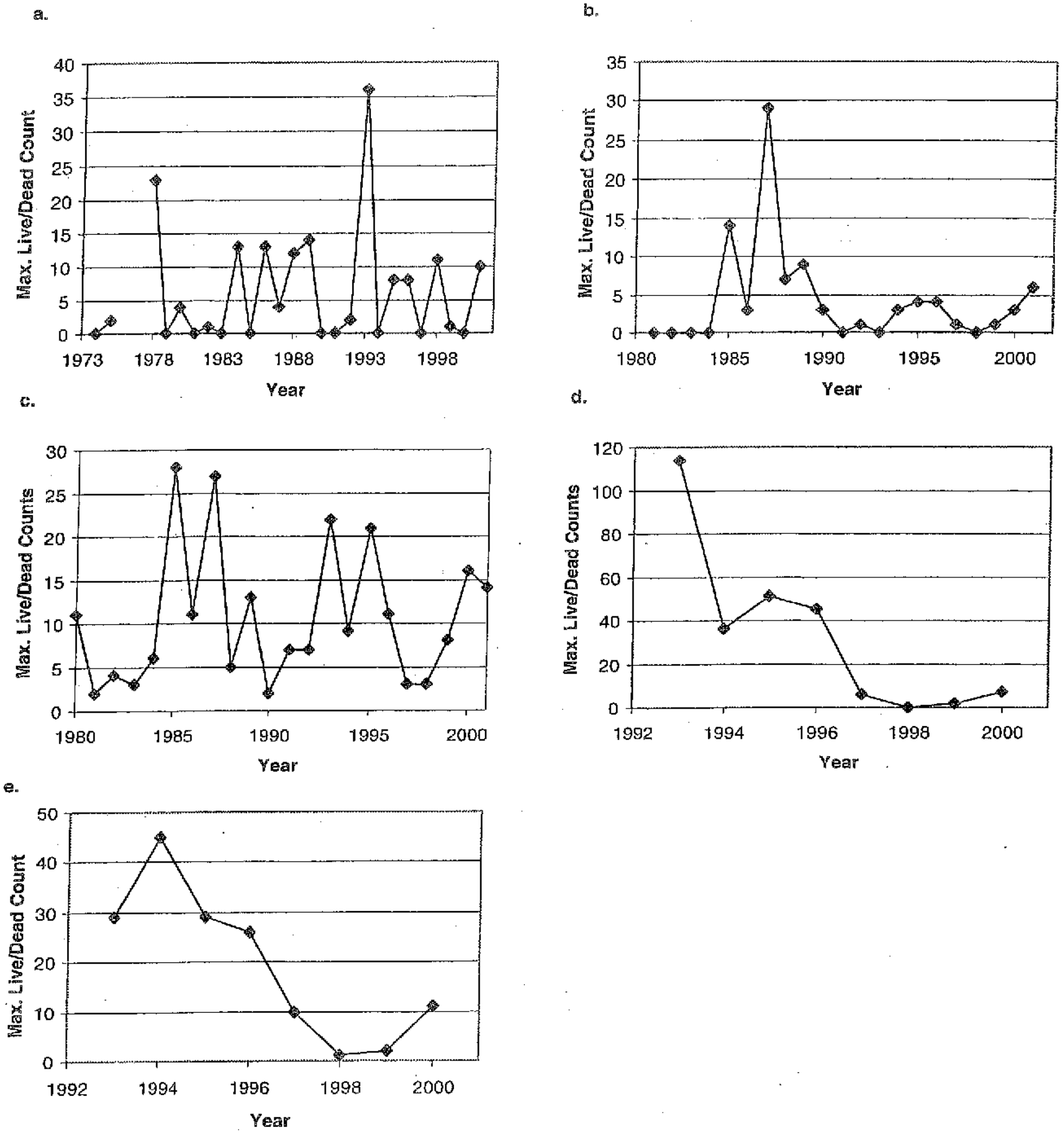

Figure C.2.2.2. Indices of spawner abundance (maximum live/dead counts) for coho salmon in SONCC river systems. a) Sprowl Creek (Eel River) surveys conducted by CDFG (PFMC 2002b); b) Cannon Creek (Mad River) surveys conducted by CDFG (PFMC 2002b); c) West Branch Mill Creek surveys conducted by J. Waldvogel, UC Cooperative Extension (unpubl. Data); d) West Branch Mill Creek surveys conducted by Stimson Timber Company; and e) East Branch Mill Creek surveys conducted by Stimson Timber Company.

Juvenile time series

Methods—Juvenile density during summer have been made at seven index sites within the Eel River basin over the past 8 to 18 years. We performed an exploratory analysis of juvenile density to determine whether such patterns observed in juveniles are consistent with those observed in the analysis of presence-absence information.

To estimate a trend, data were ln-transformed and then normalized so that each data point was expressed as a deviation from the mean of that specific time series. The normalization was intended to prevent spurious trends that could arise from different methods of data collection and reporting units. Following transformation, time series were aggregated, based on watershed structure, into groups thought to plausibly represent independent populations. Linear regression was used to estimate trends (i.e., slopes) for each aggregate dataset. Analysis was restricted to 1) sites where a minimum of 8 years of data were available, and 2) putative populations where more than 65% of the observations were non-zero values.

Results—Aggregate trends were estimated for two putative populations in the SONCC ESU: the South Fork Eel River (based on five sites) and Middle Fork Eel River (two sites). In both cases, trends were positive, but not significantly different from 0 (South Fork: slope 0.053, 95% CI from -.074 to 0.180; Middle Fork: slope 0.016, 95% CI from -0.051 to 0.180).

Oregon populations

One effect of the Oregon Plan has been increased monitoring of salmon and habitats throughout the Oregon coastal region. Besides continuation of the abundance data series analyzed in the 1997 status update, Oregon has expanded its random survey monitoring to include areas south of Cape Blanco, including monitoring of spawner abundance, juvenile densities, and habitat condition.

Spawner abundance—In the Oregon portion of the ESU, spawner abundance is monitored only in the Rogue River Basin. Other small coastal basins have limited coho salmon habitat, and are not thought to have sustainable local coho salmon populations (Jacobs et al. 2002). Within the Rogue Basin, two methods are used to monitor adult abundance: beach-seine surveys conducted at Huntley Park in the upper estuary, and stratified-random spawning ground surveys (Jacobs et al. 2002). The Huntley Park seine estimates provide the best overall assessment of both naturally produced and hatchery coho salmon spawner abundance in the basin (Figure C.2.2.3). Spawner survey-based abundance estimates are also available for the basin since 1998, when the surveys were expanded south of Cape Blanco. These estimates are consistently lower than the seine-based estimates, which may be due in part to losses during upstream migration (Jacobs et al. 2002); however, ODFW considers the seine-based estimates to be more accurate as an overall assessment of spawner abundance (S. Jacobs, ODFW, pers. comm. October 2002). The spawning-ground surveys allow examination of the distribution of spawners among subbasins: in 2001, the majority of spawners were in main tributaries (Illinois and Applegate Rivers and Evans and Little Butte Creeks).

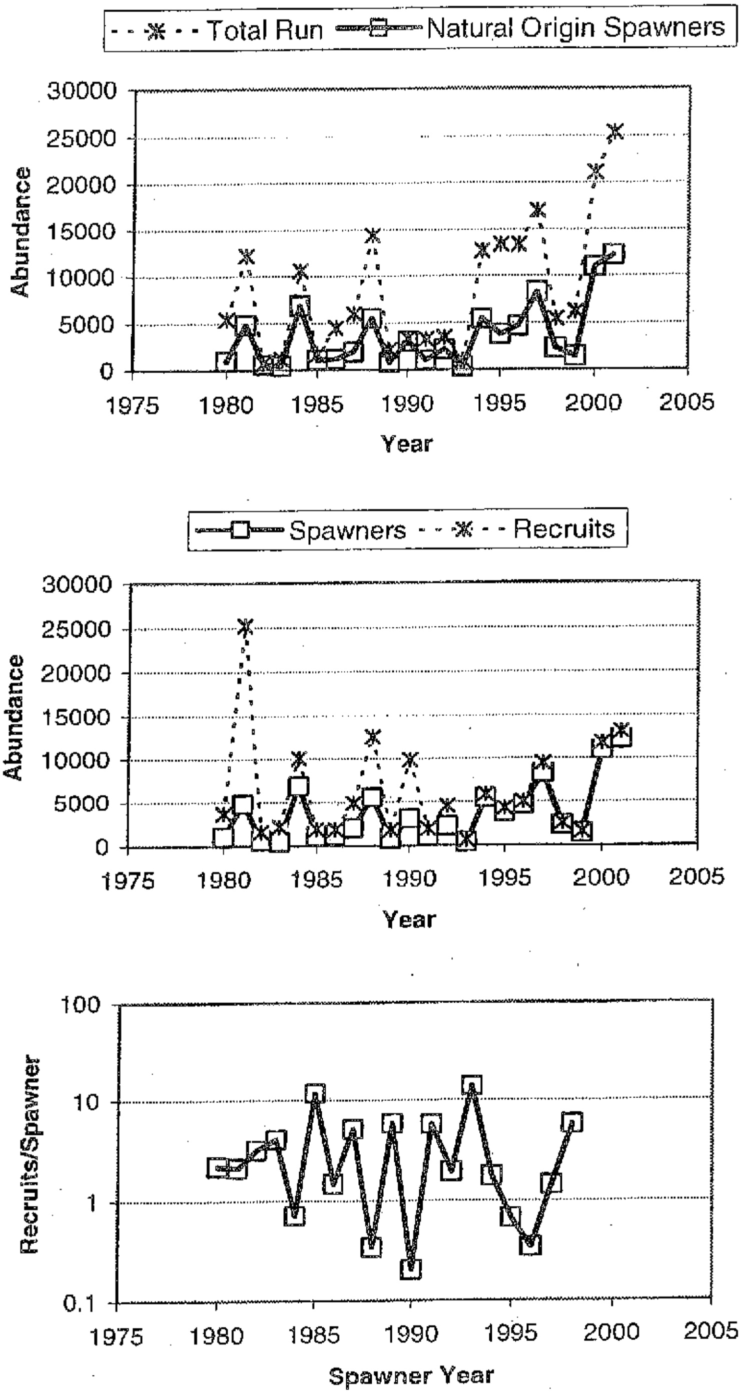

Figure C.2.2.3. Trends in Rogue River coho salmon populations, based on ODFW surveys at Huntley Park (Jacobs et al. 2002). Upper panel—total and natural-origin spawner abundance; middle panel—pre-harvest recruits and spawner abundance; bottom panel—recruits (lagged 3 years) per spawner (note logarithmic scale).

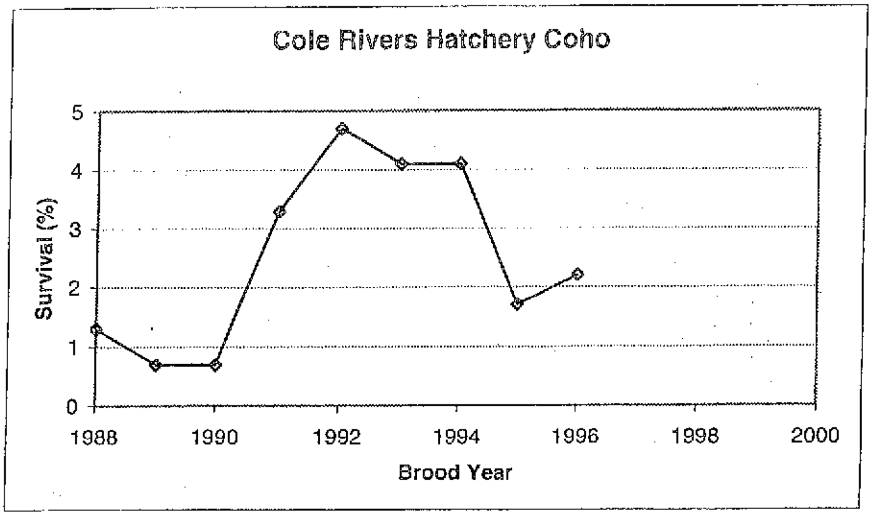

Figure C.2.2.4. Percent survival of CWT-marked coho salmon from Cole Rivers Hatchery, calculated from data in Lewis (2002).

The occurrence of hatchery fish in natural spawning areas is also a consideration for the productivity of the natural population. In Figure C.2.2.3, it can be seen that roughly half of the total spawning run in the Rogue River Basin is hatchery fish. However, many of these fish return to Cole Rivers Hatchery, rather than spawning in natural habitat. Based on fin-mark observations during spawning-ground surveys, the average percent of natural spawners that are of hatchery origin has ranged from less than 2% (2000) to nearly 20% (1998) in recent years. These hatchery spawners are largely concentrated in the mainstem tributaries, with very few hatchery fish observed in major tributaries (Jacobs et al. 2002).

Results—Mean spawner abundance and trends for Rogue River coho salmon are given in Table C.2.2.4. Both short- and long-term trends in naturally produced spawners are upward; however, this increasing trend in spawners results from reduced harvest, as trends in pre-harvest recruits are flat (Figure C.2.2.3). Recruits per spawner fluctuate widely, but has little apparent trend (Figure C.2.2.3). Fluctuations in naturally produced spawner abundance are generally in phase with survival of hatchery fish (Figure C.2.2.4), suggesting that ocean conditions play a large role in population dynamics. Note that hatchery-fish survival for the Rogue River stock is generally higher and follows a different pattern than the general OPI survival index (see Oregon Coast ESU discussion).

Juvenile density—Regular monitoring of juvenile coho salmon in the Oregon portion of the SONCC ESU began in 1998, and 4 years of data are currently available, as reported in Rodgers (2002). Several statistics are reported, including percent occupancy and mean density. Methods differ from the California surveys reported above, so direct comparison of results is problematic. The most comparable statistic to the California presence/absence data is "percentage of sites with at least one pool containing coho," which has been steadily increasing from about 30% in 1998 to 58% in 2001; this compares with a range of 52% to 80% for other parts of the Oregon coast. Percentage of pools per site containing coho salmon has also increased, reaching 41% (s.e. 4.9%) in 2001. Mean juvenile density has also increased over the 3 years. In 2001, overall mean density of juveniles in surveyed pools was 0.38 fish per square meter (fish·m^{-2}); this compares with a range of 0.27 to 0.50 fish·m^{-2} for other areas of the Oregon coast.

Table C.2.2.4 Abundance and trend estimates for Rogue River Basin coho salmon naturally-produced spawners, estimated from Huntley Park seine data (Jacobs et al. 2002) from 1980 to 2001. Shown are the most recent geometric mean (along with minimum and maximum values for the data series) and two trend estimates (see Methods section), both long- and short-term, along with the probability that the true trend is decreasing.

Parameter	Value	95% C.I.	P(decrease)
5-year geometric mean abundance			
Last 5 years	5170		
Minimum	1143		
Maximum	5170		
TREND (Regression estimate)			
Short-term (1990-2001)	1.17	(0.99, 1.38)	0.03
Long-term (1980-2001)	1.08	(1.01, 1.15)	0.01
TREND (Lamda estimate)			
Short-term (1990-2001)	1.19	(1.02, 1.39)	0.02
Long-term (1980-2001)	1.08	(0.93, 1.26)	0.12

Habitat condition—The Oregon Plan Habitat Survey (OPHS) began in 1998, as part of the ODFW Aquatic Inventories Project begun in 1990. Information here is derived from the Survey's year 2000 report (Flitcroft et al. 2001). The survey selects 500-m to 1,000-m sites along streams according to a spatially balanced random selection pattern. The survey includes both summer and winter habitat sampling. In addition to characterization of the site's streamside and upland processes, specific attributes sampled are: large wood, pools, riparian structure, and substrate. The program has established benchmark thresholds as indicators of habitat quality:

- Pool area greater than 35% of total habitat area;
- Fine sediments in riffle units less than 12% of all sediments;
- Volume of large woody debris greater than 20 m^3 per 100 m stream length;
- Shade greater than 70%;
- Large riparian conifers more than 150 trees per 305 m stream length.

For the combined 1998-2000 surveys in the Oregon portion of the SONCC ESU, 6% of sites surveyed met none of the benchmarks, 29% met one, 38% met two, 20% met three, 5% met four, and 2% met all five benchmarks. No trends in habitat condition can yet be assessed from this data, but it will provide a basis for future assessment of changes in habitat quality.

C.2.2.3 New Comments

The Siskiyou County Farm Bureau submitted comments arguing that SONCC coho salmon should not be protected under ESA, particularly because the relationship of Iron Gate Hatchery fish in the Klamath River to the SONCC ESU remains uncertain. Their principal arguments is that widespread historical outplanting of juvenile coho salmon and incorporation of non-native fish into hatchery broodstock make application of the ESU concept inappropriate; they argue that all West Coast coho salmon should be considered a single ESU.

The Siskiyou Project submitted comments supporting continued listing of coho salmon in the SONCC under ESA. They argue that 1) the status of native, naturally reproducing coho salmon in the SONCC remains unchanged since they were listed in 1997; 2) increases in adult coho salmon observed in 2001 and 2002 are mostly due to improved ocean conditions and reduced harvest, and are not indicative of long-term trends; 3) severe drought in the winter 2001-2002 and summer 2001 are likely to result in lower smolt production in spring 2002 and adult returns in 2003; 4) habitat already in poor condition is likely to deteriorate with increasing human demands for natural resources and inadequate regulations; and 5) continued large releases of hatchery coho salmon pose a threat to naturally produced fish through competition, mixed-stock fishing, and reduced fitness associated with interbreeding of hatchery and wild fish. The Siskiyou Project also includes a report authored by Cindy Deacon Williams, private consultant, titled *Review of the status of Southern Oregon/Northern California coho with thoughts on recovery planning targets*. Ms. Williams' report presents basin-by-basin assessments of the status of coho salmon (using primarily previously published analyses), habitat conditions, and ongoing activities that pose risks to coho salmon. She also recommends numeric recovery criteria for SONCC coho salmon and argues that habitat targets are needed to ensure recovery.

The Douglas County Board of Commissioners submitted a report, *Viability of coho salmon populations on the Oregon and northern California coasts*, submitted to NMFS Protected Resources Division on 12 April 2002 and prepared by S.P. Cramer and Associates, Inc. (Cramer and Ackerman 2002). This report analyzes information available for both the Oregon Coastal Coho Salmon ESU and the SONCC ESU in several areas: trends in abundance and distribution, trends in survival, freshwater habitat condition, potential hatchery-wild interactions, changes in harvest regulation, and extinction risk modeling. Little of the information presented in the report is specific to the SONCC ESU. They cite changes in fishery management, increasing spawning escapements, reduced hatchery releases, habitat restoration, and evidence of successful rearing of fry outmigrants throughout the Oregon Coast, some information for the Rogue River basin, but no new information for California populations.

Daniel O'Hanlon, attorney at law, submitted comments on two occasions (April 12, 2002 and July 24, 2002) on behalf of Save Our Shasta and Scott Valley Towns (S.O.S.S), an organization of citizens concerned about the effects of ESA regulations. The latter submission includes comments submitted to the California Fish and Game Commission regarding the petition to list coho salmon in Northern California under the state Endangered Species Act, which include, by reference, a critique of CDFG's (2002) status review prepared by Dr. Charles Hanson. Though the critique is of the state's analysis of coho status, some the arguments are germane to the federal status review since the underlying data are comparable. The essential arguments from this collection of documents are 1) the limited data presented in the initial status reviews was insufficient to assess, in a scientifically rigorous way, the degree of extinction risk facing coho salmon in the SONCC; 2) there is no evidence of an immediate or near-term risk of extinction based on analysis of either presence-absence data or abundance trend data; presence-absence data have a number of weaknesses, and historical trend data (abundance and harvest) are unreliable; and 3) existing regulatory structures are adequate to protect coho salmon; new regulations would hinder, rather than help coho recovery.

The Yurok Tribal Fisheries Program submitted recent data from various sampling efforts in the lower Klamath River and its tributaries. Included were data from downstream migrant traps, adult snorkel surveys, tribal harvest, and harvest catch-per-unit effort. Data on relative contribution of wild and hatchery fish at the lower Klamath and lower Trinity downstream migrant trapping sites are discussed in the section on New Hatchery/ESU Information below. Other data were incorporated into NMFS presence-absence analysis discussed above. None of the time series available met the minimum criterion of 8 years, which was decided upon by the BRT as the minimum needed for trend analysis.

C.2.2.4 New Hatchery/ESU Information

Weitkamp et al. (1995) identified four hatcheries that were producing and releasing coho salmon within the SONCC ESU during the mid 1990s: Mad River Hatchery, Trinity River Hatchery, Iron Gate Hatchery, and Cole Rivers Hatchery. Prairie Creek hatchery produced coho salmon for many years, but closed in 1992 (CDFG 2002). Rowdy Creek hatchery is a privately owned hatchery that has produced coho salmon in the past; however, the facility did not produce coho salmon in 1999 and 2000 due to lack of adult spawners (CDFG 2002), and no further production of coho salmon at this facility is planned (Andrew VanScoyk, Rowdy Creek Hatchery, pers. comm.).

Iron Gate Hatchery—Iron Gate Hatchery (IGH), located on the Klamath River near Hornbrook, California, approximately 306 km from the ocean, was founded in 1965 and is operated by the California Department of Fish and Game (CDFG). The IGH stock was developed initially from Trinity River coho salmon released in 1966, though releases of Cascade (Columbia River) stock were made in 4 of the first 5 years of hatchery operation. An unknown stock was also released in 1970. Since 1977, only Klamath Basin fish have been released from IGH, including 2 years when Trinity River fish were planted (1977 and 1994).

Annual releases of coho salmon from IGH have decreased from an average of approximately 147,000 fish from 1987-1991 to about 72,000 fish from 1997-1999 (Table C.2.2.5), which is near CDFG's goal of 75,000 yearlings released per year. Adult returns averaged 1,120 fish between 1991 and 2000, and an average of 161 females have been spawned annually during this period.

Table C.2.2.5. Average annual releases of coho salmon juveniles (fry and smolts) from selected hatcheries in the SONCC coho salmon ESU during release years 1987-1991, 1992-1996, and 1997-2002.

	SSHAG	Average Annual Releases		
Hatchery	**Category**	**1987-1991**	**1992-1996**	**1997-2002**
Cochran Ponds (HFAC)		35,391[a]	na[b]	0[b]
Mad River	4	372,863	91,632	82,129[c]
Prairie Creek		89,009[d]	0[e]	0[e]
Trinity River	2	496,813	385,369	527,715
Iron Gate (Klamath)	2	147,272	92,150	71,932[f]
Rowdy Creek		0	12,534[g]	10,615[h]
Cole Rivers (Rogue)	1	271,492	240,000[i]	315,000[j]
Total		**1,413,380**	**821,685**	**1,007,391**

[a] Average from 2 years (1987-1988).
[b] Coho salmon were produced by the Humboldt Fish Action Council (HFAC) through the 1994 brood year; release data for 1992 to 1996 are currently unavailable; no fish were released after 1996 (S. Holz, HFAC, pers. commun.)
[c] CDFG ceased spawning coho salmon at Mad River Hatchery in 1999; yearling were last released in 2001
[d] Average from 4 years (1987-1988, 1990-1991)
[e] Prairie Creek hatchery ceased producing coho salmon in 1992.
[f] Does not include releases from year 2002 (data not available)
[g] Average from 2 years (1995-1996); data not available for 1992-1995.
[h] Rowdy Creek hatchery ceased releasing coho in year 2001.
[i] Average from 1991-1995.
[j] Average from 1996-2002; includes juvenile coho salmon released to lakes.

The California Department of Fish and Game and National Marine Fisheries Service Joint Hatchery Review Committee (2001) noted that no accurate estimates of the relative contribution of wild vs. hatchery fish are available for the Klamath River basin. Beginning in 1995, coho salmon released from IGH have been marked with left maxillary clips; however, return information has been published for only a single year, 2000. These data indicate that 80% of 1,353 fish returning to IGH were marked hatchery fish, with 98% being Iron Gate releases. A few fish from the Trinity and Cole Rivers (Rogue River, Oregon) hatcheries were also taken. The significance of this high percentage of hatchery fish with respect to total production in the Klamath Basin is uncertain since IGH lies near the upper end of the accessible habitat.

Additional information about the composition of Klamath Basin stocks is available from downstream migrant trap data collected by Yurok Tribal Fisheries (2002) in 1997 and 1998. The lower Klamath River trap is located below the confluence of the Klamath and Trinity rivers and thus captures fish from both the Iron Gate and Trinity hatcheries. During 2 years of sampling, Trinity hatchery fish dominated the total catch accounting for 73% and 83% of all fish caught in 1997 and 1998, respectively. Iron Gate Hatchery fish accounted for around 5% of the catch in both years. Naturally produced coho salmon made up 22% of the total catch in 1997 and 12% of the catch in 1998. In 1998, a trap was also operated on the lower Trinity River. Only 9% of the smolts captured at this trap were naturally produced. Assuming that this proportion accurately reflected the relative contributions of naturally produced and hatchery Trinity River fish to catch at the Lower Klamath trap, then the percentages of naturally produced and hatchery fish exiting the Klamath River proper (above the Trinity confluence) were approximately 42% and 58%, respectively.

The BRT was uncertain about whether the use of non-native stocks to start the Iron Gate population was of sufficient importance to have lasting effects on the present population. Thus, they reached no conclusion about whether the hatchery stock should be included in the ESU (Schiewe 1997). Subsequently, Iron Gate was determined to be a Category 2 hatchery (SSHAG 2003). For other SSHAG hatchery stock categorizations, see Appendix C.5.1.

Trinity River Hatchery—Trinity River Hatchery (TRH), located below Lewiston Dam approximately 248 km from the ocean, first began releasing coho salmon in 1960. The TRH facility originally used Trinity River fish for broodstock, though coho salmon from Eel River (1965), Cascade River (1966, 1967, and 1969), Alsea River (1970), and Noyo River (1970) have also been reared and released at the hatchery as well as elsewhere in the Trinity Basin.

Trinity River Hatchery produces the largest number of coho salmon of any production facility in California. CDFG's annual production target is 500,000 yearlings. Actual production averaged 496,813 from 1987-1991, decreased to 385,369 from 1992-1996, and then increased again to 527,715 fish from 1997-2002 (Table C.2.2.5). During the period 1991-2001, an average of 3,814 adult coho were trapped and 562 females were spawned at the TRH.

It is commonly assumed that there is little production of wild coho salmon in the Trinity River system, and available data support this assumption. Outmigrant trapping on the lower Trinity River indicates that marked TRH fish made up 91%, 97%, and 65% of the catch in years 1998, 1999, and 2000, respectively. Additionally, significant fractions of the naturally produced fish are likely the progeny of hatchery strays. Between 1997 and 2001, an estimated 85% to 95% of in-river spawners upstream of the South Fork Trinity River were TRH strays (Wade Sinnen, pers. comm. cited in CDFG 2002).

The BRT concluded that coho salmon from the Trinity River Hatchery should be considered part of the SONCC ESU since out-of-basin and out-of-ESU transfers ceased by 1970 and production since that time has been exclusively from fish within the basin. The lack of natural production within the Trinity Basin, however, remains a significant concern. The Trinity Hatchery is a Category 2 hatchery (SSHAG 2003).

Mad River Hatchery—Mad River Hatchery (MRH), located approximately 20 km upriver near the town of Blue Lake, first began producing coho salmon in 1970. The original broodstock (1970) was from the Noyo River, which lies outside of the SONCC ESU, and Noyo fish were released from the hatchery during 12 additional years between 1971 and 1996. Other stocks released from the hatchery include out-of-ESU transfers from the Trask River (1972), Alsea River (1973), Klaskanie River (1973), Green River (1979), and Sandy River (1980), as well as out-of-basin, within-ESU transfers from the Trinity River (1971), Klamath River (1981, 1983, 1986-1989), and Prairie Creek (1988, 1990).

Releases of Mad River fish declined substantially during the past decade, from an average of 372,8643 fish in 1987-1991 to just over 82,000 in the period from 1997-2001 (Table C.2.2.5).

Production of coho salmon at MRH ceased after brood year 1999, thus, the year 2001 releases represent the final year of hatchery production. Adult returns were low during the 1990s, with an average of 38 adults trapped and 16 females spawned during the period between 1991 and 1999. No information was available regarding the relative contribution of naturally produced and artificially propagated fish within the Mad River basin. However, concern about both out-of-ESU and out-of-basin stock transfers, as late as 1996, was sufficiently great that the Mad River Hatchery was excluded from the SONCC ESU by NMFS (Schiewe 1997). This conclusion has been rendered moot by the decision to cease producing coho salmon at the Mad River facility.

Rowdy Creek Hatchery—Rowdy Creek Hatchery is a privately owned hatchery in the Smith River Basin constructed in 1977. Production emphasis has been on chinook and steelhead, but small numbers of coho salmon were trapped and bred during the period 1990 to 1998. Only local coho salmon broodstock have been used at the Rowdy Creek facility (Schiewe 1997).

Annual releases of coho salmon yearlings averaged 12,534 between 1995 and 1996, and 15,923 from 1997 to 2000, when releases were terminated (Table C.2.2.5). Adult returns to the hatchery averaged just 26 fish in the 11 years that coho salmon were trapped (A. Van Scoyk, Rowdy Creek Hatchery, unpublished data). No information was available on the relative contribution of Rowdy Creek Hatchery coho salmon to the Smith River population as a whole, but it was undoubtedly a minor component during the period of operation.

In its status review update, the BRT (Schiewe 1997) concluded that the Rowdy Creek Hatchery population should be considered part of the ESU, but that it was not essential for ESU recovery. This conclusion has been rendered moot by the decision to cease producing coho salmon at the facility.

Cole Rivers Hatchery—The Cole Rivers Hatchery has raised Rogue River (Oregon stock #52) coho salmon since 1973 to mitigate for lost production due to construction of Lost Creek Dam. This stock was developed from local salmon trapped in the river, and has no history of out-of-basin fish being incorporated. Recent releases (1996-2002) have averaged 315,000 per year, compared to a 1991-1995 average of 240,000 per year (Table C.2.2.5); the increase is due to inclusion in the data of large-sized coho salmon released to lakes in the basin in recent years (Bill Waknitz, NMFS, pers. comm.). Spawning of hatchery fish in nature is essentially limited to mainstem tributaries and (to a lesser extent) the Applegate River, and interbreeding with natural fish is limited by separation in spawning time (Jacobs et al. 2002). The hatchery is rated as a Category 1 hatchery (SSHAG 2003).

Summary

Artificial propagation of coho salmon within the SONCC has been substantially reduced in the past 8 to 10 years, with the exception of Cole Rivers Hatchery on the Rogue River and the Trinity River hatchery. Annual releases from the Cole Rivers and Trinity hatcheries have recently averaged 315,000 and 500,000 fish, respectively. Production has ceased at one major facility (Mad River), as well as well as several minor facilities (Rowdy Creek, Eel River, and Mattole River). Production at Iron Gate Hatchery on the Klamath River has been reduced by approximately 50%. Genetic risks associated with out-of-basin and out-of-ESU stock transfers have largely been eliminated. However, two significant genetic concerns remain: 1) the potential for domestication selection in hatchery populations such as Trinity River, where there is little or no infusion of wild genes, and 2) out-of-basin straying by large numbers of hatchery coho.

Harvest impacts

Retention of coho salmon by commercial troll fishers south of Cape Falcon, OR, has been prohibited since 1993 (PFMC 2002b). From Cape Falcon, OR, south to Horse Mountain, CA, retention of coho salmon in recreational ocean fisheries has been prohibited since 1994, and in 1995, this prohibition was extended to include all California ocean recreational fisheries (CDFG 2002). The conservation objective set by the Pacific Fishery Management Council for the past five seasons has been an overall ocean exploitation of ≤13% for SONCC coho salmon as indicated by exploitation of Rogue/Klamath hatchery stocks (PFMC 2002b). Post-season estimates of Rogue/Klamath exploitation rate are unavailable; however, projected exploitation rates ranged from 3.0% to 11.7% during the period 1998 to 2002 (PFMC 1998-2002a). Inside harvest estimates of coho salmon are not available for rivers in the California portion of the SONCC (PFMC 2002b).

C.2.2.5 Comparison with Previous Data

New data for the SONCC coho salmon ESU includes expansion of presence-absence analyses, a limited analysis of juvenile abundance in the Eel River basin, a few indices of spawner abundance in the Smith, Mad, and Eel river basins, and substantially expanded monitoring of adults, juveniles, and habitat in southern Oregon. None of these data contradict conclusions reached previously by the BRT. Nor do any of recent data (1995 to present) suggest any marked change, either positive or negative, in the abundance or distribution of coho salmon within the SONCC ESU. Coho salmon populations continued to be depressed relative to historical numbers, and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. Although the 2001 brood year appears to be the one of the strongest perhaps of the last decade, it follows a number of relatively weak years. The Rogue River stock is an exception; there has been an average increase in spawners over the last several years, despite 2 low years (1998, 1999).

No new information has been provided that suggests risks beyond those identified in previous status reviews. Termination of hatchery production of coho salmon at the Mad River and Rowdy Creek facilities has eliminated potential adverse risk associated with hatchery releases from these facilities. Likewise, restrictions on recreational and commercial harvest of coho salmon since 1994 have likely had a positive impact on coho salmon adult returns to SONCC streams.

C.2.3 CENTRAL CALIFORNIA COHO

C.2.3.1 Previous BRT Conclusions

The Central California Coast (CCC) coho salmon Evolutionarily Significant Unit extends from Punta Gorda in Northern California south to and including the San Lorenzo River in Central California (Weitkamp et al. 1995). The status of coho salmon throughout their West Coast range, including the CCC ESU, was formally assessed in 1995 (Weitkamp et al. 1995). Two subsequent status review updates with information pertaining to the CCC ESU were published by NMFS in 1996 (Schiewe 1996a, b). Analyses from those reviews regarding extinction risk, risk factors, and hatchery influences is summarized in the following sections.

Status indicators and major risk factors

Data on abundance and population trends of coho salmon within the CCC ESU were limited. Historical time series of spawner abundance for individual river systems were unavailable. Brown et al. (1994) presented several historical point estimates of coho salmon spawner abundance (excluding ocean catch) for the entire state of California for 1940 and for various rivers and regions in the early 1960s and mid 1980s (Table C.2.3.1). Coho salmon were estimated to number between 200,000 and 500,000 statewide in the 1940s (E. Gerstung, CDFG, pers. comm., cited in Brown et al. 1994). Coho salmon spawning escapement was estimated to have declined to about 99,400 fish by the mid-1960s, with approximately 56,100 (56%) originating from streams within the CCC ESU (Table C.2.3.1). In the mid-1980s, spawning escapement was estimated to have dropped to approximately 30,480 in California and 18,050 (59%) within the CCC ESU. Employing the "20-fish rule" (see status review update for Southern OR-Northern CA Coast coho salmon for details), Brown et al. (1994) estimated wild and naturalized coho salmon populations at 6,160 (47% of the statewide total) for the CCC ESU during the late 1980s (Table C.2.3.1). All of these estimates are considered to be "best guesses" based on a combination of limited catch statistics, hatchery records, and personal observations of local biologists (Brown et al. 1994).

Further information regarding status was obtained from Brown et al.'s (1994) analysis of recent (1987-1991) occurrence of coho salmon in streams historically known to support populations. Of 133 historical coho salmon streams in the CCC ESU for which recent data were available, 62 (47%) were determined to still support coho runs while 71 (53%) apparently no longer support coho salmon (Table C.2.3.2). A subsequent analysis of surveys from 1995-1996 found a somewhat higher (57%) percentage of occupied streams (Schiewe 1996b, based on pers. comm. with P. Adams, NMFS Southwest Fisheries Science Center).

Nehlsen et al. (1991) provided no specific information on individual coho salmon populations in their 1991 status review, but concluded that salmon stocks in small coastal streams north of San Francisco were at moderate risk of extinction and those in coastal streams south of San Francisco Bay were at high risk of extinction. A subsequent status review by the Humboldt Chapter of the American Fisheries Society (Higgins et al. 1992) found four populations (Pudding Creek, Garcia River, Gualala River, and Russian River) as high risk of extinction and five (Ten Mile, Noyo, Big, Navarro, and Albion rivers) as stocks of concern.

Table C.2.3.1. Historical estimates of coho salmon spawner abundance for various rivers and regions within the Central California Coast Evolutionarily Significant Unit.

	Estimated Escapement		
	CDFG (1965)[a]	**Wahle & Pearson (1987)[b]**	**Brown et al. (1994)[c]**
River/Region	**1963**	**1984-1985**	**1987-1991**
Ten Mile River	6,000	2,000	160[d]
Noyo River	6,000	2,000	3,740
Big River	6,000	2,000	280
Navarro River	7,000	2,000	300
Garcia River	2,000	500	
Other Mendocino County	10,000	7,000[e]	470[f]
Gualala River	4,000	1,000	200
Russian River	5,000	1,000	255
Other Sonoma County	1,000		180
Marin County	5,000		435
San Mateo & Santa Cruz Counties	4,100	550	140
San Mateo County	1,000		
Santa Cruz County (excl. San	1,500	50	
San Lorenzo River	1,600	500	
ESU Total	**56,100**	**18,050**	**6,160**
Statewide Total	**99,400**	**30,480**	**13,240**

[a] Values excludes ocean catch.

[b] Estimates are for wild or naturalized fish; hatchery returns excluded.

[c] Estimates are for wild or naturalized fish; hatchery returns excluded. For streams without recent spawner estimates (or estimates lower than 20 fish), assumes 20 spawners.

[d] Indicates high probability that natural production is by wild fish rather than naturalized hatchery stocks.

[e] Value may include Marin and Sonoma County fish.

[f] Appears to include Garcia River fish.

Risk factors identified by the BRT included extremely low contemporary abundance compared to historical abundance, widespread local extinctions, clear downward trends in abundance, extensive habitat degradation, and associated decreases in carrying capacity. Additionally, the BRT concluded that the main stocks of coho salmon in the CCC ESU have been heavily influenced by hatcheries and that there were relatively few native coho salmon left in the ESU (Weitkamp et al. 1995). Most existing stocks have a history of hatchery planting, with many out-of-ESU stock transfers. A subsequent status review (Schiewe 1996a), which focused on existing hatcheries, concluded that, despite the historical introduction of non-native fish, the Scott Creek (=Kingfisher Flat) and Noyo River brood stocks have regularly incorporated wild broodstock and, thus, were unlikely to differ from naturally spawning fish within the ESU. Recent droughts and unfavorable ocean conditions were identified as natural factors contributing to reduced run size.

Table C.2.3.2. Historical presence of coho salmon in the CCC ESU, as determined by Brown and Moyle (1991) and the California Department of Fish and Game's analysis of recent presence (1995-2001). County classifications are based on the location of the mouth of the river system. Data from CDFG (2002).

	Brown et al. (1994) Calendar years 1987-1990				CDFG (2002) Years 1995-2001				
County/River Basin	**no. of streams**	**no. of streams w/info.**	**coho present**	**%**	**no. of streams surveyed in 2001**	**no. of streams w/coho present**	**no. of streams w/coho assumed present**	**no. of streams w/coho not detected in 2001**	**Percent present (1995-2001)**
Mendocino									
Coastal	44	35	13	37%	30	11	10	19	52%
Ten Mile River	11	10	7	79%	11	9	0	2	82%
Noyo River	13	12	11	92%	8	7	5	1	92%
Big River	16	13	11	85%	8	3	6	5	64%
Navarro River	19	8	4	50%	14	6	1	8	47%
Subtotal	103	78	46	59%	71	36	22	35	62%
Sonoma County									
Coastal	10	2	1	50%	4	0	0	4	0%
Gualala River	11	2	1	50%	10	0	0	10	0%
Russian River	32	24	2	8%	29	1	1	28	0%
Subtotal	53	28	4	14%	43	1	1	42	4%
Marin County									
Coastal	10	7	7	100%	15	6	0	9	40%
Subtotal	10	7	7	100%	15	6	0	9	40%
Tribs. to S.F. Bay									
Coastal	7	7	0	0%	6	0	0	6	0%
Subtotal	7	7	0	0%	6	0	0	6	0%
South of S.F. Bay									
Coastal	13	13	5	38%					
Subtotal	13	13	5	38%					
ESU Total	186	133	62	47%	135	43	23	92	42%

Previous BRT conclusions

Based on the data presented above, the BRT concluded that all coho salmon stocks in the CCC ESU were depressed relative to historical abundance and that most extant populations have been heavily influenced by hatchery operations. They unanimously concluded that natural populations of coho salmon in this ESU were in danger of extinction (Weitkamp et al. 1995). After considering new information on coho salmon presence within the ESU, the majority of the BRT concluded that the ESU was in danger of extinction, while a minority concluded the ESU was not presently in danger of extinction but was likely to become so in the foreseeable future (Schiewe 1996b).

Listing status

Coho salmon in the CCC ESU were listed as threatened in October 1996.

C.2.3.2 New Data and Analyses

Significant new information on recent abundance and distribution of coho salmon within CCC ESU has become available, much of which has been summarized in two recent status reviews (NMFS 2001; CDFG 2002). Most of these data are of two types: 1) compilations of presence-absence information for coho salmon throughout the CCC during the period 1987 to the present, and 2) new data on densities of juvenile coho salmon collected at a number of index reaches surveyed by private timber companies, CDFG, and other researchers. Excepting adult counts made at the Noyo Egg Collecting Station, which are both incomplete counts and strongly influenced by hatchery returns, there are no current time series of adult abundance within this ESU that span 8 or more years. Outmigrating smolts have been trapped at two trapping facilities in Caspar Creek and Little River since the mid-1980s; however, these are partial counts and only recently have mark-recapture studies been performed that allow correction for capture efficiency at these two sites. Thus, these smolt counts can only be considered indices of abundance.

Two analyses of presence-absence data have recently been published. CDFG (2002) performed an analysis that focused on recent (1995-2001) presence of coho salmon in streams identified as historical producers of coho salmon by Brown and Moyle (1991). NMFS (2001) published an updated status review that analyzed coho salmon presence in streams throughout the CCC during the period 1989 to 2000. Scientists at NMFS' Southwest Fisheries Science Center have continued to compile information of coho salmon presence-absence and have incorporated data into a database that is now summarized by brood year (rather than year of sampling) and covers brood years 1986-2001. Data from CDFG's 2001 field survey of the Brown and Moyle (1991) streams has been incorporated into this database. Analyses presented in the present status review update supercede those presented in NMFS (2001b).

CDFG presence-absence analysis

Methods—Methods used by CDFG (2002) for analyzing presence-absence information in the CCC differed from those used for the SONCC analysis. Analysis focused on results from CDFG's 2001 summer juvenile sampling effort in which 135 of 173 streams identified by Brown and Moyle (1991) as historical coho salmon streams within the CCC ESU were sampled. Additionally, CDFG assumed presence of coho salmon in any stream for which presence had been detected during any 3 consecutive years during the period 1995-2001. An estimate of percent coho salmon presence was calculated by totaling the number of streams for which presence was either observed or assumed, and dividing by the total number of streams surveyed, inclusive of those where presence was assumed. No formal statistical analysis of trends was performed because of the lack of comparable data from previous time periods.

Results—For the CCC ESU as a whole, CDFG (2002) estimated that coho salmon were present in 42% of streams historically known to contain coho salmon. Estimated occupancy was highest in Mendocino County (62%), followed by Marin County (40%), Sonoma County (4%), and San Francisco Bay tributaries (0%) (Table C.2.3.2). Although the numbers are not directly comparable with those derived by Brown et al. (1994), because the specific streams and methods used differ between the two studies, the general regional and overall ESU patterns are similar (Table C.2.3.2). The apparent decrease in percent presence in Marin County is likely a function of the increase in number of streams surveyed by CDFG rather than actual extirpations of populations.

NMFS presence-absence analysis

Methods—Scientists at NMFS' Southwest Fisheries Science Center compiled survey information from streams with historical or recent evidence of coho salmon presence within the CCC ESU. Data were provided primarily by the California Department of Fish and Game, private landowners, consultants, academic researchers, and others who have conducted sampling within the CCC during the years 1988 to 2002. The majority of data come from summer juvenile surveys, though information from downstream migrant trapping and adult spawner surveys were also included. Observations of presence or absence for a particular stream were assigned to the appropriate brood year based on the life stages observed (or expected in the case of absences). The resulting dataset spans brood years 1987 to 2001, though data from the 2002 summer field season (brood year 2001) were not fully reported at the time the analysis was performed.

Results for NMFS' presence-absence analysis are presented by major watersheds or aggregations of adjacent watersheds. Results from larger watersheds are typically presented independently, whereas data from smaller coastal streams, where data were relatively sparse, are grouped together. In a few cases, individual smaller coastal streams with only a few observations were aggregated with adjacent larger streams if there was no logical geographic grouping of smaller streams.

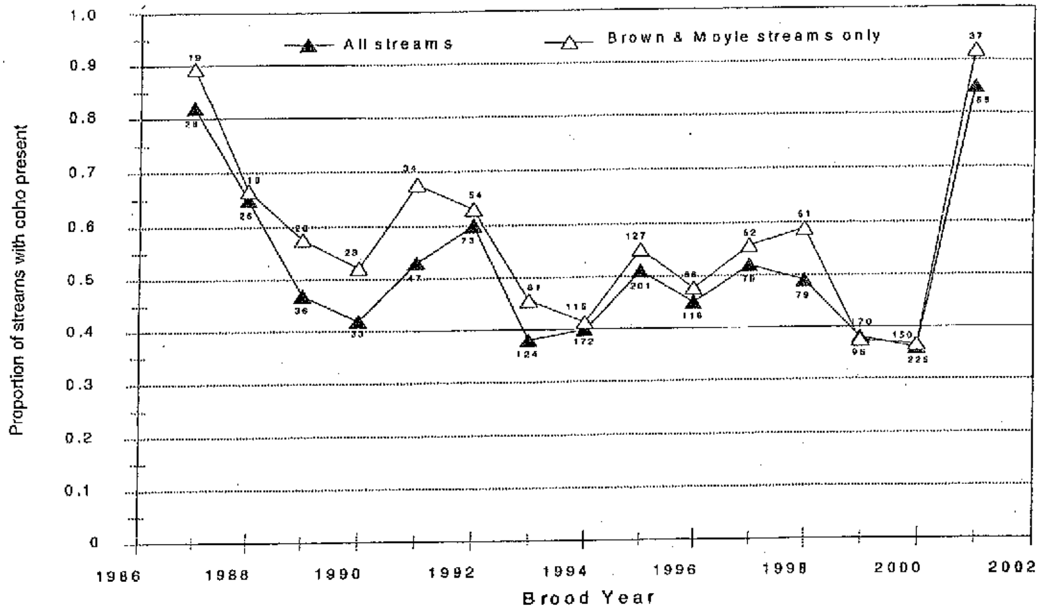

Figure C.2.3.1. Percent of streams surveyed for which coho salmon presence was detected, by brood year, for all historic coho streams (solid triangles) and coho streams identified in Brown and Moyle's (1991) historical list (open triangles) within the CCC ESU. Sample sizes (i.e. number of streams surveyed) are shown above next to data points. Data are from combined NMFS and CDFG datasets.

Results—The estimated percentage of streams in which coho salmon were detected shows a general downward trend from 1987 to 2000, followed by a substantial increase in 2001 (Figure C.2.3.1). Several caveats, however, warrant discussion. First, the number of streams surveyed per year also shows a general increase from 1987 to 2000; thus, there may be a confounding influence of sampling size if sites surveyed in the first half of the time period are skewed disproportionately toward observations in streams where presence was more likely. Second, sample size from brood year 2001 was relatively small and the data were weighted heavily toward certain geographic areas (Mendocino County and systems south of the Russian River). The data for brood year 2001 included almost no observations from watersheds from the Navarro River to the Russian River, or tributaries to San Francisco Bay, areas where coho salmon have been scarce or absent in recent years. Thus, while 2001 appears to have been a relatively strong year for coho salmon in the CCC as a whole, the high percentage of streams where presence was detected shown in Figure C.2.3.1 is likely inflated.

Two other patterns were noteworthy. First, compared with percent presence values for the SONCC ESU, values in the CCC were more highly variable and showed a somewhat more cyclical pattern. In general, percent occupancy was relatively low in brood years 1990, 1993, 1996, and 1999, suggesting that this brood lineage is in the poorest condition. In contrast, during the 1990s, percent occupancy tended to be high in brood years 1992, 1995, 1998, and 2001, suggesting that this is the strongest brood lineage of the three. Second, there is a general tendency for percent occupancy to be slightly higher (2%-15%) for the Brown and Moyle streams compared with the ESU as a whole, indicating that the Brown and Moyle streams do not constitute a random subset of CCC streams.

When data are aggregated over brood cycles (3-year periods), the percentage of streams with coho salmon detected shows a similar downward trend, from 73% in 1987-1989, to 63% in 1990-1992, to less than 50% in the last three brood cycles (Table C.2.3.3). Again there are confounding influences of increased sampling fraction through time and incomplete reporting for the 2001 brood year. Nevertheless, it appears that the percent of historical streams occupied continued to decline from the late 1980s to the mid-1990s and remains below 50% for the ESU as a whole. Additionally, coho salmon appear to be extinct or nearing extinction in several geographic areas including the Garcia River, the Gualala River, the Russian River, and San Francisco Bay tributaries. There is also evidence that some populations that still persist in the southern portion of the range, including Waddell and Gazos creeks, have lost one or more brood lineages (Smith 2001).

Results from our presence-absence analysis are generally concordant with CDFG's analysis. The two studies show consistent regional patterns suggesting that within the CCC the proportion of streams occupied is highest in Mendocino County, but that populations in streams in the southern portion of the range (excluding portions of Marin County) have suffered substantial reductions in range. NMFS analysis is more suggestive of a continued decline in percent occupancy from the late 1980s to the present; however, increased sampling in recent years may be confounding any trends.

Adult time series

No time series of adult abundance free of hatchery influence and spanning 8 or more years are available for the CCC ESU. Adult counts from the Noyo Egg Collecting Station (ECS) dating back to 1962 represent a mixture of naturally produced and hatchery fish, and counts are incomplete most years since trap operation typically ceased after brood stock needs were met. Thus, at best they represent an index of abundance. Assuming that these counts reflect general population trends, there appears to have been a significant decline in abundance of coho salmon in the South Fork Noyo River beginning in 1977 (Figure C.2.3.2). No formal analysis of trends was conducted because of the uncertainty of the relationship between catch statistics and population size, as well as the relative contribution of hatchery fish to total numbers during the entire period of record.

Smolt time series

California Department of Fish and Game personnel have trapped outmigrating smolts at Caspar Creek and Little River since 1986. These counts are partial counts, uncorrected for capture efficiency. As such, they provide only indices of abundance. However, they likely capture gross changes in smolt abundance over the years (Figure C.2.3.3). The most recent 5-year means were 1,168 and 379 for Caspar Creek and Little River, respectively. For both locations, the estimated long-term trend is negative (but not significantly different from 0), while the short-term trend is positive (also not significantly different from 0) (Table C.2.3.4). For Little River, smolt counts were higher in each year from 1986 to 1989 than in any year since. For both sites, lambda values are greater than 1, though 95% confidence limits indicate the values are not significantly different from one.

Table C.2.3.3. Percent of surveyed streams within the CCC ESU for which coho salmon were detected for four time intervals: brood years 1987-1989, 1990-1992, 1993-1995, 1996-1998, and 1999-2001. Streams include those for which historical or recent evidence of coho salmon presence exists (based on combined NMFS and CDFG data).

		1987-1989			1990-1992			1993-1995			1996-1998			1999-2001		
County and River Basins	Number of Streams with Historical Presence	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]	Number Surveyed[1]	Coho Present[2]	Coho Absent[3]
Mendocino																
Coastal (Punta Gorda to Abolabodiah Cr.)	24	4	75%	25%	6	50%	50%	16	50%	50%	11	18%	82%	19	32%	68%
Ten Mile River	25	6	50%	50%	15	53%	47%	17	65%	35%	14	57%	43%	16	94%	6%
Pudding Cr. to Noyo River	43	4	75%	25%	8	88%	13%	35	66%	34%	15	80%	20%	38	68%	32%
Coastal (Hare Cr. to Russian Gulch)	14	8	100%	0%	4	100%	0%	9	67%	33%	9	67%	33%	4	75%	25%
Big and Little Rivers	28	5	20%	80%	7	57%	43%	20	75%	25%	16	81%	19%	16	38%	63%
Albion River	16	3	100%	0%	3	100%	0%	15	80%	20%	1	100%	0%	14	86%	14%
Little Salmon & Big Salmon Cr.	6	0	0%	100%	3	100%	0%	4	75%	25%	4	75%	25%	4	100%	0%
Navarro River	30	1	100%	0%	1	0%	100%	24	58%	42%	6	67%	33%	23	52%	48%
Coastal (Greenwood Cr. to Brush Cr.)	8	3	0%	100%	2	50%	50%	8	13%	88%	0	0%	100%	8	0%	100%
Garcia River to Digger Cr.	8	3	100%	0%	2	0%	100%	8	13%	88%	5	20%	80%	7	0%	100%
Sonoma																
Gualala River	15	1	100%	0%	1	0%	100%	11	0%	100%	1	0%	100%	11	9%	91%
Fort Ross to Russian River	53	4	50%	50%	14	50%	50%	37	51%	49%	29	24%	76%	36	8%	92%
Marin																
Tomales Bay Rivers	25	3	100%	0%	4	100%	0%	14	36%	64%	10	90%	10%	21	57%	43%
Coastal (Redwood Cr. to Bolinas Lagoon)	6	0	0%	100%	1	100%	0%	2	50%	50%	4	75%	25%	5	100%	0%
San Francisco Bay																
SF Bay Rivers	6	0	0%	100%	4	0%	100%	6	0%	100%	4	0%	100%	0	0%	100%
San Mateo/Santa Cruz																
Coastal (SF Bay to Aptos Creek)	17	7	100%	0%	7	100%	0%	13	69%	31%	14	57%	43%	12	67%	33%
Monterey																
Coastal (Carmel R. to Big Sur R.)	2	0	0%	100%	0	0%	100%	2	0%	100%	0	0%	100%	2	0%	100%
ESU Total	**326**	**52**	**73%**	**27%**	**82**	**63%**	**37%**	**241**	**53%**	**47%**	**143**	**54%**	**46%**	**236**	**48%**	**52%**

[1] Total number of steams surveyed at least once within the three-year interval

[2] Percentage of surveyed streams where coho were present in one or more years during the interval

[3] Percentage of surveyed streams where coho were absent in all years of survey during the interval

Table C.2.3.4. Population trend analysis for Caspar Creek and Little River smolt outmigrant data. Trends are based on smolt counts uncorrected for trap efficiency (see text). Data source: Scott Harris, CDFG, unpublished data.

Stream	5-year mean	5-year min.	5-year max.	Lambda	Long-term trend [a]	Short-term trend [a]
Caspar Cr.	1,168	830	1,383	1.002 (0.851, 1.178)	-0.017 (-0.081, 0.048)	0.040 (-0.069, 0.149)
Little R.	379	82	1,203	0.919 (0.669, 1.347)	-0.063 (-0.358, 0.232)	0.273 (-0.256, 0.803)

[a] Values in parentheses are lower and upper bounds for 95% confidence limits.

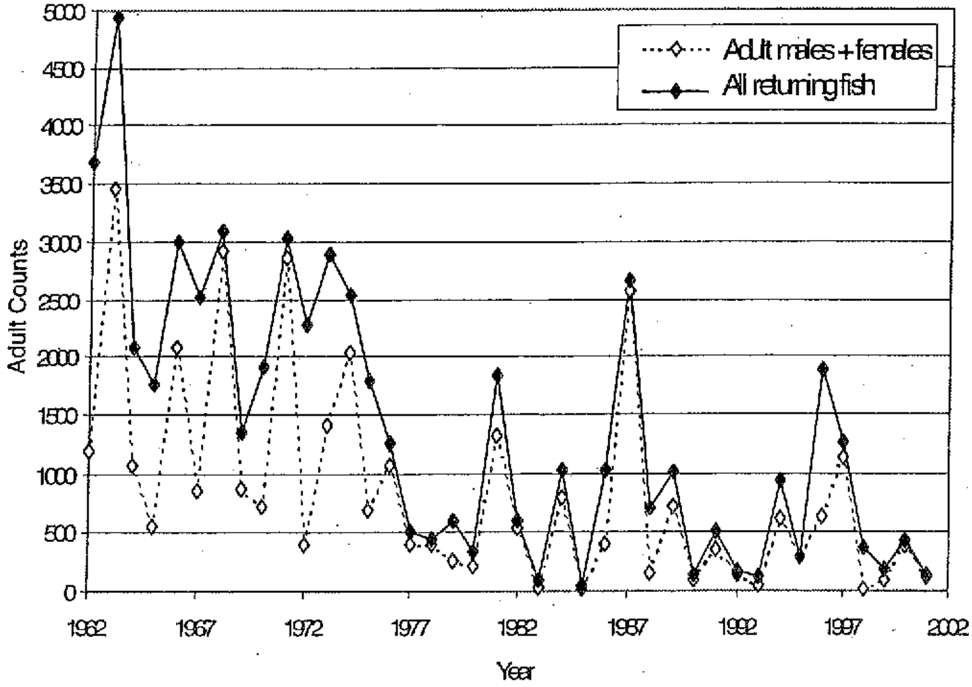

Figure C.2.3.2. Counts of adult coho salmon at Noyo Egg Collecting Station from 1962 to 2002. Solid line with closed symbol indicates total fish captured (including grilse); dashed line with open symbols indicates adult males and females only. Counts are partial counts and thus are only a crude index of adult abundance. Data source: Grass 2002.

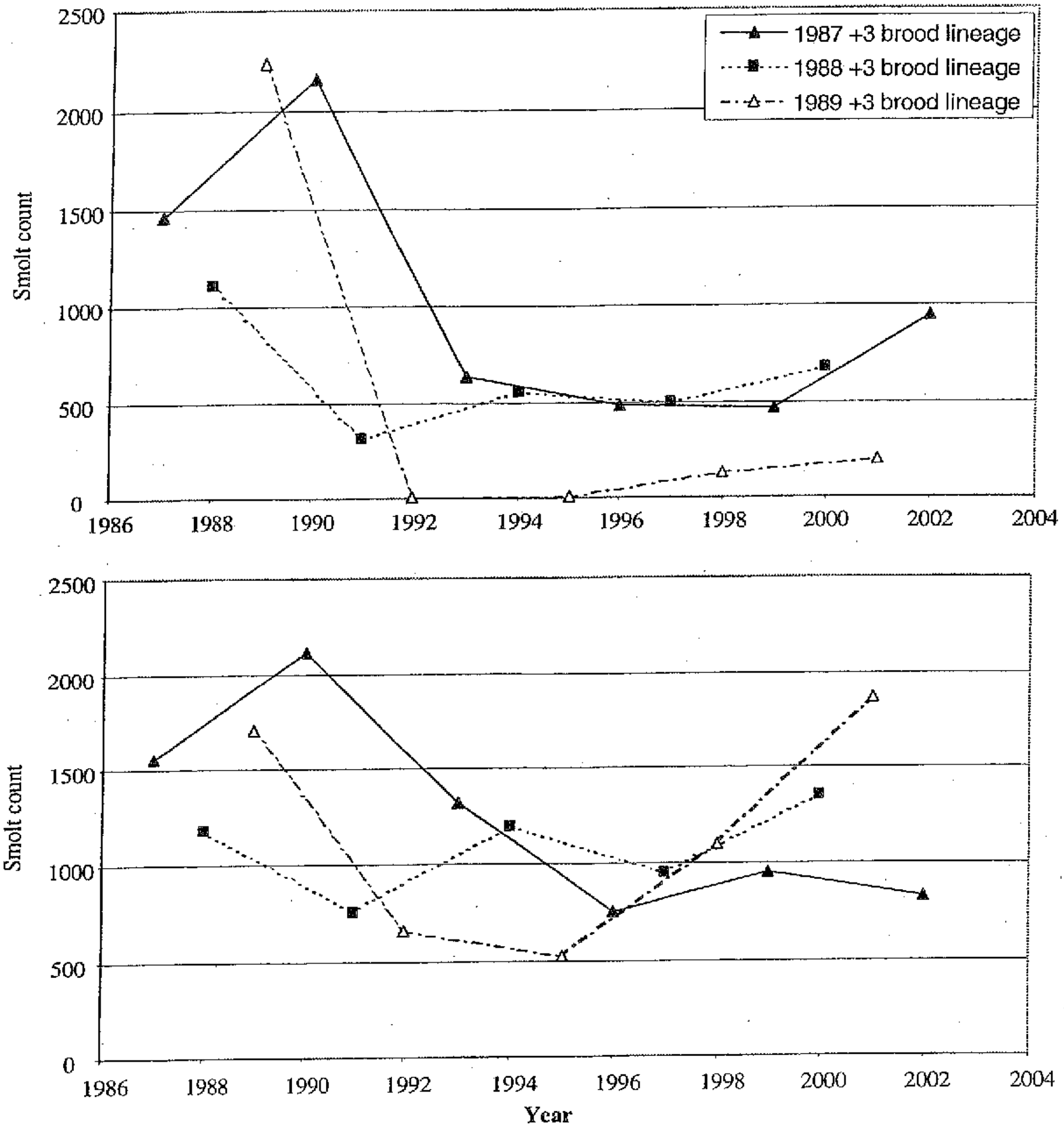

Figure C.2.3.3. Coho salmon smolt counts at a) Caspar Creek and b) Little River, Mendocino County. Lines track brood lineages. Data are counts of smolts uncorrected for trap efficiency and thus should be viewed as coarse indices of abundance.

Table C.2.3.5. Trend slopes and confidence intervals for nine putative coho populations in the CCC ESU.

Watershed	No. Sites	Aggregate Slope	95% confidence interval	
			Lower bound	**Upper bound**
Pudding Creek	1	-0.019	-0.103	0.065
Noyo River	8	-0.091	-0.195	0.013
Caspar Creek	2	-0.039	-0.109	0.030
Little River	2	-0.044	-0.118	0.029
Big River	2	0.146	-0.001	0.293
Big Salmon Creek	5	-0.005	-0.110	0.100
Lagunitas Creek	3	0.095	-0.123	0.312
Redwood Creek	1	0.091	-0.345	0.527
Waddell/Scott/Gazos creeks	3	-0.111	-0.239	0.018

Juvenile time series

Methods—While recent estimates of adult and smolt abundance are scarce for the CCC ESU, estimates (or indices) of juvenile density during summer have been made at more than 50 index sites within the CCC in the past 8 to 18 years. Methods for analyzing these data are described in detail in the SONCC coho salmon status review update. Briefly, data from individual sampling sites were ln-transformed and normalized to prevent spurious trends arising from different data collection methods or reporting units. Data were then grouped into units thought to represent plausible independent populations, based on watershed structure. Trends were then estimated for putative populations by estimating the slope (and associated 95% confidence intervals) for the aggregated data. Analysis was restricted to 1) sites where a minimum of 6 years of data were available, and 2) putative populations where more than 65% of all observations were non-zero values.

Nine geographic areas (putative populations) were represented in the aggregated data including Pudding Creek, Noyo River, Caspar Creek, Big River, Little River, Big Salmon Creek, Lagunitas Creek, Redwood Creek, and coastal streams south of San Francisco Bay, including Waddell, Scott, and Gazos creeks. Spatially, these sites cover much of the CCC ESU; however, several key watersheds are not represented, including the Ten Mile, Navarro, Garcia, Gualala, and Russian Rivers. Although considerable sampling has been done in the Ten Mile River basin, the high proportion of zero values precluded analysis of these data.

Results—Overall, analysis of juvenile data provided little evidence of either positive or negative trends for the putative populations examined. Estimated slopes were negative for six populations and positive for three; however, none of the estimated slopes differed significantly from zero (Table C.2.3.5).

C.2.3.3 New Comments

Homer T. McCrary, vice president of Big Creek Lumber, submitted 375 pages comprised primarily of excerpts from historical documents related to operation of hatcheries in Santa Cruz County from the early 1900s to 1990. The expressed intent of this compilation was "to assist the efforts of resource professionals, scientists, regulators, fisheries restoration advocates and all interested parties in establishing a more complete historical perspective on salmonid populations." Quantitative information regarding hatchery and stocking histories is discussed in the Harvest Impact section.

C.2.3.4 New Hatchery/ESU Information

The BRT (Weitkamp et al. 1995) identified four production facilities that had recently produced coho salmon for release in the CCC ESU: the Noyo Egg Collecting Station (reared at Mad River Hatchery) and Don Clausen (Warm Springs) hatchery, both operated by CDFG; Big Creek Hatchery (Kingisher Flat Hatchery), operated by the Monterey Bay Salmon and Trout Program; and the Silver-King ocean ranching operation. The latter facility closed in the late 1980s.

Noyo Egg Collecting Station—The Noyo Egg Collecting Station, located on the South Fork Noyo River approximately 17 km inland of Fort Bragg, began operating in 1961 and has collected coho salmon in all but a few years since that time. Fish have historically been reared at the Mad River Hatchery, Don Clausen (Warm Springs) Hatchery, and the Silverado Fish Transfer Station. There are no records of broodstock from other locations being propagated with Noyo fish for release back into the Noyo system, but a few out-of-ESU transfers directly into the Noyo system have been recorded, including Alsea and Klaskanine, OR stocks (SSHAG 2003).

Average annual release of coho salmon yearlings was 108,000 from 1987-1991 (Weitkamp et al. 1995), declined to about 52,000 between 1992 and 1996, and then increased again to about 72,000 fish between 1997 and 2002, inclusive of 2 years where no yearlings were released (Table C.2.3.6). Releases have been made exclusively to the ECS or elsewhere in the South Fork Noyo drainage in the past decade. Between 1991 and 2001, adult returns averaged 572 individuals, though these represent incomplete counts in most years, as counting typically ceased after broodstock needs were met (Grass 2002). On average, 91 females were spawned annually during this 11-year period (Grass 1992-2002).

There are no basin-wide estimates of natural and artificial production for the Noyo Basin as a whole; however, marking of coho salmon juveniles released from the Noyo ECS on the South Fork began in 1997, and returns have been monitored since the 1998-1999 spawning season. In the 1998, 1999, and 2000 brood years, marked hatchery fish constituted 85%, 70%, and 80%, respectively, of returning adults captured at the ECS.

The BRT (Schiewe 1996a) concluded that, although exotic stocks have occasionally been introduced into the Noyo system, the regular incorporation of local natural fish into the hatchery population made the likelihood that this population differs substantially from naturally spawning fish in the ESU is low and, therefore, included them in the ESU. Since CCC coho salmon were listed, no significant changes in hatchery practices have occurred. The Noyo ECS operation has been classified as a Category 1 hatchery (SSHAG 2003).

Don Clausen (Warm Springs) Hatchery—The Don Clausen Hatchery (a.k.a. Warm Springs stock), located on Dry Creek in the Russian River system 72 km upstream of the mouth, began operating in 1980. Initial broodstock used were from the Noyo River system, and Noyo fish were planted heavily from 1981 to 1996.

Average annual releases of coho salmon from the hatchery decreased from just over 123,000 in the 1987-1991 period to about 57,000 in the years between 1992 and 1996, and Noyo River broodstock continued to constitute about 30% of the releases during the latter period. Production of coho salmon at the facility ceased entirely after 1996 (Table C.2.3.6). Adult returns averaged 245 fish between 1991 and 1996, but following the cessation of releases, no more than four coho salmon have been trapped at the hatchery in any subsequent year.

Because the Warm Spring population was originally derived from Noyo River stock and continued to receive transfers from the Noyo system throughout its operation, the BRT concluded that the hatchery population was not a part of the ESU.

Beginning in 2001, however, a captive broodstock program was initiated at the Don Clausen facility. A total of 337 juveniles were electro-fished from Green Valley and Mark West Springs creeks, two Russian River tributaries that still appear to support coho salmon, as well as Olema Creek, a tributary to Lagunitas Creek. Specific mating protocols for these fish have not yet been determined. The captive broodstock program proposes to eventually release 50,000 fingerlings and 50,000 yearlings into five Russian River tributaries. Under the captive broodstock program, the Don Clausen Hatchery has been classified as a Category 1 hatchery (SSHAG 2003).

Kingfisher Flat (Big Creek) Hatchery—The Monterey Bay Salmon and Trout Program (MBSTP) has operated Kingfisher Flat Hatchery, located on Big Creek, a tributary to Scott Creek, since 1976. The facility is near the site of the former Big Creek Hatchery, which was operated from 1927 to 1942, when a flood destroyed the facility. An additional facility in Santa Cruz County, the Brookdale Hatchery on the San Lorenzo River, operated from 1905 to 1953. Both the Big Creek and Brookdale hatcheries were supplied with eggs taken at an egg-collection facility located on Scott Creek; additional eggs were provided from other hatcheries around the state. Production of coho salmon at both hatcheries was sporadic. Releases of Sisson (Mt. Shasta) coho salmon were made in Scott Creek and other Santa Cruz County streams in 1913, 1915, and 1917. In subsequent years, releases from both facilities back into Scott Creek in included both Scott Creek fish (1929, 1930, 1934, and 1936-1939), as well as fish from Ft. Seward, Mendocino County (1932), and Prairie Creek, Humboldt County (1933, 1935, and 1939). Throughout these years, only fry were released (generally during July through September), and numbers of fish were relatively small. In the 10 years between 1929 and 1939, during which coho salmon were planted in Scott Creek, the total fry release averaged about 34,000 fish. During the Silver-King operation, broodstock was obtained from Oregon, Washington, British Columbia, and Alaska.

Table C.2.3.6. Average annual releases of coho salmon juveniles (fry and smolts) from hatcheries in the CCC coho salmon ESU during release years 1987-1991, 1992-1996, and 1997-2002. Data sources: Weitkamp et al. 1995; Grass 1992-2002; Williams 1993; Cartwright 1994; Quinones 1995-1999; CDFG Hatchery Staff 2000; Wilson 2001-2002.

Hatchery	SSHAG Cat.	Annual Average Releases 1987-1991	1992-1996	1997-2002
Monterey Bay Salmon and Trout	1	25,764	na[a]	na[a]
Silver-King		95,074[b]	0[c]	0[c]
Noyo Egg Collecting Station	1	107,918	52,012[d]	72,363[e]
Don Clausen (Warm Springs) Hatchery	1	123,157	56,891[f]	0[g]
Total		351,913	108,903	72,363

[a] Data not available; however, operations have been sporadic over last 10 year due to low adult returns.
[b] Average from 4 years of data (1984-1988).
[c] Ceased operating in the 1980s.
[d] No yearling coho were released in 1995.
[e] No yearling coho were released in 2000 or 2001.
[f] Releases included both Warm Springs Hatchery and Noyo River ECS fish.
[g] Don Clausen Hatchery ceased releasing coho salmon in 1996.

Since 1976, when MBSTP began operating the Kingfisher Flat Hatchery, only local brood stock have been used at the hatchery. Mating protocols follow a priority scheme in which wild x wild broodstock are used in years of relatively high abundance, wild x hatchery crosses are done when wild fish are less available, and hatchery x hatchery crosses are made when wild fish are unavailable (D. Streig, MBSTP, pers. commun.). Under the current management plan, up to 30 females and 45 males can be taken with the restriction that the first 10 spawning pairs observed must be allowed to spawn undisturbed in their natural habitat, and then only one in four females may be taken to spawn. In recent years, few or no fish have been taken, due to low abundance; however, in 2001, 123 coho were observed and 26 "wild" females were taken for spawning. Of the 123 coho observed, 40% were marked hatchery fish. There are no other data available to assess the relative contribution of hatchery versus naturally produced coho salmon.

In its 1996 coho status review update, the BRT concluded that the Kingfisher Flat (Scott Creek) hatchery population should be considered part of the ESU and was essential for ESU recovery (Schiewe 1996a). This was based on the fact that there was regular incorporation of local broodstock into the hatchery population in the years that coho were produced between 1905 and 1943, and there have been no out-of-basin or out-of-ESU transfers since the hatchery was restarted in 1976. The MBSTP operation has been classified as a Category 1 hatchery (SSHAG 2003). For other SSHAG categorizations of hatchery stocks, see Appendix C.5.1.

A captive broodstock program for Scott Creek will be initiated at the NMFS Santa Cruz Laboratory in 2003.

Summary

Artificial propagation of coho salmon within the CCC ESU has been reduced since this ESU was listed in 1996 (Table C.2.3.6). The Don Clausen Hatchery has ceased production of coho salmon, and releases from the Noyo ECS operation declined over the past 6 years, in part because coho were not produced during 2 of those 6 years. The Monterey Bay Salmon and Trout Program has produced few coho salmon for release in the last 6 years due to low adult returns to

Scott Creek. Genetic risks associated with out-of-basin transfers appear minimal. However, potential genetic modification in hatchery stocks resulting from domestication selection or low effective population size remains a concern.

Harvest impacts

Retention of coho salmon by commercial troll fishers south of Cape Falcon, Oregon, has been prohibited since 1993 (PFMC 2002). From Cape Falcon, OR, south to Horse Mountain, CA, retention of coho salmon in recreational ocean fisheries has been prohibited since 1994, and in 1995 this prohibition was extended to include all California ocean recreational fisheries (CDFG 2002b). The conservation objective set by the Pacific Fishery Management Council for the past five seasons has been an overall ocean exploitation of ≤13% for CCC coho salmon as indicated by Rogue/Klamath hatchery stocks (PFMC 2002b). Post-season estimates of Rogue/Klamath exploitation rate are unavailable; however, projected exploitation rates ranged from 3.0% to 11.7% during the period 1998 to 2002 (PFMC 1998-2002a). Inside harvest estimates of coho salmon are not available for rivers in the CCC ESU (PFMC 2002b).

C.2.3.5 Comparison with Previous Data

New data for the CCC coho salmon ESU includes expansion of presence-absence analyses, an analysis of juvenile abundance in 13 river basins, smolt counts from two streams in the central portion of the ESU, and one adult time series for a population with mixed wild and hatchery fish. The presence-absence analysis suggests possible continued decline of coho salmon between the late 1980s and the late 1990s, a pattern that is mirrored in the limited smolt and adult counts. Juvenile time series suggest no obvious recent change in status, but most observations underlying that analysis were made in the period from 1993 to 2002. Coho salmon populations continued to be depressed relative to historical numbers, and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. A number of coho populations in the southern portion of the range appear either extinct or nearly so, including those in the Gualala, Garcia, and Russian Rivers, as well as smaller coastal streams in San Francisco Bay and South of San Francisco Bay. Although the 2001 brood year appears to relatively strong, data were not yet available from many of the most at-risk populations within the CCC.

No new information has been provided that suggests additional risks beyond those identified in previous status reviews. Termination of hatchery production at the Don Clausen (Warm Springs) Hatchery and reductions in production at the Noyo and Kingfisher Flat (Big Creek) facilities suggest a decrease in potential risks associated with hatcheries; however, the lack of substantive information regarding the relative contribution of hatchery and naturally produced fish at these facilities adds uncertainty as to the potential risks these operations may pose to the genetic integrity of the Noyo River and Scott Creek stocks. Restrictions on recreational and commercial harvest of coho salmon since 1994 have reduced exploitation rate on CCC coho salmon.

C.2.4 LOWER COLUMBIA RIVER COHO

C.2.4.1 Previous BRT Conclusions

- The BRT was very concerned that the vast majority (over 90%) of the historic populations in the LCR coho salmon ESU appear to be either extirpated or nearly so.
- The two populations with any significant production (Sandy and Clackamas) are at appreciable risk because of low abundance, declining trends and failure to respond after a dramatic reduction in harvest.
- The majority of the previous BRT votes were for "at risk of extinction" with a substantial minority in "likely to become endangered."

Current Listing Status—threatened

C.2.4.2 New Data and Analyses

New data include:

- Spawner abundance through 2001 (previous review had data through 1999)
- new estimates of the fraction of hatchery spawners

New analyses include:

- Tentative designation of relatively demographically independent populations (not reviewed by WLC-TRT)
- Recalculation of previous BRT metrics with additional years data
- Estimates of median annual growth rate (λ) under different assumptions about the reproductive success of hatchery fish
- Estimates of current and historically available kilometers of stream
- New PVA risk evaluation metric for estimating relative extinction risks of populations

Historical population structure—As part of its effort to develop viability criteria for LCR salmon and steelhead, the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) has identified historically demographically independent populations of chinook and steelhead (Myers et al. 2002). Population boundaries are based on an application of Viable Salmonid Populations definition (McElhany et al. 2000). Based on the framework for chinook and steelhead, we tentatively designated populations of LCR coho (Figure C.2.4.1). We hypothesized that the LCR coho ESU historically consisted of 23 populations. The populations shown in Figure C.2.4.1 are used as the units for the new analyses in this report.

For other species, the WLC-TRT partitioned LCR populations into a number of "strata" based on major life-history characteristics and ecological zones (McElhany et al. 2002). The WLC-TRT analysis suggests that a viable ESU would need a number of viable populations in each of these strata. Coho do not have the major life history variation seen in LCR steelhead or chinook and would be divided into strata based only on ecological zones. The strata and associated populations for coho are identified in Table C.2.4.1.

Table C.2.4.1. The ecological zones are based on ecological community and hydrodynamic patterns.. The recent abundance is the geometric mean of natural origin spawners of the last 5 years of available data and the min-max are the lowest and highest 5-year geometric means in the time series. The data years are the data years used for the abundance min-max estimates, the extinction risk estimate and the trends (Table C.2.4.3). The fraction hatchery is the average percent of spawners of hatchery origin over the last 4 years. The harvest rate is the percent of adults harvested averaged over 1995-1997.

Ecological Zone	Population	Recent Abundance	Data Years	Hatchery Fraction (%)	Harvest Rate (%) (1995-1997)
Coastal	Youngs Bay				
	Grays River				
	Big Creek				
	Elochoman				
	Clatskanie				
	Mill, Germany,Abernathy				
	Scappoose				
Cascade	Cispus	Extirpated			
	Tilton	Extirpated			
	Upper Cowlitz	Extirpated			
	Lower Cowltiz				
	North Fork Toutle				
	South Fork Toutle				
	Coweeman				
	Kalama				
	North Fork Lewis				
	East Fork Lewis				
	Clackamas	1126 (725-2816)	1957-2001	6	28
	Salmon Creek				
	Sandy	332 (227-1553)	1977-2001	1	29
	Washougal				
Gorge	Lower Gorge Tributaries				
	Upper Gorge Tributaries				
	White Salmon	Extirpated			
	Hood River				
Summary	**Total**	**1,468**			
	Average			4	29

Table C.2.4.2. Trend and growth rate for subset of Lower Columbia chinook populations (95% C.I. are in parentheses). The long-term analysis used the entire data set (see Table C.2.4.2 for years). The criteria for the short-term data set are defined in the methods section. In "Hatchery = 0" columns, hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural origin fish.

Population	Long-Term Analysis			Short-Term Analysis		
	Trend	Median Growth Rate (λ)		Trend	Median Growth Rate (λ)	
		Hatchery = 0	Hatchery =Wild		Hatchery = 0	Hatchery = Wild
Clackamas	1.010 (0.994-1.025)	1.024 (0.924-1.135)	1.024 (0.915-1.123)	0.941 (0.809-1.095)	0.964 (0.870-1.068)	0.963 (0.869-1.067)
Sandy	1.001 (0.940-1.065)	1.012 (0.877-1.168)	1.012 (0.867-1.152)	0.965 (0.820-1.136)	0.973 (0.843-1.124)	0.973 (0.843-1.123)

Abundance and trends

References for abundance time series and related data are in Appendix _. Recent abundance of natural origin spawners, recent fraction of hatchery origin spawners, and recent harvest rates for LCR steelhead populations are summarized in Table C.2.4.1. Natural origin fish had parents that spawned in the wild as opposed to hatchery origin fish whose parents were spawned in a hatchery. Some populations are above impassible barriers and are completely extirpated. Most of the other populations, except for the Clackamas and Sandy are believed to have very little, if any, natural production.

Clackamas—The Clackamas calculation had a recent mean abundance of 1,126 and a relatively low recent fraction of hatchery origin spawners at 6% (Table C.2.4.1). Time series for the Clackamas population are shown in Figures C.2.4.2-C.2.4.6. Figure C.2.4.2 shows the total adult count and natural origin adults passing the North Fork dam. The majority of natural coho spawning occurs above the North Fork dam. Since almost all LCR coho females and most males spawn at 3 years of age, a strong cohort structure is produced. Figure C.2.4.3 show the three adult cohorts on the Clackamas. The Clackamas basin has had a history of hatchery coho introductions from out-of-basin stocks. These out-of-basin stocks are believed to have an earlier run timing than the native Clackamas coho. One hypothesis holds that this run timing distinction persists and the Clackamas coho actually consist of two populations; an early and a late population (Figure C.2.4.4). However, records of run timing from the recent past suggest that the Clackamas coho may currently consist of a single population that has a very recent artificial bimodal distribution because of harvest patterns (see previous status review updates for more complete discussion and references). In previous analyses, both ODFW and the BRT have treated the Clackamas as a single population and in this status review update; we treat the Clackamas as a single population.

The long-term trends and growth rate (λ) estimates over the entire time series (1957-2001) have been slightly positive and the short-term trends and λ have been slightly negative (Table C.2.4.2). However, both the long-term and short-term trends and λ have relatively high probabilities of being less than one (Table C.2.4.3).

Table C.2.4.3. Probability the trend or growth rate is less than one. In the "Hatchery = 0" columns, the hatchery fish are assumed to have zero reproductive success. In the "Hatchery = Wild" columns, hatchery fish are assumed to have the same relative reproductive success as natural origin fish.

	Long-Term Analysis			Short-Term Analysis		
		Lambda			Lambda	
Population	Trend	Hatchery = 0	Hatchery = Wild	Trend	Hatchery = 0	Hatchery = Wild
Clackamas	0.507	0.380	0.481	0.817	0.619	0.623
Sandy	0.680	0.457	0.520	0.722	0.582	0.582

Since the late 1980s, the number of preharvest recruits has declined relative to the number of spawners (Figure C.2.4.5). Despite upturns in the last 2 years, the population has had more years below replacement since 1990 than above. Thus, even with the dramatic reductions in harvest rate (Figure C.2.4.6), the population failed to respond because of this recruitment failure. Although the recent increases in recruitment are encouraging, the population has not regained earlier levels and is unknown if they will persist. The recent increases in recruitment are attributed to increased marine survival, which we cannot predict with any certainty.

Sandy—The Sandy population had a recent mean abundance of 342 spawners and a very low fraction of hatchery origin spawners (Table C.2.4.1). Trends in the Sandy are similar to the Clackamas, though the long-term time series is shorter (Figures C.2.4.7-C.2.4.8). The long-term trends and growth rate (λ) estimates over the entire time series (1977-2001) have been slightly positive and the short-term trends and λ have been slightly negative (Table C.2.4.2). However, both the long-term and short-term trends and λ have relatively high probabilities of being less than one (Table C.2.4.3).

The late 1980s recruitment failure observed in the Clackamas is also present in the Sandy population (Figure C.2.4.9). If anything, it may be more pronounced and the overall abundance is lower. Again, despite reductions in harvest (Figure C.2.4.10), the population has failed to recover to earlier recruitment levels, despite the encouraging last 2 years.

Other Oregon populations

The lower Columbia coho ESU is dominated by hatchery production. There is very little (and in some years practically no) natural production in Oregon outside the Clackamas and Sandy. ODFW has conducted coho spawner surveys in lower Colombia tributaries since the late 1940s. We have combined these surveys to obtain spawners-per-mile information at the scale of our population units (Figures C.2.4.11- C.2.4.14). In many years over the last 2 decades, these surveys have observed no natural origin coho spawners.

Table C.2.4.4. Total coho hatchery releases into the Columbia basin (Data from DART website http://www.cqs.washington.edu/dart/hatch.html made available by the Fish Passage Center).

Year	Hatchery Releases
2000	29,902,509
2001	25,730,650
2002	9,558,355

Washington populations

The Washington side of this ESU is also dominated by hatchery production and there are no populations with appreciable natural production. A study by NRC (1996) indicated that 97% of 425 fish surveyed on the spawning grounds were first-generation hatchery fish. Based on smolt trap data, some natural production of coho does occur in the Cedar River, a tributary of the East Fork Lewis (D. Rawding, pers comm.). However, there is no indication that this sub-population is self-sustaining.

C.2.4.3 New Hatchery/ESU Information

Hatchery production

The Lower Columbia coho ESU is dominated by hatchery production. Recent coho releases in the Columbia basin (including releases upstream of the ESU boundary) are shown in Table C.2.4.4. The total expected return of hatchery coho salmon to the Columbia basin in 2002 was over a million adults (ODFW News Release, 13 September, 2002; we have not yet obtained the final 2002 return data.).

Loss of habitat from barriers

An analysis was conducted by Steel and Sheer (2002) to assess the number of stream km historically and currently available to salmon populations in the LCR (Table C.2.4.5). Stream km usable by salmon are determined based on simple gradient cut offs and on the presence of impassable barriers. This approach will over estimate the number of usable stream km, as it does not take into consideration habitat quality (other than gradient). However, the analysis does indicate that for some populations the number of stream habitat km currently accessible is greatly reduced from the historical condition.

ESU summary

Based on the updated information provided in this report, the information contained in previous LCR status reviews, and preliminary analyses by the WLC-TRT, we have tentatively identified the number of historical and currently viable populations (Table C.2.4.5). Only two populations have appreciable levels of natural production (Clackamas and Sandy). Thus, 21 of the 23 historical populations (91%) are currently extirpated, or nearly so. Of the two populations with natural production, both have experienced recruitment failure over the last decade. Recent abundances of the two populations are relatively low (especially the Sandy), placing them in a range where environmental, demographic and genetic stochastity can be significant risk factors.

Table C.2.4.5. Loss of habitat from barriers. The potential current habitat is the kilometers of stream below all currently impassible barriers between a gradient of 0.5% and 4%. The potential historical habitat is the kilometers of stream below historically impassible barriers between a gradient of 0.5% and 4%. The current-to-historical habitat ratio is the percent of the historical habitat that is currently available. This table does not consider habitat quality.

Population	Potential Current Habitat(%)	Potential Historical Habitat (km)	Current-to Historical Habitat Ratio
Youngs Bay	178	195	91
Grays River	133	133	100
Big Creek	92	129	71
Elochoman	85	116	74
Clatskanie	159	159	100
Mill, Germany,Abernathy	117	123	96
Scappoose	122	157	78
Cispus	0	76	0
Tilton	0	93	0
Upper Cowlitz	4	276	1
Lower Cowltiz	418	919	45
North Fork Toutle	209	330	63
South Fork Toutle	82	92	89
Coweeman	61	71	86
Kalama	78	83	94
North Fork Lewis	115	525	22
East Fork Lewis	239	315	76
Clackamas	568	613	93
Salmon Creek	222	252	88
Sandy	227	286	79
Washougal	84	164	51
Lower Gorge Tributaries	34	35	99
Upper Gorge Tributaries	23	27	84
White Salmon	0	71	0
Hood River	35	35	100
Total	3,286	5,272	62

Table C.2.4.6. Number of populations in the ESU. Populations with "some current natural production" may have some natural origin recruits present but are not necessarily considered self-sustaining ("viable").

	Total
Historical	23
Some current natural production	3-20
Currently "viable"	0-2

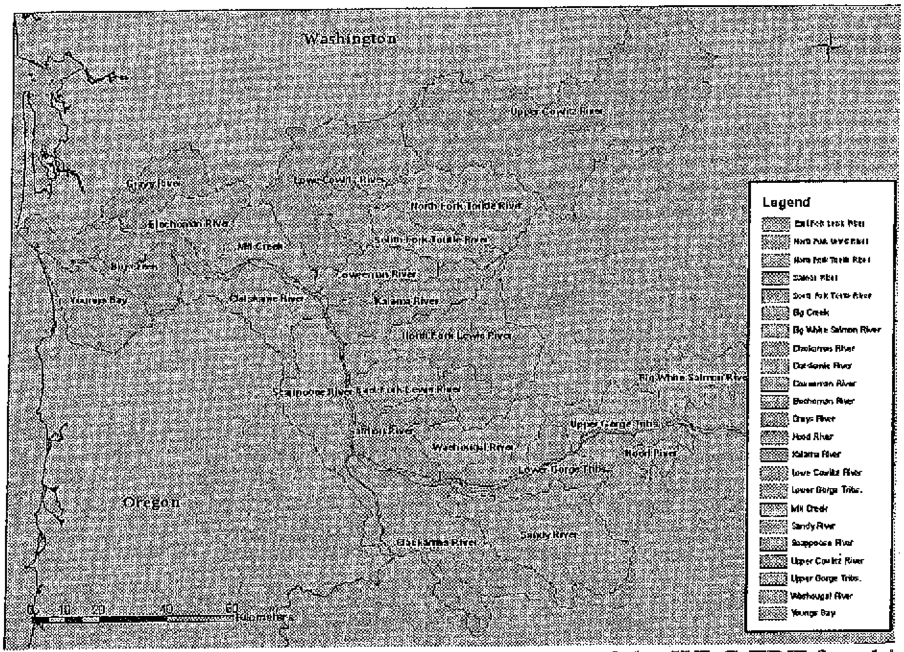

Figure C.2.4.1. Tentative populations of LCR coho. Based on work by WLC-TRT for chinook and steelhead (Myers et al. 2002).

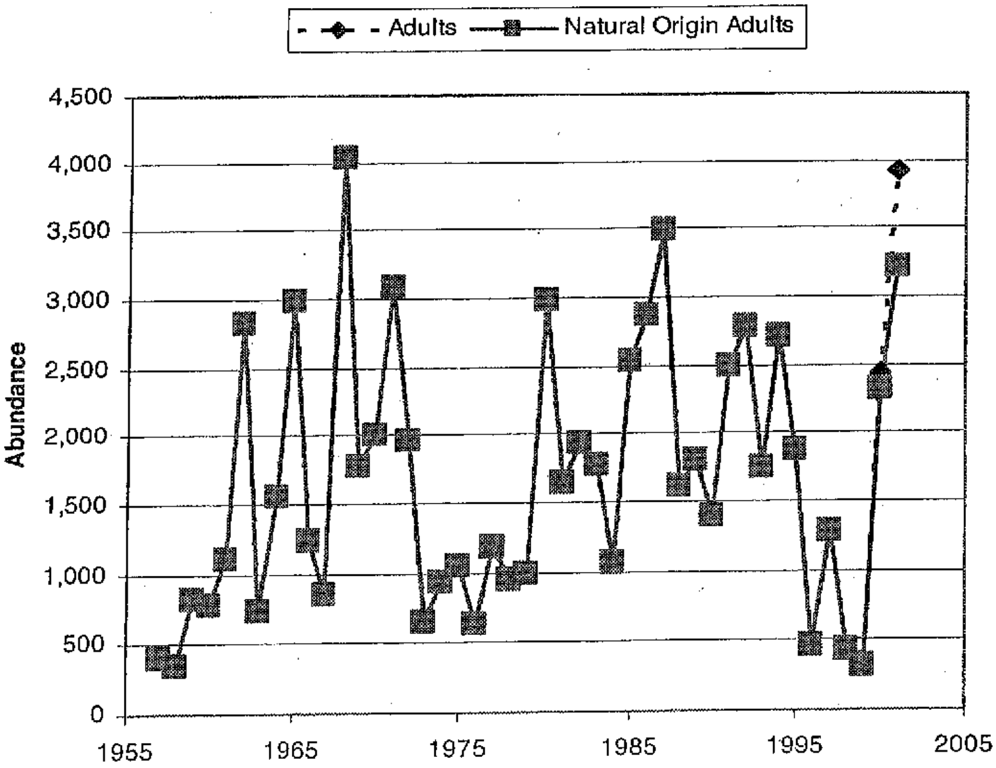

Figure C.2.4.2. Clackamas North Fork Dam counts of coho salmon.

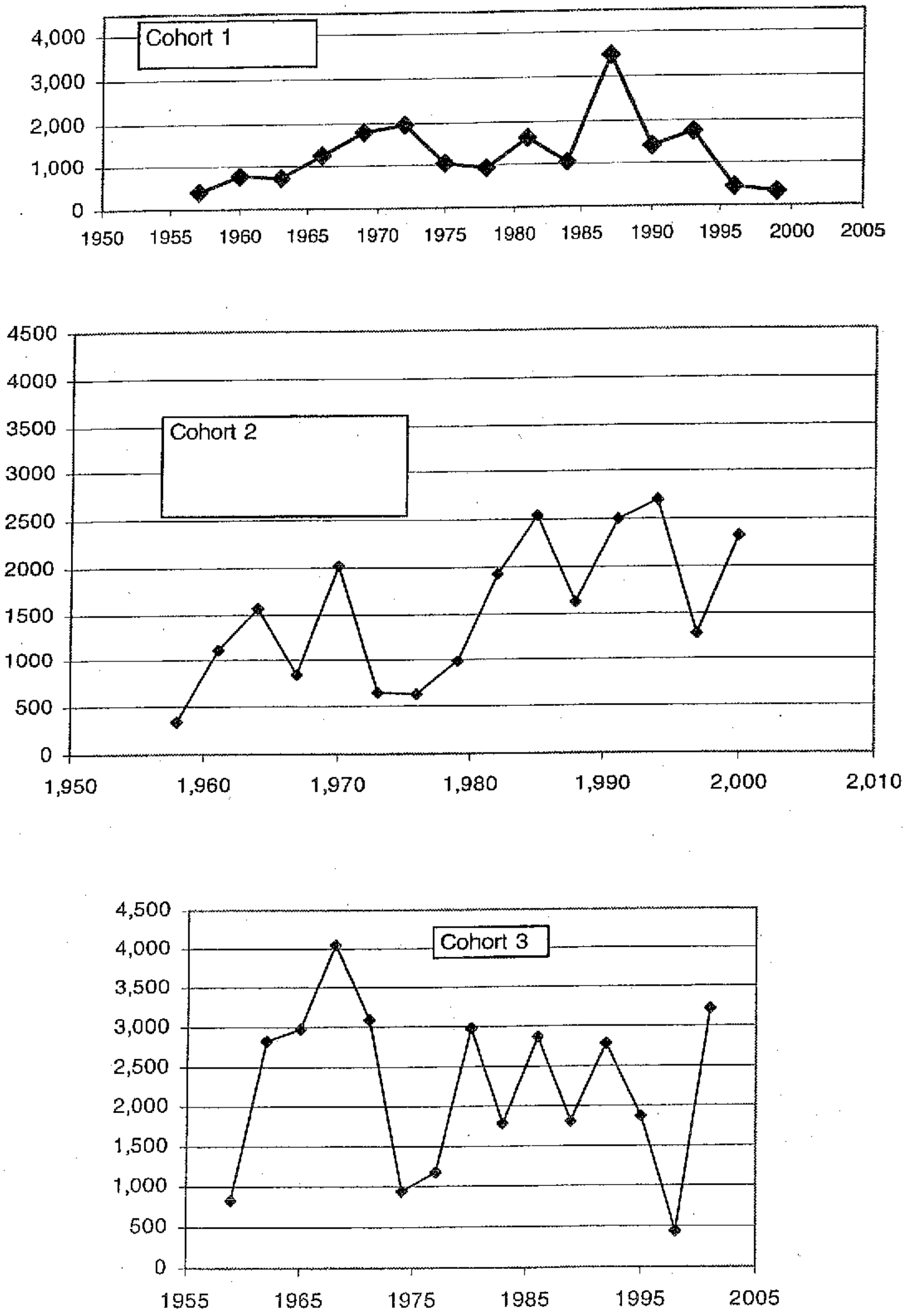

Figure C.2.4.3. Adult Clackamas River coho (North Fork dam count) by cohort.

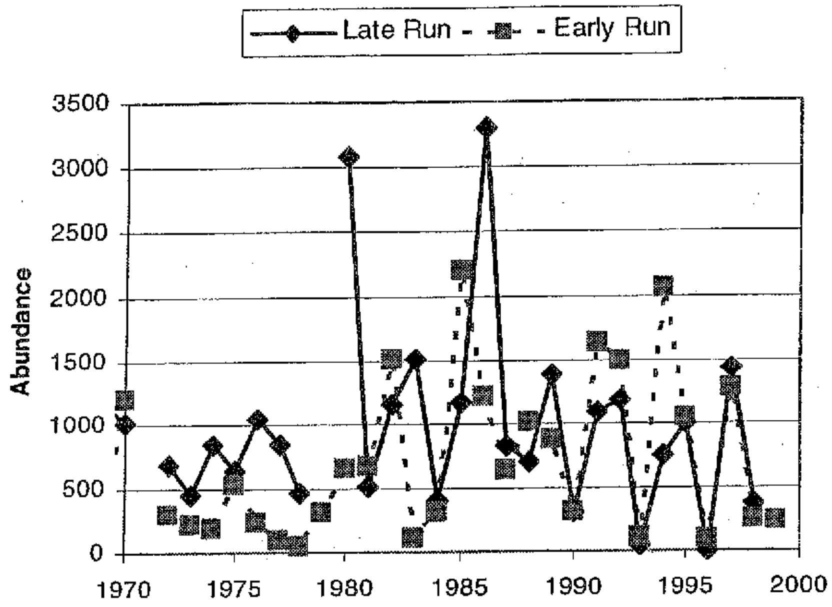

Figure C.2.4.4. Clackamas River early-run and late-run coho. Coho that arrive before November 1st are considered early run and those that arrive after November 1st are considered late run.

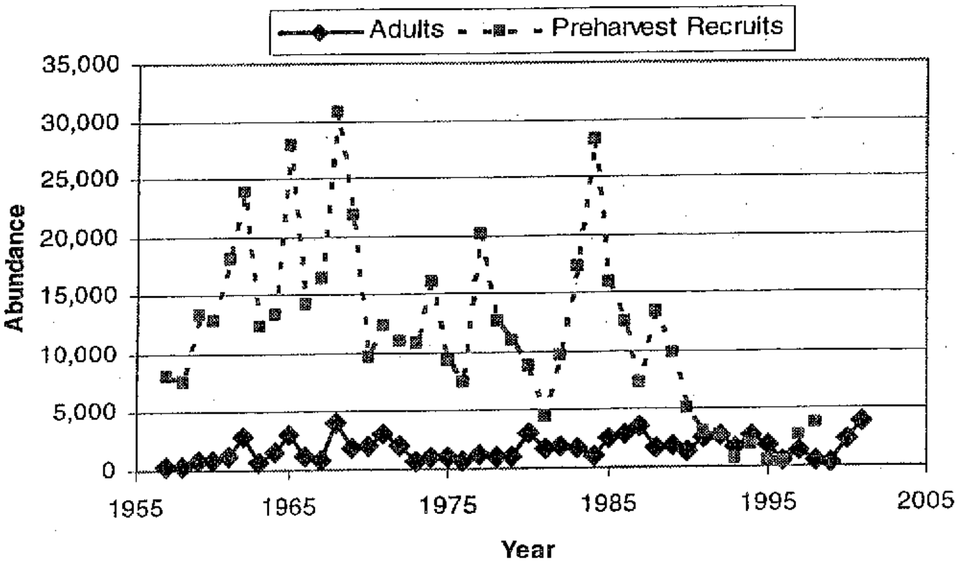

Figure C.2.4.5. Estimate of preharvest coho recruits and spawners in the Clackamas River. Based on adult counts at North Fork dam.

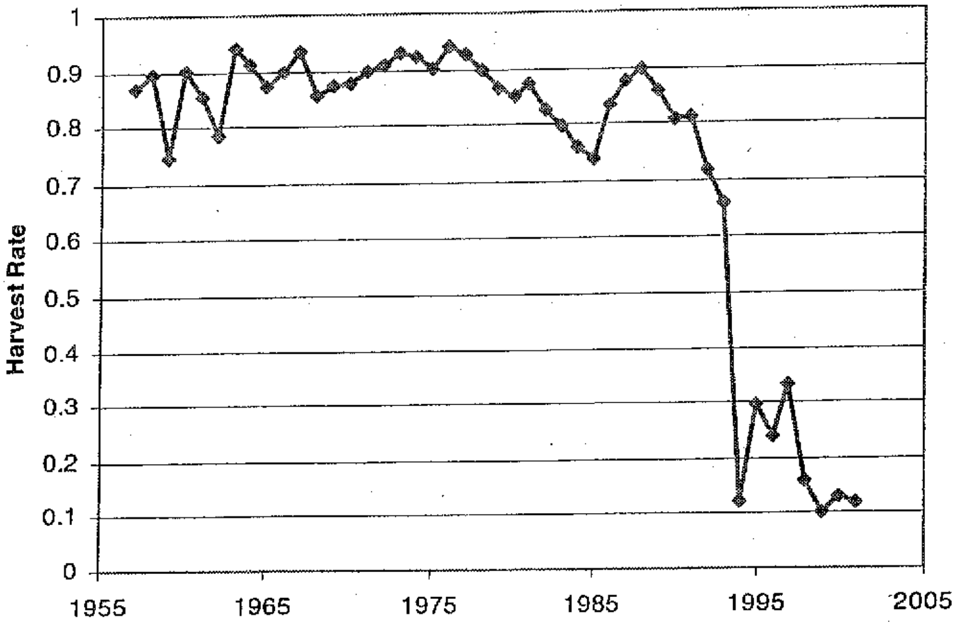

Figure C.2.4.6. Clackamas River natural origin coho harvest rate (M. Chilcote, pers. comm.). The reduction in harvest rate was achieved by a switch to retention-only marked hatchery fish and timing the fishery to protect natural runs.

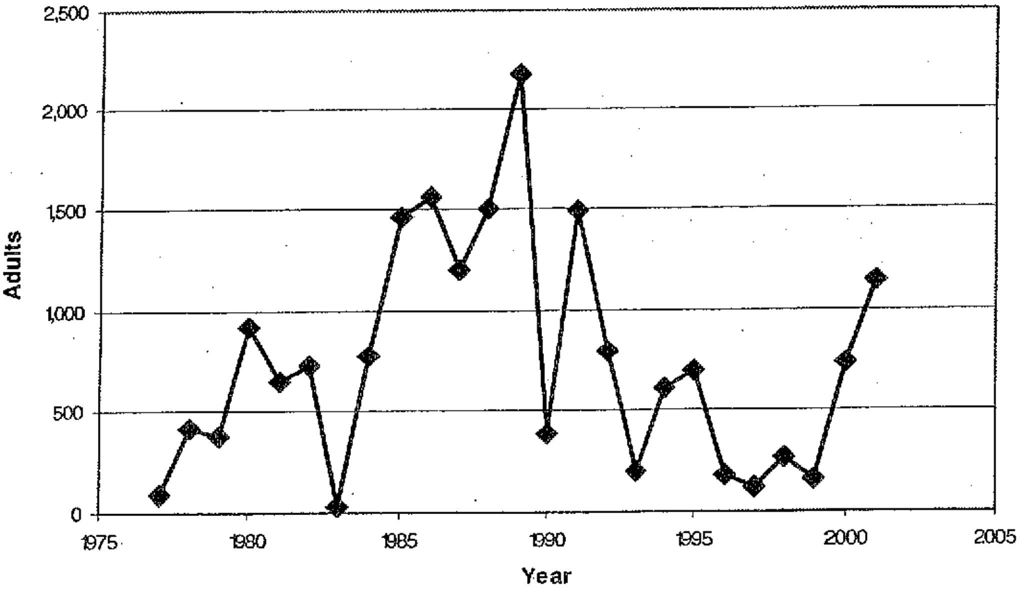

Figure C.2.4.7. Count of adult (≥3 years old) coho at the Marmot dam on the Sandy River.

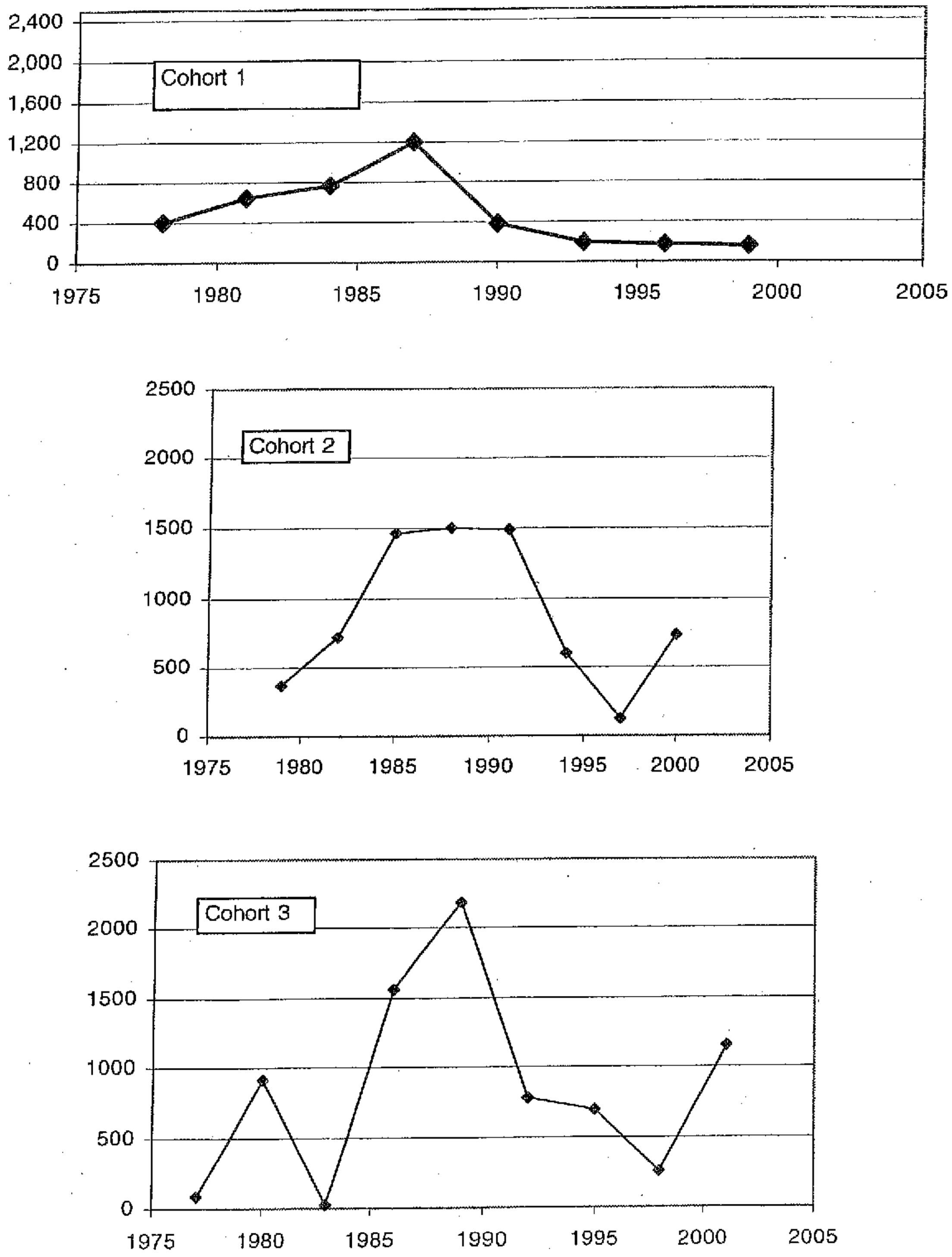

Figure C.2.4.8. Adult Sandy River coho (Marmot dam count) by cohort.

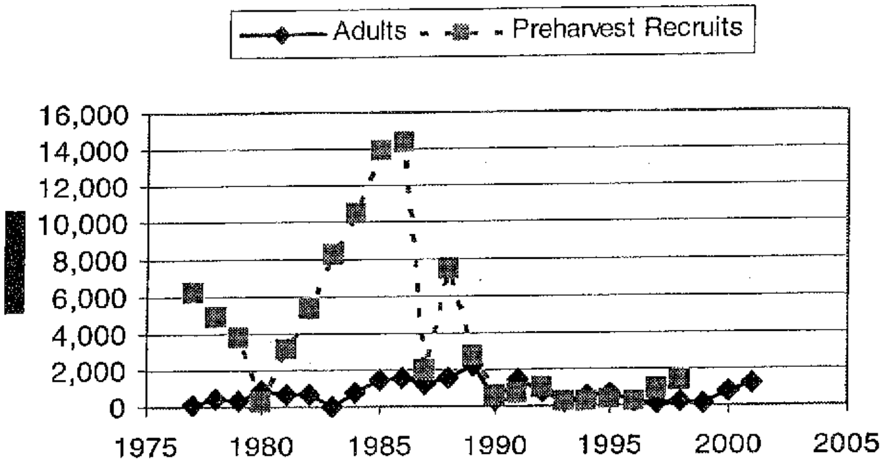

Figure C.2.4.9. Estimate of preharvert coho recruits and spawners in the Sandy River. Based on adult counts at Marmot dam.

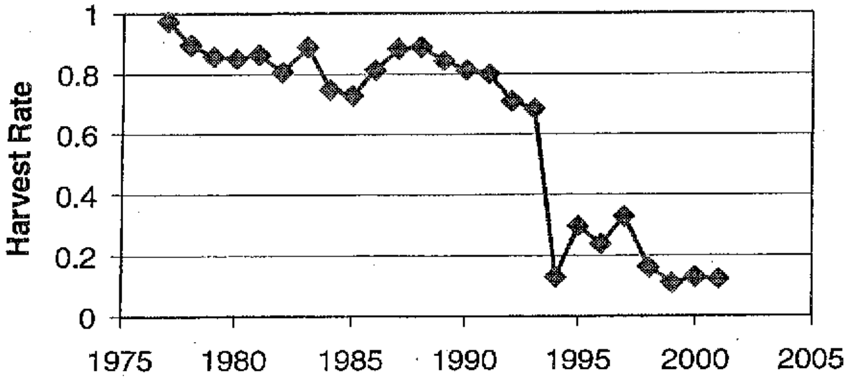

Figure C.2.4.10. Sandy River natural origin coho harvest rate (M. Chilcote, pers. comm.). The reduction in harvest rate was achieved by switch to retention only marked hatchery fish and timing the fishery to protect natural runs.

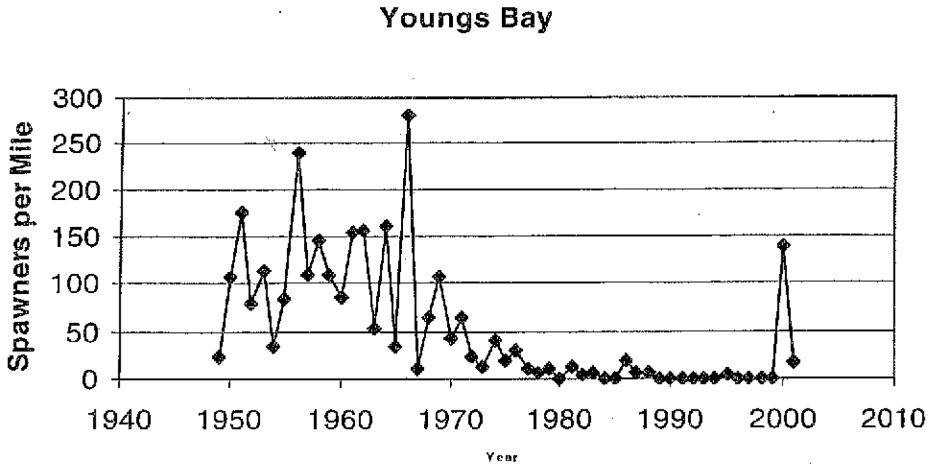

Figure C.2.4.11. Youngs Bay coho spawners per mile.

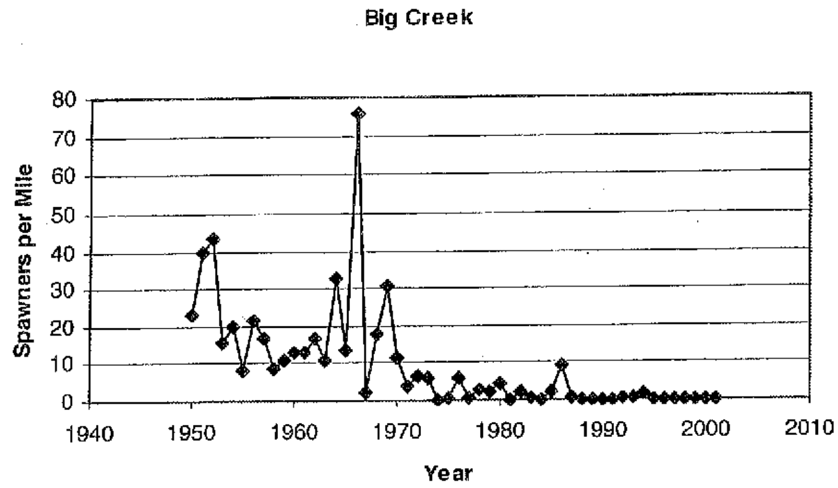

Figure C.2.4.12. Big Creek Spawners per mile.

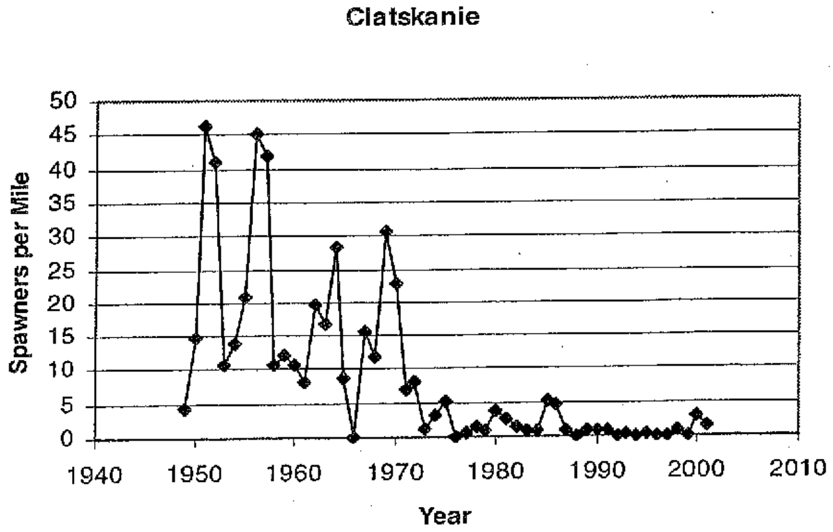

Figure C.2.4.13. Clatskanie Spawners per mile.

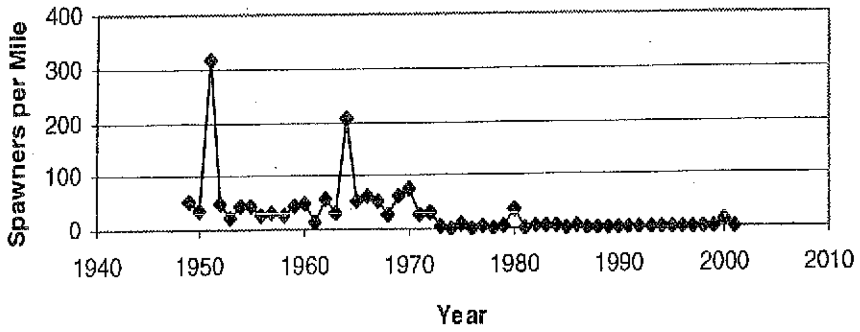

Figure C.2.4.14. Scappoose Spawners per mile.

C.3 PRELIMINARY COHO BRT CONCLUSIONS

Oregon Coast coho

This ESU continues to present challenges to those assessing extinction risk. The BRT found several positive features compared to the previous assessment in 1997. Adult spawners for the ESU in 2001 exceeded the number observed for any year in the past several decades, and preliminary indications are that 2002 numbers may be higher still, at least in some areas. Some notable increases in spawners have occurred in many streams in the northern part of the ESU, which was the most depressed area at the time of the last status review evaluation. Hatchery reforms have continued, and the fraction of natural spawners that are first-generation hatchery fish has been reduced in many areas compared to highs in the early to mid 1990s.

On the other hand, the recent years of good returns were preceded by 3 years of low spawner escapements—the result of 3 consecutive years of recruitment failure, in which the natural spawners did not replace themselves the next generation, even in the absence of any directed harvest. These 3 years of recruitment failure, which immediately followed the last status review in 1997, are the only such instances that have been observed in the entire time series of data collected for Oregon coast coho salmon. Whereas the recent increases in spawner escapement have resulted in long-term trends in spawners that are mixed or slightly positive, the long-term trends in productivity in this ESU are still negative.

The BRT votes (the majority of which were cast in the "likely to become endangered" category) reflected ongoing concerns for the long-term health of this ESU. Although the BRT considered the significantly higher returns in recent years to be encouraging, most members felt that the factors responsible for the increases were more likely to be unusually favorable marine productivity conditions than improvements in freshwater productivity. The majority of BRT members felt that to have a high degree of confidence that the ESU is healthy, high spawner escapements should be maintained for a number of years, and the freshwater habitat should demonstrate the capability of supporting high juvenile production from years of high spawner abundance. As indicated in the risk matrix results, the BRT considered the decline in productivity to be the most serious concern for this ESU (mean score 3.8; Table C.3.1). With all directed harvest for these populations already eliminated, harvest management can no longer compensate for declining productivity by reducing harvest rates. The BRT was concerned that if the long-term decline in productivity reflects deteriorating conditions in freshwater habitat, this ESU could face very serious risks of local extinctions during the next cycle of poor ocean conditions.

A minority of the BRT felt that the large number of spawners in the last few years (together with preliminary projections of another "good" year in 2003) demonstrate that this ESU is not currently at significant risk of extinction or likely to become endangered. Furthermore, these members felt that the recent years of high escapement, following closely on the heels of the years of recruitment failure, demonstrate that populations in this ESU have the resilience to bounce back from years of depressed runs.

Southern Oregon/Northern California Coasts coho

A majority of BRT votes fell into the "likely to become endangered" category, with minority votes falling in the "endangered," and "not warranted" categories. The BRT found moderately high risks for abundance and growth rate/production, with mean matrix scores of 3.5 to 3.8, respectively, for these two categories. Risks to spatial structure (mean score = 3.1) and diversity (mean score = 2.8) were considered moderate by the BRT (Table C.3.1).

The BRT remained concerned about low population abundance throughout the ESU relative to historical numbers and long-term downward trends in abundance; however, the paucity of data on escapement of naturally produced spawners in most basins continued to hinder assessment of risk. A reliable time series of adult abundance is available only for the Rogue River. These data indicate that long-term (22-year) and short-term (10-year) trends in mean spawner abundance are upward in the Rogue; however, the positive trends reflect effects of reduced harvest (rather than improved freshwater conditions) since trends in pre-harvest recruits are flat. Less-reliable indices of spawner abundance in several California populations reveal no apparent trends in some populations and suggest possible continued declines in others. Additionally, the BRT considered the relatively low occupancy rates of historical coho streams (between 32% and 56% from brood year 1986 to 2000) as an indication of continued low abundance in the California portion of this ESU. The relatively strong 2001 brood year, likely due to favorable conditions in both freshwater and marine environments, was viewed as a positive sign, but was a single strong year following more than a decade of generally poor years.

The moderate risk matrix scores for spatial structure reflected a balancing of several factors. On the negative side was the modest percentage of historical streams still occupied by coho salmon (suggestive of local extirpations or depressed populations). The BRT also remains concerned about the possibility that losses of local populations have been masked in basins with high hatchery output, including the Trinity, Klamath, and Rogue systems. The extent to which strays from hatcheries in these systems are contributing to natural production remains uncertain; however, it is generally believed that hatchery fish and progeny of hatchery fish constitute the majority of production in the Trinity River, and may be a significant concern in parts of the Klamath and Rogue systems a well. On the positive side, extant populations can still be found in all major river basins within the ESU. Additionally, the relatively high occupancy rate of historical streams observed in brood year 2001 suggests that much habitat remains accessible to coho salmon. The BRT's concern for the large number of hatchery fish in the Rogue, Klamath, and Trinity systems was also evident in the moderate risk rating for diversity.

Central California Coast coho

A majority of the BRT votes fell into the "endangered" category, with the remainder falling into the "likely to become endangered" category. The BRT found CCC coho salmon to be at very high risk in three of four risk categories, with mean scores of 4.8, 4.5, and 4.7 for abundance, growth rate/productivity, and spatial structure, respectively (Table C.3.1). Scores for diversity (mean 3.6) indicated BRT members considered CCC coho salmon to be at moderate or increasing risk with respect to this risk category. Principal concerns of the BRT continue to be low abundance and long-term downward trends in abundance of coho salmon throughout the ESU, as well as extirpation or near extirpation of populations across most of the southern two-thirds of the historical range of the ESU, including several major river basins. Potential loss of genetic diversity associated with range reductions or loss of one or more brood lineages, coupled with historical influence of hatchery fish, were primary risks to diversity identified by the BRT. Improved oceanic conditions coupled with favorable stream flows apparently contributed to a strong year class in broodyear 2001, as evidenced by an increase in detected occupancy of historical streams. However, data were lacking for many river basins in the southern two-thirds of the ESU where populations are considered at greatest risk. Although viewed as a positive sign, the strong year follows more than a decade of relatively poor returns. The lack of current estimates of naturally produced spawners for any populations within the ESU—and hence the need to use primarily presence-absence information to assess risk—continues to concern the BRT.

Lower Columbia River coho

The status of this ESU was reviewed by the BRT only a year ago, so relatively little new information was available. A majority of the likelihood votes for Lower Columbia River coho fell in the "danger of extinction" category, with the remainder falling in the "likely to become endangered" category. As indicated by the risk matrix totals (Table C.3.1), the BRT had major concerns for this ESU in all risk categories (mean scores ranged from 4.3 for growth rate/productivity to 4.8 for spatial structure/connectivity). The most serious overall concern was the nearly total absence of naturally produced spawners throughout the ESU, with attendant risks associated with small population, loss of diversity, and fragmentation and isolation of the remaining naturally produced fish. In the only two populations with significant natural production (Sandy and Clackamas), short- and long-term trends are negative and productivity (as gauged by preharvest recruits) is down sharply from recent (1980s) levels. On the positive side, adult returns in 2000 and 2001 were up noticeably in some areas.

The paucity of naturally produced spawners in this ESU can be contrasted with the very large number of hatchery-produced adults. Although the scale of the hatchery programs, and the great disparity in relative numbers of hatchery and wild fish, produce many genetic and ecological threats to the natural populations, collectively these hatchery populations contain a great deal of genetic resources that might be tapped to help promote restoration of more widespread naturally spawning populations.

Table C.3.1. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the four coho ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/ Productivity	Spatial Structure and Connectivity	Diversity
Oregon Coast	2.5 (2-5)	3.8 (3-5)	2.5 (2-4)	25 (2-4)
S. Oregon / N. California Coast	3.8 (2-5)	3.5 (2-5)	3.1 (2-4)	2.8 (2-4)
Central California	4.8 (4-5)	4.5 (4-5)	4.7 (4-5)	3.6 (2-5)
Lower Columbia	4.8 (4-5)	4.3 (4-5)	4.8 (4-5)	4.5 (4-5)

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C.5 APPENDICES

Appendix C.5.1. Preliminary SSHAG (2003) categorizations of hatchery populations of the four coho ESUs reviewed. See "Artificial Propagation" in General Introduction for explanation of the categories.

	Stock	Run	Basin	SSHAG Category
Oregon Coast	NF Nehalem	(# 32)	Nehalem	3
	Fishhawk Lake	(# 99)	Nehalem	3
	Trask River	(# 34)	Trask	3
	Siletz	(# 33)	Siletz	3
	Umpqua	(# 55)	Umpqua	3
	Cow Creek	(# 18)	Umpqua	3
	Woahink		Stilcoos	1
	Coos	(# 37)	Coos	1
	Coquille	(# 44)	Coquille	1
S. Oregon/N. California	Rogue River	(# 52)	Rogue River	1
	Iron Gate		Klamath	2
	Trinity River		Trinity	2
	Mad River		Mad River	4
Central California	Noyo River		Noyo River	1
	Don Clausen		Russian	1
	Monterey Bay		Scott Creek	1
Lower Columbia River	Big Creek		Big Creek	2 or 3
	Klaskanine		Klaskanine	4
	Tanner Creek		Lower Gorge	3
	Sandy River	late	Sandy	2 or 3
	Eagle Creek		Clackamas	3
	Little White Salmon		Upper Gorge	3
	Toutle	Type S	Cowlitz	2
	Type S Complex	Type S	various	3
	Cowlitz	Type N	Cowlitz	2
	Type N Complex	Type N	various	3

Appendix C.5.2. Lower Columbia Coho Time Series References

Population	Clatskanie River Coho
Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish/Mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, Eric. 2002.
Abundance Notes	data from Streamnet
Population	Scappoose Coho
Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish/Mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, Eric. 2002
Abundance Notes	data from Streamnet
Population	Big Creek Coho
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish/Mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, Eric. 2002.
Abundance Notes	data from Streamnet
Population	Clackamas River Coho
Years of Data, Length of Series	1950 - 2001, 52 years
Abundance Type	Fish/Mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, Eric. 2002
Abundance Notes	data from Streamnet
Population	Youngs Bay Coho
Years of Data, Length of Series	1949 - 2001, 53 years
Abundance Type	Fish/Mile
Abundance References	Fulop, J.; Whisler, J.; Morgan, B.. 1998; Morgan, B., Whisler, J. and Fulop, J.. 1998; White, E., Morgan, B. and Fulop, J.. 1999; Ollerenshaw, Eric. 2002
Abundance Notes	data from Streamnet

Population	Sandy River Coho (Marmot Dam)
Years of Data, Length of Series	1977 - 2001, 25 years
Abundance Type	Dam count
Abundance References	Cramer 2002
Population	Clackamas River Coho (North Fork Dam)
Years of Data, Length of Series	1957 - 2001, 45 years
Abundance Type	Dam count
Abundance References	Cramer 2002

A.2.7 CALIFORNIA COASTAL CHINOOK

A.2.7.1 Previous BRT Conclusions

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

ESU structure

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

Summary of risk factors and status

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

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

Historical estimates of escapement are presented in Table A.2.7.1. These estimates are based on professional opinion and evaluation of habitat conditions, and thus do not represent rigorous estimates based on field sampling. Historical time series of counts of upstream migrating adults are available for Benbow Dam (South Fork Eel River; 1938-1975), Sweasy Dam (Mad River; 1938-1964), and Cape Horn Dam (Van Arsdale Fish Station, Eel River); the

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

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

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

latter represent a small, unknown and presumably variable fraction of the total run to the Eel River. Data from cursory, nonsystematic stream surveys of two tributaries to the Eel River (Tomki and Sprowl Creeks) and one tributary to the Mad River (Canon Creek) were also available; these data provide crude indices of abundance.

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

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

Listing status

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

A.2.7.2 New Data and Analysis

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

New or updated time series for chinook salmon in this ESU include (1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River; (2) cursory, quasi-systematic spawner surveys on Canon Creek (tributary to the Mad River), Tomki Creek (tributary to the Eel River), and Sprowl Creek (tributary to the Eel River); (3) counts of returning spawners at a weir on Freshwater Creek (tributary to

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

"Lumped"	"Split"
Redwood Creek	
Mad River	
Humboldt Bay Tributaries	
Eel River[1]	
	South Fork Eel River
	Van Duzen River
	Middle Fork Eel River
	North Fork Eel River
	Upper Eel River
Bear River	
Mattole River	
Tenmile to Gualala[2]	
Russian River	

[1] Plausible hypotheses regarding the population structure of chinook salmon in the Eel River basin include scenarios ranging from five independent populations (South Fork Eel River, Van Duzen River, Upper Eel River, Middle Fork Eel River, and North Fork Eel River) to a single, strongly structured independent population.

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

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

	5 year Geometric Mean			Trend	
	Rec	Min	Max	Long	Short
Freshwater Creek	22	13	22	0.137 (-0.405, 0.678)	0.137 (-0.405, 0.678)
Mad River					
Canon Creek	73	19	103	0.0102 (-0.106, 0.127)	0.155 (-0.069, 0.379)
Eel River					
Sprowl Creek	43	43	497	-0.096 (-0.157, -0.0336)	-0.183 (-0.356, -0.0096)
Tomki Creek	61	13	2,233	-0.199 (-0.351, -0.0464)	0.294 (0.0547, 0.533)

Humboldt Bay). None of these time series is especially suitable for analysis of trends or estimation of population growth rates. For this reason, we have presented the data graphically, and restricted analysis to estimation of long- and short-term trends, rather than pursue more sophisticated analysis.

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

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

Eel River—The Eel River plausibly harbors anywhere from one to five independent populations (NCCC-TRT, *in preparation*, Table A.2.7.2). Three current time series provide information for the population(s) that occupy this basin: (1) counts of adults reaching Van Arsdale Fish Station near the effective headwater terminus of the Eel River (Figure A.2.7.3a); (2) spawner surveys on Sprowl Creek (tributary to the Eel River) (Figure A.2.7.3b); and (3) spawner surveys on Tomki Creek (tributary to the Eel River) (Figure

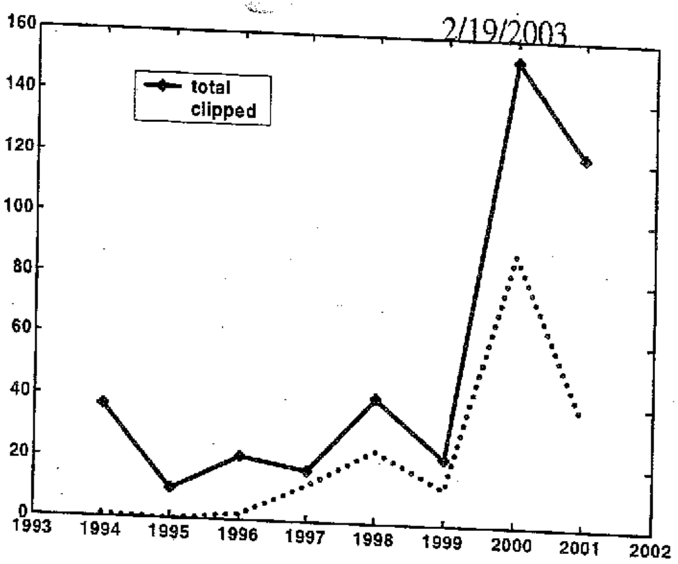

Figure A.2.7.1. Counts of chinook salmon at the weir on Freshwater Creek.

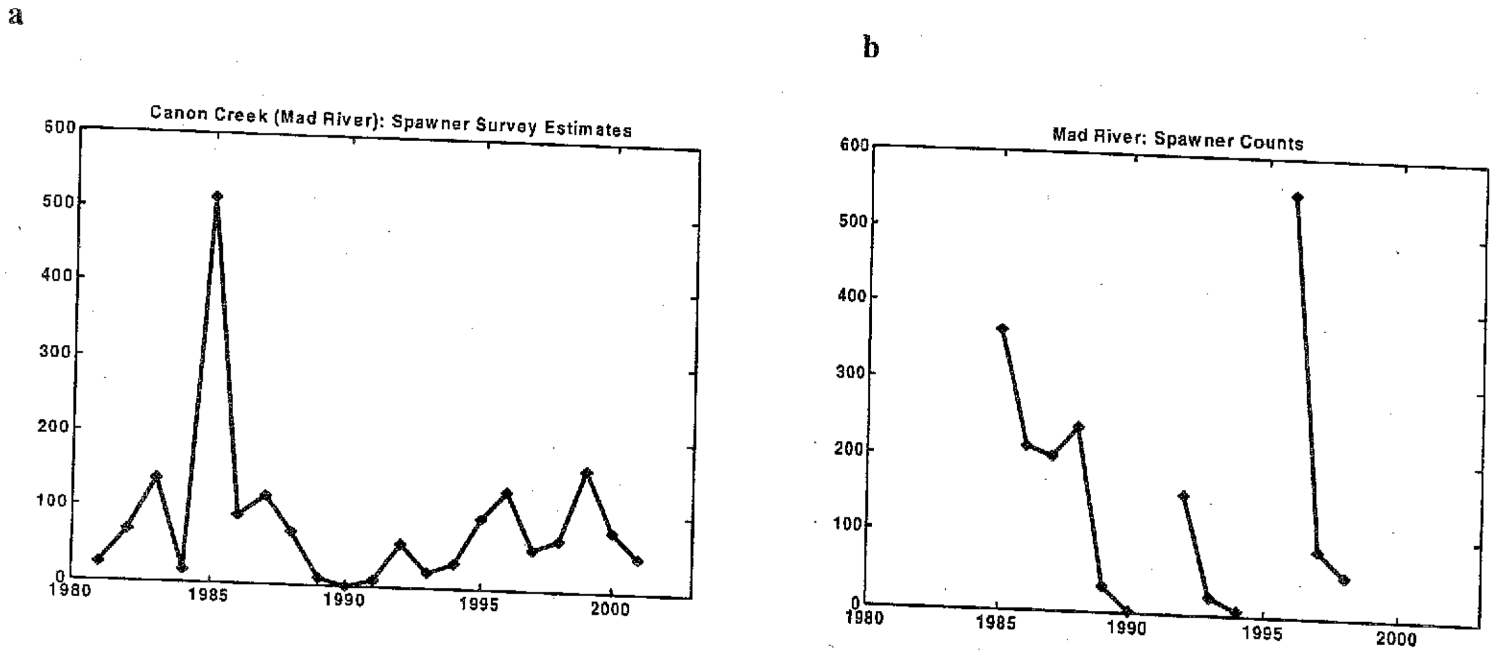

Figure A.2.7.2. Abundance time series for chinook salmon in portions of the Mad River basin. (a) spawner counts on Canon Creek; and (b) spawner counts on portions of the mainstem Mad River.

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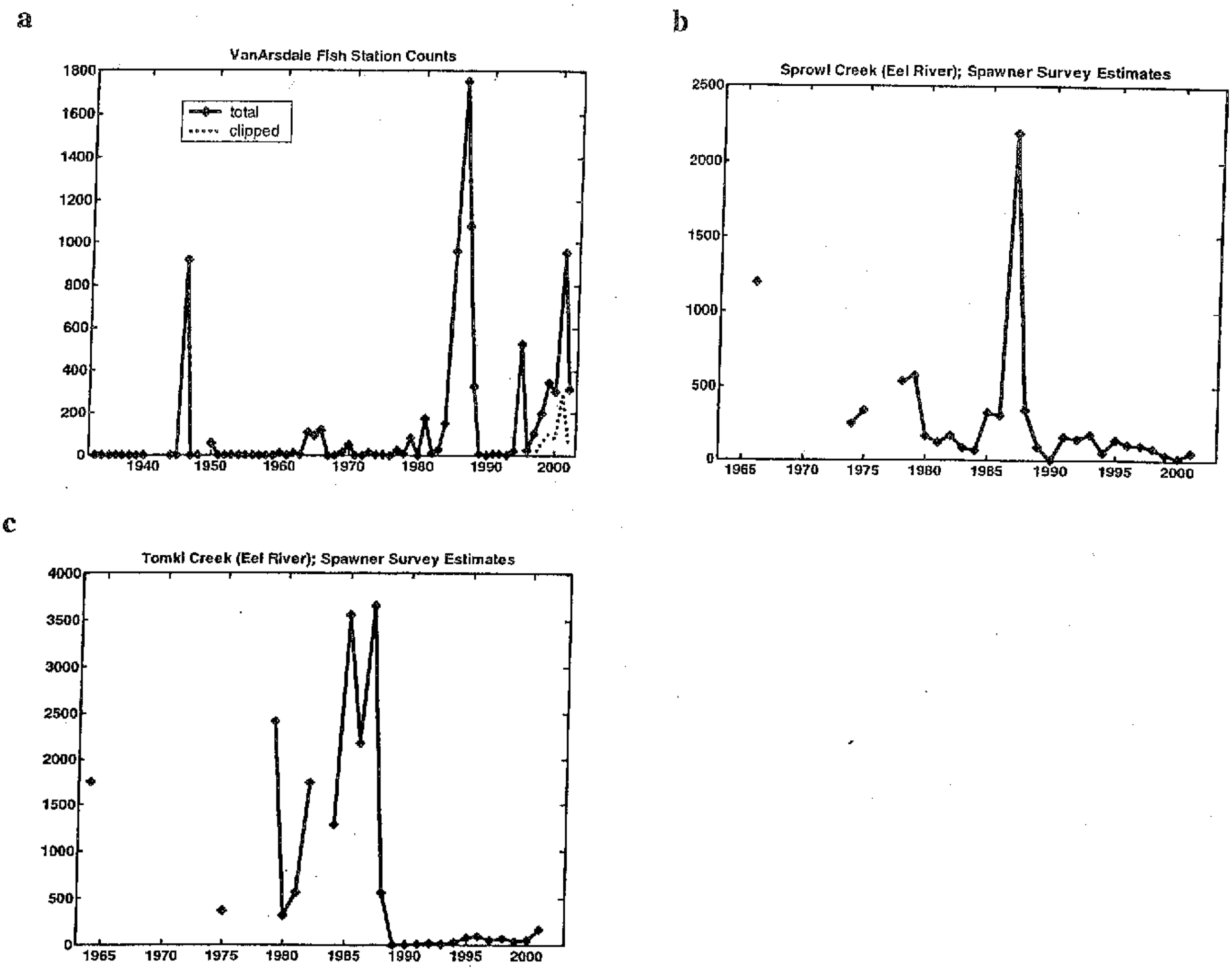

Figure A.2.7.3. Abundance time series for chinook salmon in portions of the Eel River basin. (a) counts of chinook salmon at Van Arsdale Fish Station at the upstream terminus of anadromous access on the mainstem Eel River; (b) estimates of spawner abundance based on spawner surveys and additional data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

A.2.7.3c). These data are not especially suited to rigorous analysis of population status for a number of reasons, and sophisticated analyses were not pursued.

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

Additional data for the Eel River population or populations are available from spawner surveys from Tomki and Sprowl Creeks, which yield estimates of abundance based on (1) quasi-systematic index site spawner surveys that incorporate mark-recapture of carcasses and (2) additional so-called "compatible" data from other surveys. Analysis for Sprowl Creek indicates negative long-term and short-term trends; similar analysis indicates a long-term decline and short-term increase for Tomki Creek (Table 3). Caution in interpreting these results is warranted, particularly given the quasi-systematic collection of these data, and the likelihood that these data include unquantified variability due to flow-related changes in spawners' use of mainstem and tributary habitats. In particular, inferences regarding population status based on extrapolations from these data to basin-wide estimates of abundance are expected to be weak and perhaps not warranted.

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

Russian River—No long-term, continuous time series are available for sites in the Russian River basin, but sporadic estimates based on spawner surveys are available for some tributaries. Video-based counts of upstream migrating adult chinook salmon passing a temporary dam near Mirabel on the Russian River are available for 2000-2002. Counts are incomplete, due to technical difficulties with the video apparatus, occasional periods of poor water clarity, occasional overwhelming numbers of fish, and disparities between counting and migration periods; thus, these data represent a minimum count of adult chinook. Counts have exceeded 1,300 fish in each of the last three years (5,465 in 2002); and a rigorous mark-recapture estimate of outmigrant abundance in 2002 exceeded 200,000 (Shawn Chase, Sonoma County Water Agency, *personal communication*). Since chinook salmon have not been produced at the Don Clausen Hatchery since 1997, so these counts represent natural production or straying from other systems. No data were available to assess the genetic relationship of these fish to others in this or other ESUs.

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

A.2.7.3 Hatchery Information

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

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

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

Eel River—Four hatcheries, none of which are major production hatcheries, contribute to production of chinook salmon in the Eel River Basin: hatcheries on Yager Creek (recent effort: ~12 females spawned per year), Redwood Creek (~12 females), Hollow Tree Creek, and the Van Arsdale Fish Station (VAFS) (~60 males and females spawned). At the first three hatcheries, broodstock is selected from adults of non-hatchery origin; at VAFS, broodstock includes both natural and hatchery origin fish. In all cases, however, insufficient data on naturally spawning chinook salmon are available to estimate the effect of hatchery fish on production or other characteristics of naturally spawning chinook salmon in the Eel River basin. Since 1996, all fish released from VAFS have been marked. Subsequent returns indicate that approximately 30% of the adult chinook salmon trapped at VAFS are of hatchery origin. It is not clear what these numbers indicate about hatchery contributions to the population of fish spawning below VAFS.

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

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

Summary

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

A.2.7.4 Comparison with Previous Data

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

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

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

A.2.8. SACRAMENTO RIVER WINTER-RUN CHINOOK

A.2.8.1. Previous BRT Conclusions

Summary of major risk factors and status indicators

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

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

In addition to having only a single extant population dependent on artificially-created conditions, winter chinook face numerous other threats. Chief among these is small population size: escapement fell below 200 fish in the 1980s. Population size declined monotonically from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival. There are questions of genetic integrity due to winter chinook having passed through several bottlenecks in the 20th century. Other threats include inadequately screened water diversions, predation at artificial structures and by nonnative species, overfishing, pollution from Iron Mountain mine (among other sources), adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures (especially, until recently, Red Bluff Diversion Dam), and vulnerability to drought.

BRT conclusions

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

Listing status

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

A.2.8.2 Summary of New Information

Viability assessments

Two studies have been done on the population viability of Sacramento River winter chinook. Botsford and Brittnacher, (1998), in a paper that is part of the draft recovery plan, developed de-listing criteria using a simple age-structured, density-independent model of spawning escapement. They concluded, on the basis of the 1967-1995 data, that winter chinook were certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with less than 50 females.

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

Draft recovery plan

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

New abundance data

The winter chinook spawning run has been counted at Red Bluff Diversion Dam (RBDD) fish ladders since 1967. Escapement has been estimated with a carcass survey since 1997. Through the mid-1980s, the RBDD counts were very reliable. At that time, changes to the dam operation were made to alleviate juvenile and adult passage problems. Now, only the tail end of the run (about 15% on average) is forced over the ladders, greatly reducing the accuracy of the RBDD counts. The carcass mark-recapture surveys were initiated to improve escapement estimates. The two measures are in very rough agreement, and there are substantial problems with both estimates, making it difficult to choose one as more reliable than the other. It does appear that the RBDD count is an underestimate, since the carcass survey crews have handled more carcasses than the RBDD estimate in some years, and only a fraction of the carcasses are available for capture. The problem with the carcass-based estimate is the estimation of this fraction—it appears that the probability of initial carcass recovery depends strongly on the sex of the fish and possibly on whether it has been previously recovered. In spite of these problems, both abundance measures suggest that the abundance of winter chinook is increasing. Based on the RBDD counts, the winter chinook population has been growing rapidly since the early 1990s (Figure A.2.8.1), with a short-term trend of 0.26 (Table A.2.8.1). On the population growth rate-population size space, the winter chinook population has a somewhat low population growth and moderate size compared to other Central Valley salmonid populations (Figure A.2.8.2).

Table A.2.8.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sac. R. winter chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Cr. spring chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Cr. spring chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Cr. spring chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)
Sac. R. steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	-0.06 (-0.26, 0.15)

Winter chinook may be responding to a number of factors, including wetter-than-normal winters, reduced harvest, changes in RBDD operation, installation of a cold-water release device on Shasta Dam, changes in operations of the state and federal water projects, and a variety of other habitat improvements. While the status of winter chinook is improving, there is only one winter chinook population and it is dependent on cold-water releases of Shasta Dam, which could be vulnerable to a prolonged drought. The recent 5-year geometric mean is only 3% of the maximum post-1967 5-year geometric mean.

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

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

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

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

	model	
parameter	constant ☐	step change ☐
μ	-0.085	-0.214
	-0.181,0.016	(-0.322,-0.113)
δ	NA	0.389
	NA	(0.210, 0.574)
σ^2_p	0.105	0.056
	(0.0945, 0.122)	(0.046, 0.091)
σ^2_m	0.0025	0.011
	(2.45×10^{-6}, 0.0126)	(3.92×10^{-6}, 0.022)
P_{100}(ext)[a]	0.40	0.003
	(0.00, 0.99)	(0.0, 0.0)

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

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

$$y_t = N_t \exp(\varepsilon_t), \tag{2}$$

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

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

According to Akaike's information criterion (AIC), the step-change model is a much better approximation to the data than the constant population growth rate model, with an AIC difference of 9.61 between the two models (indicating that the data provide almost no support for the constant-growth model). The step-change model suggests the winter chinook population currently has a λ of 1.21, while for the constant population growth rate model, $\lambda = 0.97$[1]. The extinction risks predicted by the two models are extremely different: winter chinook have almost no risk of extinction if the apparent recent increase in λ holds in the future, but are certain to go extinct if the population grows at its average rate, with a most likely time of extinction being 100 years. While it would be dangerous to assume that recent population growth will hold indefinitely, it does appear that the status of winter chinook is improving.

Harvest impacts

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

Because they mature before the onset of the ocean fishing season, winter chinook should have lower harvest rates than fall chinook. At the time of the last status review, the only information of the harvest rate of winter chinook came from a study conducted in the 1970s. The impact rate (direct and indirect effects of harvest) of ocean fisheries on winter chinook was estimated to be 0.54, and the river sport fishery at that time was thought to have an impact rate of 0.08.

The recent release of significant numbers of ad-clipped winter chinook provides new, but limited, information on the harvest of winter chinook in coastal recreational and troll fisheries. The 1998 brood year was the first brood to have sufficient tag releases. Dan Viele (Sustainable Fisheries, SWR) conducted a cohort reconstruction of the 1998 broodyear. Winter chinook are mainly vulnerable to ocean fisheries as 3-year olds. Viele calculated, on the basis of 123 coded-wire-tag recoveries, that the ocean fishery impact rate on 3-year-olds is 0.21 and the in-river sport fishery impact rate is 0.24. For a given year, these fisheries combine to reduce spawning escapement by about 43%. The high estimated rate of harvest in the river sport fishery, which arises from the recovery of 8 coded-wire tags, was a surprise, because salmon fishing is closed from January 15 to July 31 to protect winter-run chinook. The tags were recovered in late December/early January, at the tail end of the fishery for late-fall chinook. The estimate of river sport fishery impact is much less certain than the ocean fishery impact estimate because of the lower number of tag recoveries, less rigorous tag sampling, and larger expansion factors. Never the less, in response to this information, the California Fish and Game Commission is moving

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

forward with an emergency action to amend sport fishing regulations to ban retention of salmon caught in river sport fisheries on January 1 rather than January 15. Had such regulations been in place in 1999/2000, the harvest rate would have been 20% of that observed.

New hatchery information

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

A.2.8.3 New Comments

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

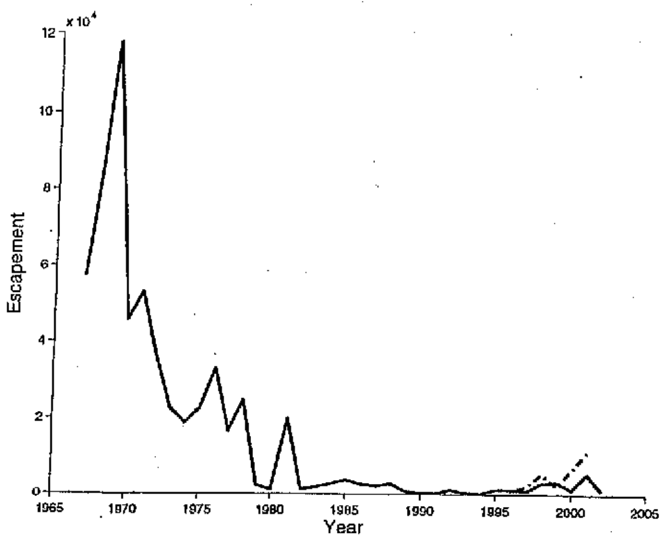

Figure A.2.8.1. Estimated winter chinook spawner abundance as determined by RBDD fish ladder (solid line) and carcass mark-recapture (dashed line).

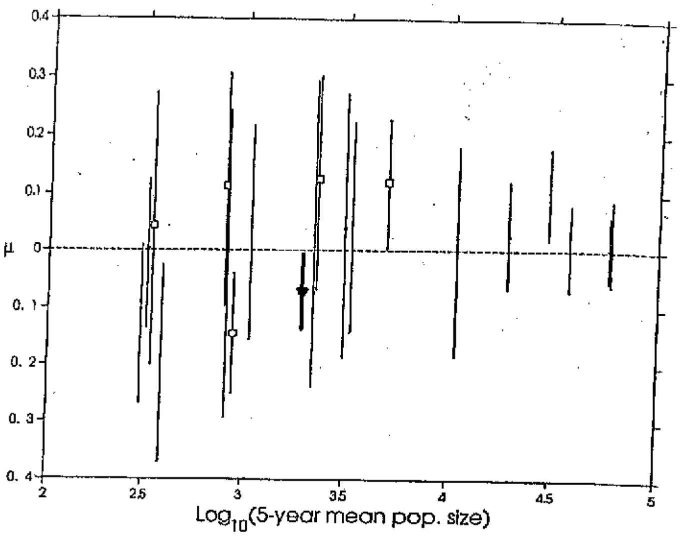

Figure A.2.8.2. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; open squares- spring chinook; filled triangle- winter chinook; small black dots- other chinook stocks. Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in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

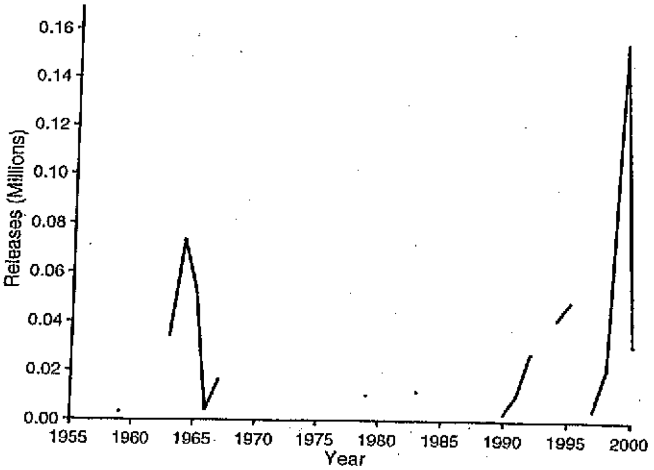

Figure A.2.8.3. Number of juvenile winter-run chinook released by Coleman and Livingston Stone National Fish Hatcheries.

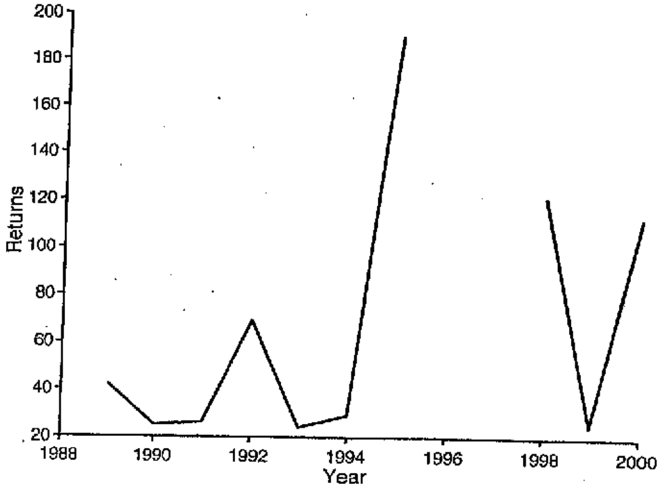

Figure A.2.8.4. Number of adult winter-run chinook captured by Coleman and Livingston Stone National Fish Hatcheries.

A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK

A.2.9.1. Previous BRT Conclusions

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring chinook fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring chinook program. Like most spring chinook, CV spring chinook require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500m elevation, and most such habitat in the CV is now behind impassable dams (Figure A.2.9.1). Only three self-sustaining wild populations of spring chinook (on Mill, Deer and Butte creeks, tributaries to the lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on catches in the early gill-net fishery). Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain, and these are apparently dependent on the Feather River Hatchery.

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

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

BRT conclusions

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

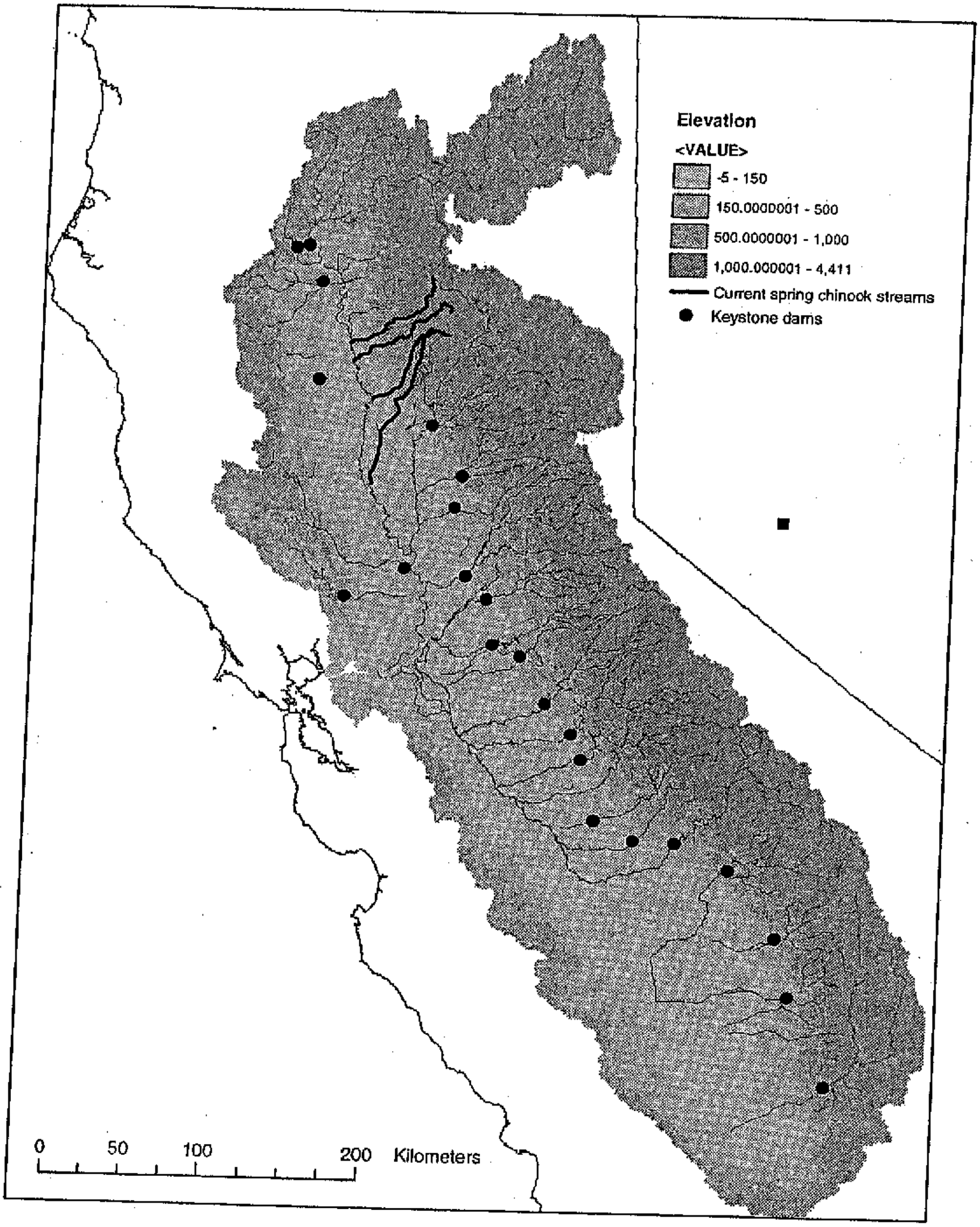

Figure A.2.9.1. Map of Central Valley showing the locations of self-sustaining spring chinook populations. These populations are found in the only watersheds with substantial accessible habitat above 500 m eleveation.

Listing status

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

A.2.9.2 New Data

Status assessments

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

Population structure

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

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring chinook are not closely related to sympatric fall chinook populations or the FRH spring chinook stock (Figure A.2.9.2). FRH spring chinook, putative Feather River natural spring chinook, and Yuba River spring chinook fell into a large cluster composed mostly of natural and hatchery fall chinook.

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

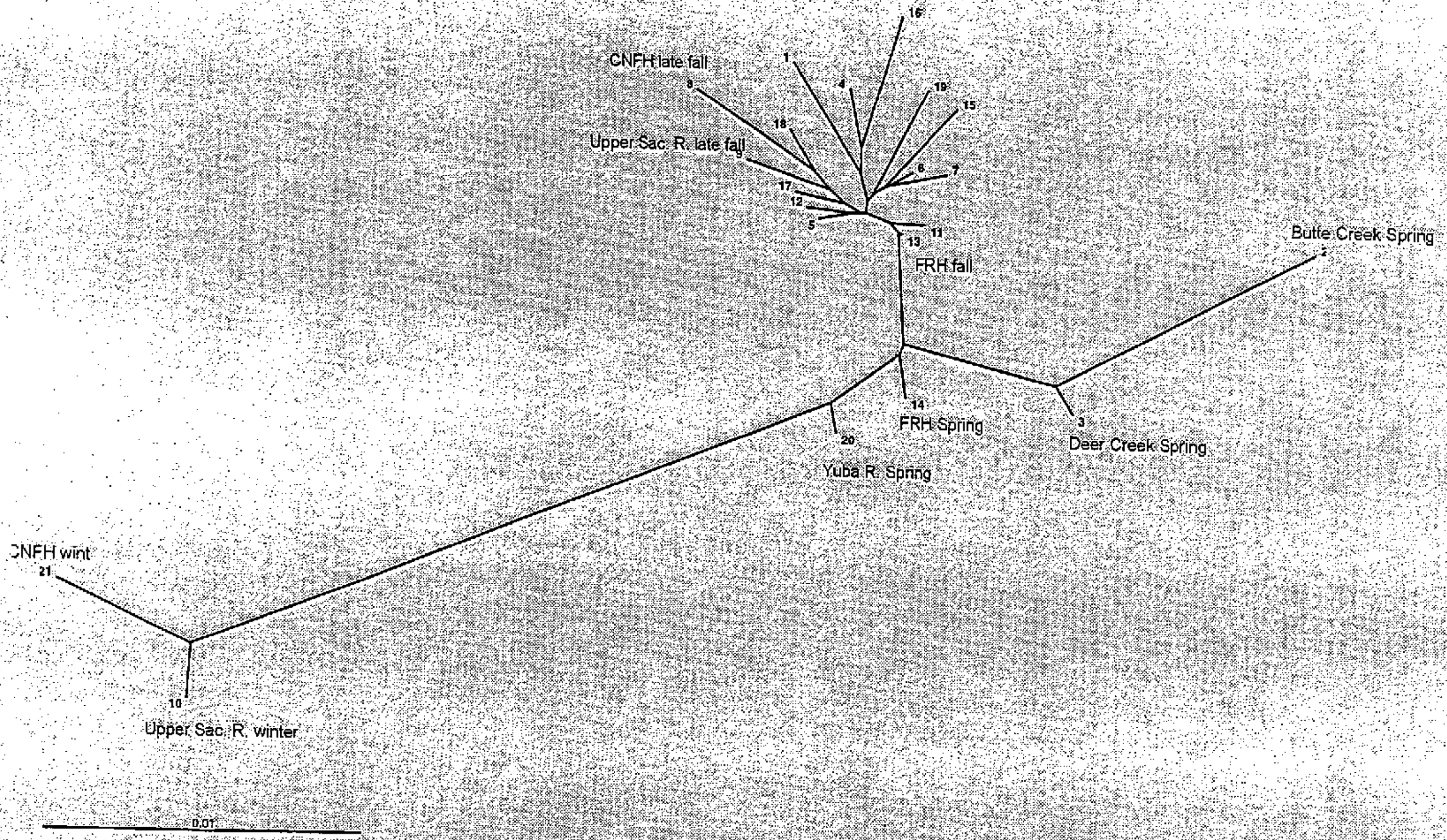

Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall chinook populations.

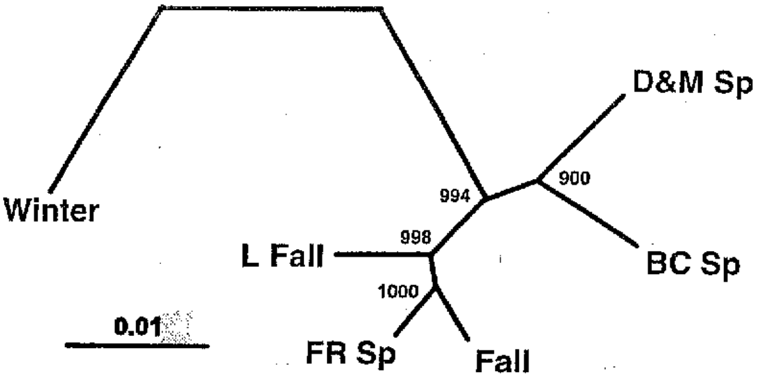

Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring chinook; L Fall = late-fall chinook; Winter = winter chinook. The tree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

At least two hypotheses could explain the Feather River observations:

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

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

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

Historic habitat loss

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

Life history

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

New harvest information

Coded-wire tagging of juvenile spring chinook in Butte Creek provides some limited information on current harvest rates of this population. Based on eight CWT recoveries in the ocean fisheries and 15 CWT recoveries in Butte Creek, the harvest rate on age 3 Butte Creek spring chinook is 0.44 (Ward et al. 2002).

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

A.2.9.3 New Comments

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

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation

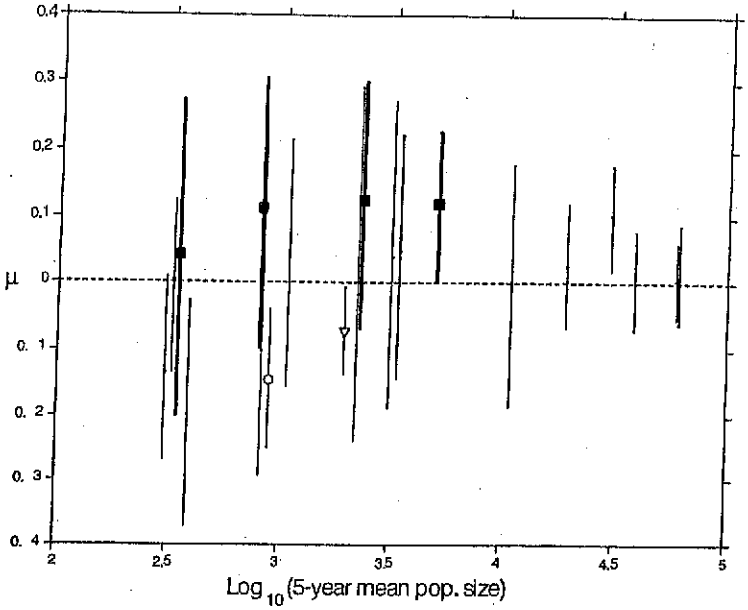

Figure A.2.9.4. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring chinook; open triangle- winter chinook; small black dots- other chinook stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log[\lambda]$.)

3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included (1) an analysis by B.J. Miller showing that significant and expensive changes to water operations in the Delta provide fairly modest benefits to chinook populations; (2) "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," discussed in the preceding paragraph; (3) a memo from J. F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

New abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico creek spring chinook have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant

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

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

habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial climate.

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

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

A.2.9.4 New Hatchery Information

FRH currently aims to release 5 million spring chinook smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.5). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.6).

A.2.9.5 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer and Butte creek populations noted in the previous status review have apparently continued. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring chinook are not closely related to the Mill, Deer and Butte creek spring chinook populations.

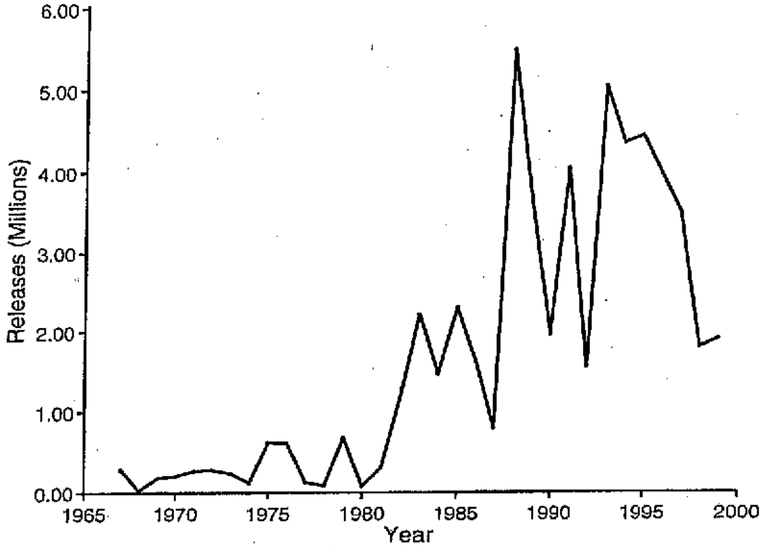

Figure A.2.9.5. Number of spring-run chinook released by Feather River Hatchery.

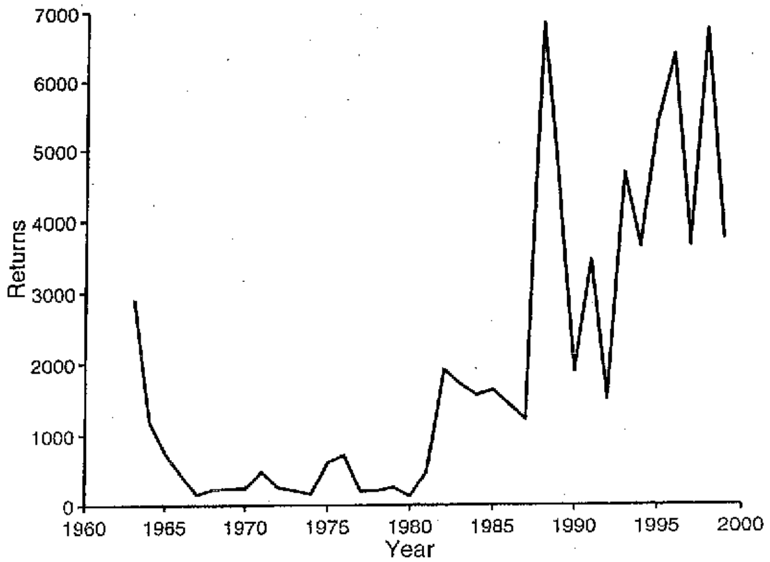

Figure A.2.9.6. Number of spring-run chinook returning to Feather River Hatchery.