20 May 2011

MEMORADUM

TO: Rod McInnis, Southwest Regional Administrator
Will Stelle, Northwest Regional Administrator

FROM: Cisco Werner, Southwest Science Director

SUBJECT: Updated status information for west coast salmon and steelhead – update to 5 January 2011 report.

The attached report responds to a 23 February 2010 request from Southwest and Northwest Regions of the National Marine Fisheries Service to the Southwest and Northwest Fisheries Science Centers to summarize the status of listed ESUs/DPSs. Specifically, the Centers were asked whether there is new information since the last listing determinations to suggest that the status may have changed. Below, we briefly summarize our findings. The attached report will eventually be edited and formatted for publication either as a Technical Memorandum or, more likely, a manuscript for submission to a peer-reviewed publication.

This report updates information provided by NMFS Southwest Fisheries Science Center (SWFSC) to NMFS Southwest Region (SWR) on 5 January 2011. The SWR initially requested in February 2010 a status review update for all salmonids listed as threatened or endangered under the Endangered Species Act (ESA). Subsequently, the SWR modified its request to exclude status updates for the Central California Coast Coho Salmon ESU, which was being considered in a separate ESA-related process, and coastal steelhead DPSs based on preliminary findings that suggested there was a need to convene a Biological Review Team to review DPS boundary delineations. Subsequent to the completion and transmittal of the 5 January 2011 report, SWR revised their request to SWFSC and asked that status updates for coastal steelhead DPSs be included using the existing DPS delineations so as to fulfill the need for a five- year update. This revised report incorporates that request. Findings for listed ESUs and DPSs previously covered in 5 January 2011 report have not changed, although text has been modified to include discussion of all reviewed ESUs and DPSs.

This summary is for listed ESUs/DPSs in California, including the Southern Oregon / Northern California Coho Salmon ESU that includes coastal basins in southern Oregon. A similar report has been compiled by the Northwest Fisheries Science Center summarizing status information for ESUs/DPSs in the Northwest Region.

Boundary delineation for the Central California Coast (CCC) Coho Salmon ESU has recently been reviewed (Spence et al. 2011), as has the status of the ESU (Spence and Williams 2011), as part of an ongoing ESA petition process. Consequently, CCC Coho Salmon are not considered in this report.

For each listed ESU/DPS in California reviewed, the attached report briefly summarizes whether there was new information since the 2005/2006 listings to suggest that there has been a change in the extinction risk. The two areas of emphasis in this review included (1) information on ESU/DPS boundaries, and (2) trends and status in abundance, productivity, spatial structure and diversity specifically addressed by viability criteria developed by Technical Recovery Teams (TRT).

ESU/DPS boundary issues:

The initial process was directed at consideration of new information relevant to ESU/DPS boundaries by a working group of both Centers. Through this process it was determined that sufficient new information was available for listed steelhead DPSs along the California coast to warrant convening a Biological Review Team to more rigorously consider the information.

The recent genetic data suggest several potential boundary changes may be warranted for coastal California steelhead DPSs. No potential changes in DPS boundaries involving the Central Valley were suggested by these recent genetic data. Based on these new data and information, the Southwest Region has requested that a BRT be convened to compile, review, and evaluate the best available scientific and commercial information on steelhead genetics, life history and biology, and the ecological/habitat requirements of steelhead that is relevant to evaluation of current DPS boundaries and potential boundary changes, including information generated by the TRTs, (2) evaluate to what extent this information does or does not support the current DPS boundaries; and (3) describe how this information individually (e.g., genetics only) and collectively would support potential alternative DPS boundaries.

The existing boundary delineations of coastal California steelhead DPSs were used in this report.

Another ESU boundary issue dealt with the existing ESU boundaries for Chinook salmon that left an area between the Russian River in the north and inclusive of the San Francisco/San Pablo Bay complex that is not part of an ESU and within which Chinook salmon spawning activity has been observed in the past several years. We concluded that populations recently identified in the Napa and Guadalupe rivers, along with future populations found in basins inclusive of the San Francisco/San Pablo Bay complex that express a fall-run timing should be included in the Central Valley Fall/Late Fall Run Chinook salmon ESU. The geographic proximity and ecological similarities of the Lagunitas Creek watershed to other coastal basins in the California Coastal Chinook Salmon ESU and recently available genetic information suggest that Lagunitas Creek and other populations identified between the Russian River and the Golden Gate should be placed in the CC Chinook salmon ESU. As new information becomes available, these conclusions should be revisited.

Changes in extinction risk:

New biological information indicates there has been no significant change in the extinction risk of the following ESUs/DPSs: SONCC Coho Salmon ESU, Coastal California Chinook Salmon ESU, Northern California Steelhead DPS, Central California Coast Steelhead DPS, South-Central California Steelhead DPS, Southern California Steelhead DPS, and Sacramento Winter-run Chinook Salmon ESU since 2005.

New biological information indicates there has been an increase in extinction risk for Central Valley Spring Chinook Salmon ESU and Central Valley Steelhead DPS since 2005.

cc: John Stein (NWFSC)
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STATUS REVIEW UPDATE FOR PACIFIC SALMON AND STEELHEAD LISTED UNDER THE ENDANGERED SPECIES ACT: SOUTHWEST

20 May 2011 – Update to 5 January 2011 report

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1 Introduction and Summary of Findings

Note: This is a revision to a report provided by NMFS Southwest Fisheries Science Center (SWFSC) to NMFS Southwest Region (SWR) on 5 January 2011. The SWR initially requested in February 2010 a status review update for all salmonids listed as threatened or endangered under the Endangered Species Act (ESA). Subsequently, the SWR modified its request to exclude status updates for the Central California Coast Coho Salmon ESU, which was being considered in a separate ESA-related process, and coastal steelhead DPSs based on preliminary findings that suggested there was a need to convene a Biological Review Team to review DPS boundary delineations. Subsequent to the completion and transmittal of the 5 January 2011 report, SWR revised their request to SWFSC and asked that status updates for coastal steelhead DPSs be included using the existing DPS delineations so as to fulfill the need for a five- year update. This revised report incorporates that request. Findings for listed ESUs and DPSs previously covered in 5 January 2011 report have not changed, although text has been modified to include discussion of all reviewed ESUs and DPSs.

1.1 Introduction

The Endangered Species Act (ESA) requires that the National Marine Fisheries Service (NMFS) review the status of listed species under its authority at least every five years and determine whether any species should be removed from the list or have its listing status changed. In June 2005, NMFS issued final listing determinations for 16 Evolutionarily Significant Units (ESUs) of Pacific Salmon (*Oncorhynchus* spp.), and in January 2006 NMFS issued final listing determinations for 10 Distinct Population Segments (DPS) of steelhead (the anadromous form of rainbow trout: *O. mykiss*). The NMFS is therefore conducting a review in 2010 and early 2011 of 26 of the 28 currently listed Pacific salmonid ESUs/DPSs of West Coast Pacific salmonids[1]. The review is being conducting by the NMFS Northwest and Southwest Regions. This report is in response to a 23 February request from the Regions to the Northwest and Southwest Fisheries Science Centers to provide a scientific summary of the status of the subject ESUs/DPSs. The information in the report will be incorporated into the Regions' reviews, and the Regions will make final determinations about any proposed changes in listing status, taking into account not only biological information but also threats to the species and ongoing or planned protective efforts.

This report covers nine of the 10 ESA-listed ESUs/DPSs that lie wholly or partially in California[2]. The Central California Coast Cho Salmon ESU in not included in this report; the status of this ESU was recently reviewed as part of a response to an ESA petition that challenged the current southern boundary of this ESU. A Biological Review Team (BRT) concluded that the southern boundary should be extended south to the Aptos

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[1] FR 75:13082 – see http://www.nwr.noaa.gov/Publications/FR-Notices/2010/upload/75FR13082.pdf
[2] The Southern Oregon/Northern California Coast Coho Salmon ESU includes populations in coastal basins of southern Oregon.

Creek watershed (Spence et al. 2011), and a status review was published shortly thereafter (Spence and Williams 2011). The Northwest Fisheries Science Center has developed a companion report for listed ESUs/DPSs in Oregon, Washington, and Idaho (Ford et al. 2011). Information in this review will be incorporated into the Regions' review, and the Regions will make final determinations about any proposed changes in status.

In this review, we consider 1) new information relevant to the delineation of ESU/DPS boundaries, and 2) new information on status and trends in abundance, productivity, spatial structure and diversity specifically addressed by viability criteria developed by Technical Recovery Teams (TRTs). The development of viability criteria for each ESU/DPS represents a notable difference between this status review and the most recent comprehensive status review (Good et al. 2005). NMFS initiated its salmon recovery planning in 2000, publishing guidelines for developing viability criteria for Pacific salmonids (McElhany et al. 2000) and launching a series of regional Technical Recovery Teams (TRTs) to develop viability criteria for each listed ESU/DPS. At the time of the 2005 status review, however, only one TRT (Puget Sound Chinook Salmon) had produced final viability criteria, and no formal recovery goals had been adopted for any ESU/DPS. In contrast, in 2010 all ESUs/DPSs have TRT-developed viability criteria and several have formal recovery goals (Table 1). Therefore, this review summarizes current information (through the 2009-2010 spawning year) with respect to the viability criteria developed by the TRTs. Consequently, the current review considers not only changes in populations that have occurred since the 2005 review (through the 2009-2010 spawning year) but also the status of populations and ESUs/DPSs in relation to the viability criteria developed by the TRTs.

1.2 An Overview of New Information for Consideration of Boundary Delineations of Listed California ESUs/DPSs[3]

As previously discussed, NMFS is required to review the status of Endangered Species Act (ESA) listed groups every five years. As part of that process, it is necessary to evaluate the geographic or ecological boundaries of listed Evolutionarily Significant Units (ESUs) and Distinct Population Segments (DPSs) to determine if new information is available that suggests a boundary change could be warranted. In general, there have been significant amounts of genetic information and ecological analyses of California anadromous salmonids since the previous status reviews. Specifically, efforts by the SWFSC Molecular Ecology and Genetic Analysis Team in recent years have produced substantial amounts of population genetic data that contribute to our understanding of population structure of ESA-listed salmonids. Additionally, Technical Recovery Teams have examined both existing and newly acquired ecological and environmental information in their development of historical population structure and viability criteria (Lindley et al. 2004, Bjorkkstedt et al. 2005, Boughton et al. 2006, Lindley et al. 2006,

[3] Prepared by J. C. Garza, D. Boughton, B. Spence, S. Lindley, and T.Williams (NMFS Southwest Fisheries Science Center, Santa Cruz, California).

Boughton et al. 2007, Lindley et al. 2007, Williams et al. 2006, Spence et al. 2008, Williams et al. 2008). Furthermore, there are new analyses of environmental and ecological characteristics besides the TRT reports (Boughton et al. 2009). For specific species and ESUs/DPSs, these new data warrant the convening of a Biological Review Team for consideration in the context of other information (e.g., ecological, zoogeographical). The new genetic information are summarized below by species.

Chinook salmon

Chinook salmon are distributed in coastal basins north of the Golden Gate (entrance to San Francisco Bay) and in the Sacramento/San Joaquin River and associated Bay/Delta systems of California's Central Valley. In California, six ESUs have currently been identified. The Southern Oregon/Northern California Coastal (SONCC) ESU includes populations from Cape Blanco in the north to the lower Klamath River in the south. The California Coastal (CC) ESU includes populations from Redwood Creek in the north to the Russian River (inclusive) in the south. The Upper Klamath and Trinity Rivers ESU includes populations spawning upstream of the confluence of these two rivers. The Central Valley contains three ESUs, one of which, Fall Run/Late Fall Run Chinook salmon, currently extends from Carquinez Strait into the Sacramento and San Joaquin rivers and their tributaries. The other two ESUs, Sacramento River Winter Run and Central Valley Spring Run Chinook salmon, do not extend into the Bay/Delta Region at all. The Coastal California and the Central Valley Spring run ESUs are ESA listed as threatened, the Sacramento River Winter Run ESU is ESA listed as endangered, and the other ESUs are not listed. The currently-defined ESU boundaries leave an area between the Russian River in the north and inclusive of the San Francisco/San Pablo Bay complex that are not part of an ESU and within which Chinook salmon spawning activity has been observed in the past several years.

Since the previous status reviews, large amounts of microsatellite and single nucleotide polymorphism (SNP) genetic data have been collected for California populations of Chinook salmon and, through collaboration, much more broadly throughout the entire range of the species (Garza et al. 2008; Seeb et al. 2007; Narum et al. 2008). There are no new genetic data that we are aware of that suggest a boundary change is necessary for the SONCC or Upper Klamath/Trinity Chinook Salmon ESUs. Nor do any of these recent data indicate a need for reassessment of ESU boundaries, spatially or temporally, in the Central Valley. However, genetic data are now available for Chinook salmon in basins between the California Coastal Chinook ESU and the Central Valley Fall/Late Run ESUs, specifically from adults returning to Lagunitas Creek (Garza, unpublished data A), which enters Tomales Bay, and the Napa and Guadalupe rivers (Garza, unpublished data B; Garza and Pearse 2008a), which enter into San Pablo and San Francisco bays, respectively. These data provide a means to determine membership of these populations in one of the adjacent ESUs.

Genetic data from tissues samples collected from Chinook salmon adults in the Napa and Guadalupe rivers indicate that these fish have a strong affinity to the Central Valley Fall

Chinook salmon ESU (Garza et al., unpublished data B; Garza and Pearse 2008a). Although there are similarities in the genetic make-up of the non-listed Central Valley Fall Chinook salmon ESU and the listed Central Valley Spring-run Chinook salmon ESU, the genetic baselines employed in these analyses accurately assign fish to these ESUs at least 85% of the time and all 41 fish from the Napa River and 25 of 28 fish from the Guadalupe River were assigned to the Central Valley Fall Run ESU. Moreover, the adults sampled in the Napa River were observed during the period of late November through early January which is consistent with the fall-run or late-fall-run life-history type. We conclude that populations recently identified in the Napa and Guadalupe rivers, along with future populations found in basins inclusive of the San Francisco/San Pablo Bay complex that express a fall-run timing should be included in the Central Valley Fall/Late Fall Run Chinook salmon ESU.

Analysis of tissue samples from relatively small numbers (N=17) of adult Chinook salmon collected in Lagunitas Creek are more equivocal, with equal numbers of fish assigning to both California Coastal and Central Valley Fall Chinook salmon groups, with three fish also identified as fish from the Oregon Coast (Garza, unpublished data A). The geographic proximity and ecological similarities of the Lagunitas Creek watershed to other coastal basins in the California Coastal Chinook Salmon ESU suggest that Lagunitas Creek and other populations identified between the Russian River and the Golden Gate should be placed in the CC Chinook salmon ESU given the rather ambiguous findings provided by the recently collected genetic information. As new information becomes available, this conclusion should be revisited.

Coho salmon

Coho salmon are distributed in coastal California basins from the Oregon border in the north to Monterey Bay in the south and historically were present in the San Francisco/San Pablo Bay system, where they are now extirpated. Populations to the north of Punta Gorda, from the Mattole River north, are assigned to the SONCC Coho Salmon ESU, whereas populations to the south of Punta Gorda to the San Lorenzo River are part of the Central California Coast (CCC) Coho Salmon ESU. The SONCC ESU is ESA Threatened, whereas the CCC Coho Salmon ESU is ESA Endangered. Abundant new genetic data are available for California populations of coho salmon, including microsatellite genotypes from over 8000 fish from nearly every extant population in the state (Garza, unpublished data C; Garza and Gilbert-Horvath unpublished data). These recent genetic data do not suggest the need for a reexamination of the boundaries of these two ESUs, as these data show a clear separation between populations south and north of Punta Gorda, and no signal of populations at the southern end of the range having been derived from hatchery broodstock from another ESU. Environmental conditions and the recent observation of juvenile fish in Soquel Creek, to the south of the current ESU boundary (the San Lorenzo River) suggest the need to revise the southern boundary of this ESU south to include Soquel and Aptos creeks as suggested by the recently convened BRT (Spence et al. 2011). Otherwise, recent genetic data are all consistent with the current ESU boundaries and provide no reason to reassess them.

Steelhead

Steelhead/rainbow trout (*O. mykiss*) are distributed throughout California, in coastal streams from the Oregon border in the north to the border with Mexico in the south, and throughout the Central Valley. In addition, *O. mykiss* populations are present in nearly all of the tributaries upstream of dams constructed over the last century. There are a total of six DPSs in California, with one in the Central Valley and five on the coast. The Klamath Mountains Province Steelhead DPS begins at the Elk River in Oregon and extends to the Klamath/Trinity basin in California, inclusive. The Northern California Steelhead DPS extends from Redwood Creek in the north to the Gualala River in the south, inclusive. The Central California Coast Steelhead DPS begins at the Russian River, contains populations in streams tributary to the San Francisco/San Pablo Bay system, and stretches south to Aptos Creek, inclusive. This leaves an approximately 30 km stretch of coast, containing numerous small coastal streams (e.g., Ft. Ross Creek) with steelhead, not included in either of the two previously mentioned, adjacent DPSs. The South-Central California Coast Steelhead DPS starts at the Pajaro River in the Monterey Bay Region and continues to Arroyo Grande in San Luis Obispo Bay. The Southern California Steelhead DPS begins at the Santa Maria River, inclusive, and stretches to the border with Mexico. The California Central Valley Steelhead DPS includes all populations in the Sacramento/San Joaquin River system and its delta. All of these DPSs include only potentially anadromous fish below definitive natural or manmade barriers to anadromy. The Klamath Mountains Province DPS is not ESA listed, the Southern California DPS is listed as endangered, and all of the others are listed as threatened under the ESA.

Abundant new genetic data are available for these populations, primarily microsatellite, but also single-nucleotide polymorphism (SNP) and mitochondira DNA (mtDNA) data (Clemento et al. 2009; Garza et al. 2004; Aguilar et al. unpublished; Pearse et al. In review). These data include a systematic evaluation of populations from the Oregon border to the southern portion of the South Central California Coast DPS and a subsequent evaluation of groups of populations above and below dams in the two southernmost DPSs with a large number (18-24) microsatellite markers. Additional data have been collected on numerous populations from the Central Valley and Klamath/Trinity Basin, as well as comparisons of summer and winter steelhead in the Eel and Klamath/Trinity River Basins, with these same microsatellites. Subsets of the coastal and Central Valley populations have been assessed with large numbers (89-169) of new SNP markers as well, and have provided consistent results. One additional dataset that has provided data relevant to assessing DPS boundaries is an analysis of museum specimens collected in 1897 and 1909 by John Otterbein Snyder from populations ranging from the upper Salinas River to the South Fork of the Eel. These specimens have so far only yielded mtDNA sequences, but these data provide a unique glimpse at historical population structure in these DPSs.

The recent genetic data suggest several potential boundary changes may be warranted for coastal California DPSs. For example, Clemento et al. (2009) found no evidence for a genetic boundary between the two southernmost DPSs and Bjorkstedt et al. (2005) presented analyses indicating that genetic boundaries in the northern coastal DPSs coincide with current boundaries in one regional area, between the Northern and Central California Coast DPSs. No potential changes in DPS boundaries involving the Central Valley were suggested by these recent genetic data.

Based on these new data and information, the Southwest Region has requested that a BRT be convened to compile, review, and evaluate the best available scientific and commercial information on steelhead genetics, life history and biology, and the ecological/habitat requirements of steelhead that is relevant to evaluation current boundaries and potential DPS boundary changes, including information generated by the TRTs, (2) evaluate to what extent this information does or does not support the current DPS boundaries; and (3) describe how this information individually (e.g., genetics only) and collectively would support potential alternative DPS boundaries.

The existing boundary delineations of coastal California steelhead DPSs were used in this report

1.3 Summary of Findings

For seven of the ESUs/DPSs (SONCC coho salmon, Sacramento winter Chinook salmon, California Coastal Chinook salmon, Northern California steelhead, CCC steelhead, South-central California steelhead, and Southern California steelhead) the new information suggests that there has been no change in extinction risk since 2005 status review (Table 2). For three ESUs/DPSs (CCC coho salmon, Central Valley spring Chinook salmon, and Central Valley steelhead) the new information suggest an increase extinction risk. For the Central Valley Steelhead DPS, the previous BRT (Good et al. 2005) considered it likely to become extinct, new data and information indicates that the status has gotten worse for this DPS and the DPS faces an even greater extinction risk.

For considering if there has been a change in the extinction risk of an ESU/DPS, data and information were considered in the context of the recently developed TRT viability criteria and in not solely determined by a change in trend/status since the 2005 BRT. In general, as Table Intro2 illustrates, ESUs or DPSs that the previous BRT (Good et al. 2005) considered likely to become endangered are missing populations from diversity strata and only a portion of the populations are currently known to be extant. For example, the ESUs/DPSs determined to be in danger of extinction by Good et al. (2005) included Sacramento River Winter Chinook Salmon ESU and Central Valley Steelhead ESU. Both continue to exhibit a limited distribution across diversity strata identified by TRTs and a large percentage of the identified populations are missing (Table Intro2).

In two cases, the California Coastal Chinook Salmon ESU and the Central Valley Spring Chinook Salmon ESU the development of the TRT viability criteria since the last BRT provides measures to assess extinction risk. For the Central Valley Spring Chinook Salmon ESU new data and information did not indicate a negative trend since the previous BRT review, but 14 of the 18 populations identified by the TRT are extinct. For the California Coast Chinook Salmon ESU, there continue to be few data sets available to assess population trends. With the delineation of independent populations and diversity strata by the TRTs, this review had measures to evaluate spatial structure.

Table 1. List of viability reports completed by Technical Recovery Teams.

Domain	Viability Criteria document name	Year completed
Puget Sound – Chinook Salmon	Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit	2002
Puget Sound - Hood Canal Summer Chum Salmon	Determination of Independent Populations and Viability Criteria for the Hood Canal Summer Chum Salmon Evolutionarily Significant Unit	2007
Puget Sound - Lake Ozette Sockeye Salmon	Viability Criteria for the Lake Ozette Sockeye Salmon Evolutionarily Significant Unit	2009
Willamette/Lower Columbia	Revised viability criteria for salmon an steelhead in the Willamette and Lower Columbia Basins 2003 and 2006	2006
Oregon Coast	Biological recovery criteria for the Oregon Coast Coho Salmon Evolutionarily Significant Unit	2007
Interior Columbia Basin	Viability criteria for application to Interior Columbia Basin salmonid ESUs	2007
North Central California Coast	A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Coast recovery domain	2008
Southern Oregon Northern California Coast	Framework for assessing viability of threatened Coho salmon in the Southern Oregon/Northern California Coast Evolutionarily Significant Unit	2008
Southern-Central California Coast	Viability criteria for steelhead of the south-central and southern California coast	2007
California Central Valley	Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin	2007

Table 2. Summary of previous Biological Review Team findings (Good et al. 2005), current listing status, and summary of current review of new and additional data, changes in trends/status since last review, spatial extend of current populations, and current viability of populations. Note that know low-risk independent populations are those populations that are demonstrably low-risk.

ESU/DPS	2005 BRT (Good et al. 2005)	Listing Status	Current review: Change in trend/status since 2005 BRT	Diversity strata occupied (occupied/total)	Extant populations (extant/total)	Known low-risk independent populations (viable/total)	5-year Update (this report)
SONCC coho salmon	Likely to become endangered	Threatened	Negative	7/7	29/31	0/31	No change
CCC coho salmon	Danger of extinction	Endangered	Recently reviewed by Spence and Williams (2011)				
Coastal Chinook salmon	Likely to become endangered	Threatened	Uncertain	3/4 fall run 0/2 spring run	9/15 fall run 0/6 spring run	0/15 0/6	No change
Northern CA steelhead	Likely to become endangered	Threatened	Uncertain	5/5 winter run 2/2 summer run	42/42 5/10	0/42 0/10	No change
CCC steelhead	Likely to become endangered	Threatened	Uncertain	5/5	26?/37[a]	0/37	No change
South-central CA steelhead	Likely to become endangered	Threatened	Uncertain	4/4	40/42	0/42	No change
Southern CA steelhead	Danger of extinction	Endangered	None	3/5	17/48	0/48	No change
CV Spring Chinook salmon	Likely to become endangered	Threatened	Mixed	3/4 (2/4)[b]	4/18	1/18	Increased risk of extinction
Central Valley steelhead	Danger of extinction	Threatened	Negative		50?/81[c]	0/81[d]	Increased risk of extinction
Sac. Winter Chinook salmon	Danger of extinction	Endangered	Negative	0/1	1/4	1/4	No change

a – Current occupancy uncertain for 6-8 populations in San Francisco Bay area and coastal Marin and Santa Cruz counties.

b – As proposed by the TRT, one diversity stratum for CV Spring Chinook salmon consisted only of dependent populations, so only 2 of 4 diversity strata in this ESU are occupied by independent populations.

c – Populations assumed extant if some historical habitat currently accessible.

d – Most populations in this DPS are data deficient; the few with data are at high risk of extinction.

2 Recovery Domain Summaries – Southwest

2.1 Southern Oregon / Northern California Coast

2.1.1 Southern Oregon / Northern California Coast Coho Salmon ESU[4]

The geographic setting of the SONCC Coho Salmon ESU includes coastal watersheds from Elk River (Oregon) in the north to Mattole River (California) in the south. The ESU is characterized by three large basins and numerous smaller basins across a diverse landscape. The Rogue River and Klamath River extend beyond the Coast Range and include the Cascade Mountains. The Eel River basin also extends well inland, including inland portions at relatively high elevation and portions that experience dryer and warmer summer temperature. The numerous moderate and smaller coastal basins in the ESU experience relatively wet, cool, and temperate conditions that is in contrast to interior sub-basins of the Rogue, Klamath, and Eel basins, which exhibit a range of conditions including snowmelt-driven hydrographs, hot dry summers, and cold winters. The lower portions of these large basins are more similar to the smaller coastal basins in terms of environmental conditions than they are to their interior sub-basins.

ESU/DPS Boundary Delineation

The SONCC Coho Salmon ESU currently includes populations spawning from Elk River (Oregon) in the north to Mattole River (California) in the south, inclusive. New genetic data are available, including microsatellite genotypes for fish from most extant populations in California, and included samples from populations coast wide (Garza, Unpublished data C; Garza and Gilbert-Horvath Unpublished data). These recent genetic data do not suggest the need for a re-examination of the boundaries between the Central California Coast Coho Salmon ESU and the SONCC Coho Salmon ESU. These data show clear separation between populations south and north of Punta Gorda, the current southern boundary of the ESU. Recently, the Biological Review Team for Oregon Coast Coho Salmon ESU reviewed new information, primarily genetic data, to determine if a reconsideration of the northern boundary of the SONCC Coho Salmon ESU and the southern boundary of the Oregon Coast Coho Salmon ESU was warranted (Stout et al. 2010). After considering the new information, the BRT concluded that a reconsideration of the ESU boundary the between the SONCC and Oregon Coast coho salmon ESUs was not necessary. The basis for their conclusion was that the environmental and biogeographical information considered by Weitkamp et al. (1995) remains unchanged, and new tagging and genetic analysis published subsequently to the original ESU boundary designation continue to support the current ESU boundary at Cape Blanco, Oregon.

[4] Section prepared by T. H. Williams

Summary of Previous BRT Conclusions

Good et al. (2005) concluded that the SONCC Coho Salmon ESU was likely to become endangered. The BRT found that data did not suggest any marked change, either positive or negative, in the abundance or distribution of coho salmon within the SONCC ESU. They stated that coho salmon populations continued to be depressed relative to historical numbers, and there were strong indications that breeding groups had been lost from a significant percentage of streams within their historical range (Good et al. 2005). The BRT did note that the 2001 broodyear appeared to be one of the strongest perhaps of the last decade, following a number of relatively weak years (the exception being the numbers of fish in the Rogue River that had an average increase in spawners in early 2000 despite low years in 1998 and 1999 [Good et al. 2005]). Risk factors identified in previous status reviews such as severe declines from historical run sizes, the apparent frequency of local extinctions, long-term trends that were clearly downward, and degraded freshwater habitat and associated reduction in carrying capacity continued to be a concern to the BRT. The BRT did note several risk factors that had been reduced, including termination of hatchery production of coho salmon at the Mad River and Rowdy Creek and restrictions on recreational and commercial harvest of coho salmon since 1994 (Good et al. 2005). An additional risk identified by the BRT was the illegal introduction of nonnative Sacramento pikeminnow (*Ptychocheilus grandis*) to the Eel River (Good et al. 2005).

Brief Review of TRT Documents and Findings

The Technical Recovery Team (TRT) for the SONCC Coho Salmon ESU prepared two documents intended to guide recovery planning efforts for the ESA-listed coho salmon. The first of these reports described the historical population structure of the ESU (Williams et al. 2006). In general, the historical population structure of coho salmon in the SONCC ESU was characterized by small-to-moderate-sized coastal basins where high quality habitat is in the lower portions of the basin and by three large basins where high quality habitat was located in the lower portions, middle portions of the basins provided little habitat, and the largest amount of habitat was located in the upper portions of the sub-basins. The SONCC TRT categorized populations into one of four distinct types based on its posited historical functional role in the ESU:

> Nineteen *functionally independent populations*, defined as populations with a high likelihood of persisting over 100-year time scales and that conform to the definition of independent "viable salmonid populations" offered by McElhany et al. (2000).
>
> Twelve *potentially independent populations*, defined as populations with a high likelihood of persisting over 100-year time scales, but that were too strongly influenced by immigration from other populations to be demographically independent.

Seventeen small *dependent populations* of coho salmon, which are believed to have had a low likelihood of sustaining themselves over a 100-year time period in isolation and that received sufficient immigration to alter their dynamics and extinction risk.

Two *ephemeral populations*, defined as populations that were both small enough and isolated enough that they were only intermittently present.

In addition to categorizing individual populations, the population structure report also placed populations into *diversity strata*, which are groups of populations that likely exhibit genotypic and phenotypic similarity due to exposure to similar environmental conditions or common evolutionary history (Williams et al. 2006). This effort was a prerequisite for development of viability criteria that consider processes and risks operating at spatial scales larger than those of individual populations.

The second TRT report proposes a framework for assessing viability of coho populations in the SONCC Coho Salmon ESU (Williams et al. 2008). This report established biological viability criteria, from which delisting criteria are currently being developed by federal recovery planning teams. These criteria consist of both population-level viability criteria and ESU-level criteria. Application of these criteria requires time series of adult spawner abundance spanning a minimum of four generations for independent populations.

The population viability criteria represent an extension of an approach developed by Allendorf et al. (1997) and include criteria related to population abundance (effective population size), population decline, catastrophic decline, spawner density, and hatchery influence (Table 3). In general, the spawner density low-risk criterion, which seeks to ensure a population’s viability in terms its ability to fulfill its historical functional role within the ESU, is the most conservative. Preliminary viability targets for each population are determined by the spawner density low-risk criterion (Table 4). The ESU-level criteria are intended to ensure representation of the diversity within and ESU across much of its historical range, to buffer the ESU against potential catastrophic risks, and to provide sufficient connectivity among populations to maintain long-term demographic and genetic processes. These criteria are summarized in Table 5.

The lack of time series of adult abundance at the appropriate spatial scale or temporal scale (i.e., enough years of data from present back 9 to 12 years) precluded rigorous application of the criteria proposed by Williams et al. (2008). Although the appropriate data were lacking for the TRT to assess population viability using the framework proposed, data available to the TRT and used by Good et al. (2005) were in agreement with earlier assessments (Weitkamp et al. 1995; California Department of Fish and Game 2002) that component populations were in decline and that SONCC coho salmon were likely to become endangered in the foreseeable future.

New Data and Updated Analyses

Consideration of information from public
No public input in on the status of SONCC Coho Salmon was received (e.g., time series data of adult abundance, smolt counts, juvenile counts and distribution, etc.).

Abundance and Trends
Quantitative population-level estimates of adult spawner abundance spanning more than 9 –12 years are scarce for independent or dependent populations of coho salmon in the SONCC ESU. New data since publication of the previous status review (Good et al. 2005) consists of continuation of a few time series of adult abundance, some of which had only a few years of data at the time of the last status review, expansion of efforts in coastal basins of Oregon to include SONCC ESU populations, and continuation and addition of several "population unit" scale monitoring efforts in California.

The Oregon Department of Fish and Wildlife (ODFW) initiated monitoring and reporting of time series of adult coho salmon estimates for five of the seven independent populations in the Oregon portion of the SONCC ESU (ODFW 2010). These estimates are based on spawning habitat distribution as sampling frames and Environmental Monitoring and Assessment Program (EMAP) site selection process to provide random, spatially balanced set of sites. These estimates are of wild spawners derived through application of carcass fin-mark observations. The Chetco and Winchuck rivers along with dependent populations are not included in the current sampling frame and counts from the Elk River and Lower Rogue were minimal for the period of record (2002 – 2009) due to inadequate samples for determining total or wild abundance (Table 6, Figures 1 and 2). Sampling did not occur in 2005 and 2009 due to reported budget constraints. These efforts, although at this time not of the duration to satisfy viability criteria (12 years), are reported here to establish their use in future status reviews and to provide some insight into numbers of wild adult coho salmon in these populations. In addition to spawner density, the percent of marked fish was also estimated. The average percent marked fish was very low (<0.1%) in all but the Middle Rogue/Applegate rivers population (Figure 2).

In California, there are two independent populations currently monitored at the "population unit" scale, although neither of the duration to satisfy viability criteria (12 years) and currently only counts are made, estimates of adult abundance are not determined. These adult counts from the Scott and Shasta rivers emphasize the current precarious situation in the Klamath Basin (Table 6, Figure 3). In particular, the Shasta River count is now nine years in duration (3 generations) and from this time series a decline is apparent, the slope being significantly different from zero ($p = 0.04$) and an almost 50% decline in abundance from one generation to the next ($\hat{C}$ from Williams et al. 2008). In addition, the number of adult coho salmon counted at the Shasta River weir is less than the depensation threshold of 531 adults (Williams et al. 2008).

Other than the Shasta River and Scott River adult counts, reliable current time series of naturally produced adult migrant or spawners are not available for the California portion of the SONCC ESU at the "population unit" scale. As discussed by Good et al. (2005), CDFG has conducted annual spawner surveys on 4.5 miles of Sprowl Creek, tributary to the Eel River, since 1974 (except of 1976-1977) and on 2 miles of Canon Creek, tributary to the Mad River, since 1981 (PFMC 2010). These counts are conducted primarily to generate minimum Chinook salmon counts and detecting coho salmon is problematic due to conditions during those surveys (Good et al. 2005) and the number of adult coho salmon observed over the past 29 years has never exceeded 29 fish (Table 5). Spawning surveys have been conducted on tributaries of the Smith River to generate minimum coho salmon escapement estimates (McLeod and Howard 2010). On the West Branch of Mill Creek four survey reaches totaling 4.75 miles and on the East Branch five survey reaches totaling 5.4 miles were included, although occasional exclusion or inclusion of specific reaches within each stream varied (see McLeod and Howard 2010 for details). The Smith River population unit has approximately 386 IPkm, so this partial count can not be used to determine current status of this population and the trends of the estimates over the past nine years at each site is not significantly different than zero (Table 7).

Two other partial counts from California streams included an AUC derived estimate of spawners over the past 12 years in Prairie Creek, a tributary of Redwood Creek, and an eight year time series from Freshwater Creek, a tributary of Humboldt Bay (Table 7). The Prairie Creek estimate has a non-significant negative trend ($p > 0.05$) over the past 12 years (Figure 4). The Freshwater Creek time series, which includes estimates from 2003 to 2009, fish counts for 2001 and 2002, has a significant negative trend ($p = 0.001$) over the eight years (Table 7, Figure 5).

The best available short- and long-term time series data (12 years, > 21 years, respectively) for adult coho salmon in the SONCC ESU are from the Rogue River (T. Satterwaite, Oregon Department of Fish and Wildlife, personal communication). Unfortunately, neither of these estimates are of a single independent population, rather these data sets represent counts of a composite of several populations (estimates based on Huntley Park sampling effort) or portions of an independent population (Gold Ray Dam counts). However, these counts do provide valuable insight into the general status of fish in the Rogue Basin. In addition, coded-wire-tag returns (CWT) to Cole Rivers Hatchery provide an estimate of marine survival. Such estimates are lacking elsewhere in the ESU.

The Huntly Park seine estimates provide the best overall assessment of naturally produced coho salmon spawner abundance in the basin (Good et al. 2005). Four independent populations contribute to this count (Lower Rogue River, Illinois River, Middle Rogue and Applegate rivers, and Upper Rogue River) that has had a significant positive trend ($p = 0.025$) over the past 30 years and a non-significant negative trend ($p > 0.05$) over the past 12 years or four generations (Table 7; Figures 6 and 7). Passage estimates at Gold Ray Dam provide a partial count of wild adult coho salmon of the Upper Rogue River population. Similar to the basin-wide trends, Gold Ray Dam passage over the past 30 years shows a significant positive trend ($p = 0.001$) with an average of 3,724 fish while over the past 12 years there is a non-significant negative trend ($p > 0.05$) with an average of 6,688 fish (Table 7; Figures 8 and 9).

Of particular note are data from coded-wire-tag (CWT) returns to Cole Rivers Hatchery on the Rogue River that provide an estimate of survival of hatchery fish and therefore estimates of marine survival. Since 2003, survival of hatchery fish has been less than 2%, with extremely low survival rates for the 2005 and 2006 broodyears of 0.05% and 0.07%, respectively (Figure 10; S. Clements, ODFW Corvallis, personal communication).

Other data

The Mattole Salmon Group has developed an "escapement index" for coho salmon in the Mattole River from data from the past 16 years (Thompson 2010). Their escapement index is based on redd surveys and is an attempt to correct for differences in survey coverage from year to year. The index is based on the number of redds observed divided by the accumulated miles surveyed. Although not a spawner abundance estimate, this "population unit" scale index provides some insight into the general status of the coho salmon population in the Mattole River. The trend in the escapement is negative, but not significantly different from zero ($p > 0.05$). Following the trends from Freshwater Creek, the Rogue Basin estimate (Huntley Park), and Gold Ray Dam counts, the escapement index for the Mattole River shows a recent high during the 2004-2005 surveys, followed by a decline to the present (Figure 11). This 2001 broodyear hatchery fish at Cole Rivers Hatchery experienced the greatest marine survival of the past seven years (Figure 10). In the context of the various time series of counts and indices available, marine survival throughout the SONCC ESU appears to have been relatively uniform across the ESU and in decline for the past six years.

Juvenile survey data are available from various populations throughout the ESU. A coordinated juvenile survey is conducted by ODFW throughout Oregon coastal basins using their rearing distribution of juvenile salmonids as sampling frames and the Environmental Monitoring and Assessment Program (EMAP) site selection process to provide random, spatially balanced set of sites for their snorkel surveys (Jepson and Leader 2008). There is one frame and stratum for 1^{st}-3^{rd} order stream reaches in the SONCC Coho Salmon ESU. In 2007, 21 of the targeted 25-30 sites were surveyed from the sampling stratum that contained 469 miles of rearing habitat, resulting in 2.8% of the stratum being surveyed (Jepson and Leader 2008). In summary, Jepson and Leader (2008) report that coho salmon juveniles occurred in 81% of the sites surveyed and average percent pool occupancy was 62% in 2007. For SONCC Coho Salmon, the time series of data are not that of the Oregon Coast Coho Salmon ESU (10 years) and therefore discussion of trends was not possible. These data from the Oregon portion of the SONCC Coho Salmon ESU do suggest that coho salmon are present through much of the available habitat represented by the sampling frame.

The Mattole Salmon Group also operates a downstream migrant trap that provides counts of coho salmon smolts. Due do low numbers, estimates were not calculated for 2009. This "population unit" scale sampling will be extremely useful as the time series continues. Recent trap counts of smolts have been 450, 222, 313, and 225, 2006-2009 respectively (James 2008). Outmigrant trapping has also been conducted in the West Branch and East Fork of Mill Creek (McLeod and Howard 2010). These traps capture fish from only a small portion of the Smith River population. Counts are available from 1994 to 2009, with estimates (DARR) available from 2001 to 2009. For West Branch of Mill Creek, the number of smolts between 2001 to 2009 has ranged from 763 to 10821 with an average of 4303; on East Branch Mill Creek the number of smolts between 2001 to 2009 has ranged from 496 to 3184 with and average of 1668 (McLeod and Howard 2010).

Discussion

Although long-term data on coho abundance in the SONCC Coho Salmon ESU are scarce, all available evidence from shorter-term research and monitoring efforts indicate that conditions have worsened for populations in this ESU since the last formal status review was published (Good et al. 2005). For all available time series (except the parietal counts from West Branch and East Fork of Mill Creek), recent population trends have been downward. The longest existing time series at the "population unit" scale is from the past nine years for Shasta River, it has a significant negative trend. The two extensive time series from the Rogue Basin both have recent negative trends, although neither is statistically significant.

We received little new data to determine if occupancy throughout the ESU has changed since the last status review of Good et al. (2005). In their review, Good et al. (2005) noted that they had strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. Good et al. (2005) also noted that the 2001 boodyear appeared to be the strongest of the last decade and that the Rogue River stock had an average increase in spawners over the last several years (as of Good et al. 2005 review). For this evaluation of status, none of the time series examined (other than West Branch and East Fork Mill Creek) had a positive short-term trend and examination of these time series indicates that the strong 2001 broodyear was followed by a decline across the entire ESU. The exception being the Rogue Basin estimate from Huntly Park that exhibited a strong return year in 2004, stronger than 2001, followed by a decline to 394 fish in 2008, the lowest estimate since 1993 and the second lowest going back to 1980 in the time series.

These short-term declines across the ESU are of concern, but are considered here in the context of the one estimate we have for marine survival from CWT hatchery fish at Cole Rivers Hatchery (Figure 10) that indicated extraordinarily low marine survival for the 2005 and 2006 broodyears. The estimate for 2004 broodyear was also low at 0.97%. This is in contrast to survival rates of Cole Rivers Hatchery fish of 4.35%, 7.81%, and 4.89% for the broodyears 1997, 1998, and 1999 respectively. These three broodyears were the three most recent broodyears considered by Good et al. (2005). Williams et al. (2008) cautioned that interpretation of trend must be made in the context of marine and freshwater survival during the period being examined. It is not surprising that negative short-term trends were observed in the limited number of time series available given the apparent low marine survival in recent years. Troubling is that we were not aware of information that would suggest freshwater conditions are improving and the dangerously low number of fish being observed in the few "population unit" scale time series (e.g., Shasta River – 30 adults 2008, 9 adults 2009) and the second lowest number of fish from Huntly Park estimates since 1980.

Additionally, it is evident that many independent populations are well below low-risk abundance targets, and several are likely below the high-risk depensation thresholds specified by the TRT (Table 4). Though population-level estimates of abundance for most independent populations are lacking, it does not appear that any of the seven diversity strata currently supports a single viable population as defined by the TRT's viability criteria, although all diversity strata are occupied.

The SONCC Coho Salmon ESU is currently considered likely to become endangered. The apparent negative trends across the ESU are of great concern as is the lack of information to determine if there has been improvement in freshwater habitat and survival. However, the negative trends were considered in the context of the apparent low marine survival over the past five years that likely contributed to the observed declines. Williams et al. (2008) state that the interpretation of trend must be made in the context of marine and freshwater survival. The concern is that the Technical Recovery Team did not want to set up a situation where an ESU's extinction risk was switching from greater risk to lesser risk or vice versa over very short time periods based on short-term population responses to marine conditions alone. The new information available since Good et al. (2005) while cause for concern, does not appear to suggest a change in extinction risk at this time.

2.2 North-Central California Coast Domain[5]

The North-Central California Coast Recovery Domain encompasses the geographic region from Redwood Creek (Humboldt County) south to Soquel Creek (Santa Cruz County) inclusive. Two salmon ESUs and two steelhead DPSs lie wholly within this region: California Coastal Chinook salmon, Central California Coast coho salmon, Northern California steelhead, and Central California Coast steelhead. A portion of a fifth ESU, the Southern Oregon-Northern California Coast (SONCC) coho salmon ESU, also lies in this geographic region; however, this ESU was addressed by the SONCC Workgroup of the Oregon and Northern California Coast Technical Recovery Team.

The Technical Recovery Team (TRT) for the North-Central California Coast Recovery Domain prepared two documents intended to guide recovery planning efforts for the ESA-listed salmonids within the domain. The first of these reports described the historical population structure of the four listed ESU/DPSs within the recovery domain (Bjorkstedt et al. 2005). Within this document, the TRT categorized each population into one of three distinct types based on its posited historical functional role:

> *Functionally independent populations*: populations with a high likelihood of persisting over 100-year time scales and that conform to the definition of independent "viable salmonid populations" offered by McElhany et al. (2000).
>
> *Potentially independent populations*: populations with a high likelihood of persisting over 100-year time scales, but that were too strongly influenced by immigration from other populations to exhibit independent dynamics.
>
> *Dependent populations*: populations that had a substantial likelihood of going extinct within 100-year time period in isolation, yet received sufficient immigration to alter their dynamics and reduce their risk of extinction.

In addition to categorizing individual populations, the population structure report also places populations into *diversity strata*, which are groups of populations that likely exhibit genotypic and phenotypic similarity due to exposure to similar environmental conditions or common evolutionary history (Bjorkstedt et al., 2005; revised in Spence et al. 2008). Here, the TRT set the stage for development of viability criteria that consider processes and risks operating at spatial scales larger than those of individual populations.

The second TRT report proposes a framework for assessing viability of populations and ESU/DPSs within the recovery domain (Spence et al. 2008). This report establishes biological viability criteria, from which delisting criteria are currently being developed by federal recovery planning teams. These criteria consist of both population-level viability criteria and ESU- or DPS-level criteria.

The population viability criteria represent an extension of an approach developed by Allendorf et al. (1997) and include criteria related to population abundance (effective

[5] Section prepared Brian C. Spence

population size), population decline, catastrophic decline, spawner density, and hatchery influence (Table 8). In general, the spawner density low-risk criterion, which seeks to ensure a population's viability in terms its ability to fulfill its historical functional role within the ESU, is the most conservative, and preliminary viability targets for each population are determined by this criterion. The ESU-level criteria are intended to ensure representation of the diversity within and ESU/DPS across much of its historical range, to buffer the ESU/DPS against potential catastrophic risks, and to provide sufficient connectivity among populations to maintain long-term demographic and genetic processes. These criteria are summarized in Table 9.

In the sections that follow, we evaluate status of each ESU using the TRTs viability criteria as the framework. Application of these criteria requires time series of adult spawner abundance spanning a minimum of 4 generations for independent populations. For the vast majority of salmon and steelhead populations delineated by the TRT in this domain, population-level estimates of abundance are lacking, and only indices of spawner abundance or local population estimates representing only a portion of the population are available. In the few cases where population-level estimates do exist, the time series seldom exceed the 4-generations recommended by the TRT for application of the criteria. These data are presented despite the shortcomings, as they provide the only basis for evaluating current status and trends. However, the reader is cautioned that short-term trends in abundance or abundance indices are difficult to interpret against the backdrop of variation in environmental conditions in both the freshwater and marine environments.

2.2.1 Central California Coast Coho Salmon ESU

Boundary delineation for the Central California Coast (CCC) Coho Salmon ESU has recently been reviewed (Spence et al. 2011), as has the status of the ESU (Spence and Williams 2011), as part of an ongoing ESA petition process. Consequently, CCC Coho Salmon are not considered further in this report.

2.2.2 California Coastal Chinook Salmon ESU

ESU Boundary Delineation

The initial status review for Chinook salmon (Myers et al. 1998) proposed a single ESU for Chinook salmon populations inhabiting coastal watersheds from Cape Blanco, Oregon, south to but not including San Francisco Bay, and including tributaries of the Klamath River downstream of its confluence with the Trinity River. Subsequent review led to division of the originally proposed ESU into the Southern Oregon and Northern California Coastal (SONCC) ESU, and the California Coastal (CC) ESU, the latter including populations spawning in coastal rivers from Redwood Creek (Humboldt County) south to the Russian River, inclusive (NMFS 1999). The Central Valley currently contains three ESUs, one of which, the Central Valley (CV) Fall/Late Fall

Chinook ESU includes populations in the Sacramento-San Joaquin River basin upstream of Carquinez Straits. This leaves an area between the Russian River and Carquinez Straits, including rivers and streams entering San Francisco and San Pablo bays, that is not included in either ESU. Spawning Chinook salmon have been observed in several streams and rivers of this region, including Lagunitas Creek, the Guadalupe River, and the Napa River.

Since the previous status reviews, large amounts of microsatellite and single nucleotide polymorphism (SNP) genetic data have been collected for California populations of Chinook salmon and, through collaboration, much more broadly throughout the entire range of the species (Garza et al. 2008; Seeb et al. 2007; Narum et al. 2008). Genetic data are now available for Chinook salmon in basins between the California Coastal Chinook ESU and the Central Valley Fall/Late Run ESUs, specifically from adults returning to Lagunitas Creek (Garza, unpublished data A), which enters Tomales Bay, and the Napa and Guadalupe rivers (Garza, unpublished data B; Garza and Pearse 2008a), which enter into San Pablo and San Francisco bays, respectively. These data provide a means to determine membership of these populations in one of the adjacent ESUs.

Genetic data from tissues samples collected from Chinook salmon adults in the Napa and Guadalupe rivers indicate that these fish have a strong affinity to the Central Valley Fall Chinook salmon ESU (Garza et al., unpublished data B; Garza and Pearse 2008a). Although there are similarities in the genetic make-up of the non-listed Central Valley Fall Chinook salmon ESU and the listed Central Valley Spring-run Chinook salmon ESU, the genetic baselines employed in these analyses accurately assign fish to these ESUs at least 85% of the time and all 41 fish from the Napa River and 25 of 28 fish from the Guadalupe River were assigned to the Central Valley Fall Run ESU. Moreover, the adults sampled in the Napa River were observed during the period of late November through early January which is consistent with the fall-run or late-fall-run life-history type. We conclude that populations recently identified in the Napa and Guadalupe rivers, along with future populations found in basins inclusive of the San Francisco/San Pablo Bay complex that express a fall-run timing should be included in the Central Valley Fall/Late Fall Run Chinook salmon ESU.

Analysis of tissue samples from relatively small numbers (N=17) of adult Chinook salmon collected in Lagunitas Creek are more equivocal, with equal numbers of fish assigning to both California Coastal and Central Valley Fall Chinook salmon groups, with three fish also identified as fish from the Oregon Coast (Garza, unpublished data A). The geographic proximity and ecological similarities of the Lagunitas Creek watershed to other coastal basins in the California Coastal Chinook Salmon ESU suggest that Lagunitas Creek and other populations identified between the Russian River and the Golden Gate should be placed in the CC Chinook salmon ESU given the rather ambiguous findings provided by the recently collected genetic information. As new information becomes available, this conclusion should be revisited.

Summary of Previous BRT Conclusions

Myers et al. (1998) and Good et al. (2005) concluded that California Coastal Chinook salmon were likely to become endangered. Good et al. (2005) cited continued evidence of low population sizes relative to historical abundance, mixed trends in the few available time series of abundance indices available, and low abundance and extirpation of populations in the southern part of the ESU. The most recent BRT cited the apparent loss of the spring-run life history type throughout the entire ESU as a significant diversity concern. The BRT also expressed concern about the paucity of information and resultant uncertainty associated with the few estimates of abundance, natural productivity, and distribution of Chinook salmon in the ESU.

Brief Review of TRT Documents and Findings

Bjorkstedt et al. (2005) concluded that the CC-Chinook salmon ESU historically comprised 15 independent populations (i.e., 10 functionally independent and 5 potentially independent) of fall-run Chinook salmon and 6 independent populations (all functionally independent) of spring-run Chinook salmon. Notable in the TRT's structure is the division of Eel River Chinook salmon into two populations: the Lower Eel River population, which includes fish spawning in the South Fork Eel River as well as all mainstem and tributary spawners downstream of the South Fork confluence, and the Upper Eel River population, which includes all fish spawning upstream of the South Fork Eel River confluence, including major tributaries such as the Middle Fork Eel River. The lack of historical data on Chinook salmon in smaller watersheds within this ESU, none of which currently support persistent populations of Chinook salmon, confounded efforts to identify dependent populations. The TRT tentatively identified 17 watersheds as possibly supporting dependent populations, but suggested that perhaps only two of these were consistently occupied by Chinook salmon. Populations were assigned to four geographically based strata, with two of these strata further subdivided into fall-run and spring-run life history types (Bjorkstedt et al. 2005; modified in Spence et al. 2008). For fall-run populations, viability targets based on density criteria developed by Spence et al. (2008) are shown in Table NCC6. Such targets were not developed for spring-run populations because availability of over-summering habitat for adults was considered more likely to limit abundance than availability of spawning or juvenile rearing habitat.

The lack of time series of adult abundance estimates spanning 3-4 generations for any of the 15 independent Chinook populations precluded the TRT from rigorously applying the viability criteria for this ESU (Spence et al. 2008). However, based on the limited ancillary data that was available, the TRT concluded that six independent populations of fall Chinook salmon in this ESU were at high risk of extinction or possibly extinct, including the Ten Mile, Noyo, Big, Navarro, Garcia, and Gualala river populations. One population of fall-run Chinook was determined to be at moderate or high risk (Mattole River), and the remaining populations were deemed to be data deficient. All six putative historical populations of spring-run Chinook salmon were believed extinct (Spence et al. 2008).

New Data and Updated Analyses

Consideration of information from public

Comments on the status of CC-Chinook salmon were received from Friends of the Eel River (FOER 2010), who concluded that the status of this ESU should be changed from threatened to endangered. Concerns expressed by FOER included (1) the apparent loss of several Chinook populations in the southern half of the ESU, including the Ten Mile, Noyo, Big, Little, Navarro, Gualala, and Garcia rivers, as well as the spring-run life history; (2) general degradation of freshwater habitats; (3) potential impacts of harvest, including incidental take in ocean salmon fisheries, bycatch in Pacific Whiting fisheries, and recreational catch-and-release fishing; and (4) potential effects of past and current artificial propagation. In the analysis below, we consider biological information relevant to the assessment of status and trends as it relates to viability criteria; evaluation of threats to Chinook salmon in the CC- ESU will be addressed separately by the NMFS Southwest Regional Office.

Biological information provided by FOER relevant to the status of Chinook salmon included plots representing spawner survey data collected by the California Department of Fish and Game (CDFG) for various sampling reaches in the Eel River, and summary statistics derived from these data. These data included spawner index data from two sites in the Eel River basin, Sproul and Tomki creeks, which have been complied by CDFG since the mid-1970s. These data have been considered in previous status reviews, and are addressed in the section "Abundance and Trends" below. FOER (2010) also presented plots of live fish counts from spawner surveys conducted in a number of tributaries of the South Fork Eel River (e.g., Redwood Creek, China Creek, Pollock Creek, Bull Creek, Cow Creek, and Squaw Creek), the Van Duzen River (Lawrence Creek, Grizzly Creek), and mainstem Eel River (Chadd Creek, Bear Creek) between 2002 and 2008. We acquired these data from CDFG. However, interpretation of this information is difficult. Unlike for Sproul, Tomki, and Cannon creeks, standardized indices have not been developed by CDFG for these other Eel River sites (M. Gilroy, California Department of Fish and Game, Eureka, personal communication, 2 September 2010). This is in part because these surveys have generally been opportunistic and, as a consequence, the level of survey effort for these sites has been both lower and far more variable among years than for the Tomki, Sproul, and Cannon creek surveys. Some sites have been sampled only sporadically, and in the years they have been surveyed, the number of site visits has varied from as few as one to as many as eight. FOER (2010) plotted the total number of live fish observed at each site over all surveys in a given year. However, this analysis is problematic since individual live fish may be counted more than once on successive surveys and because year-to-year differences in total counts may be entirely a function of sampling intensity rather than trend in population abundance. As a result, we do not consider these numbers to be reliable indicators of either status or trend.

Abundance and Trends

New data available since the publication of the last status review (Good et al. 2005) consist primarily of continuation of time series of (1) spawner indices (maximum live/dead counts) at three sites in the Eel and Mad river basins where data have been collected since the 1970s, (2) weir counts at Freshwater Creek that began in 1994, (3) dam counts at Van Arsdale Fish Station in the upper Eel River, (4) spawner estimates (AUC method) for Prairie Creek, a tributary to Redwood Creek (Humboldt County); and (5) video counts of adults at Mirabel in the Russian River that began in 2000. Only the Russian River video counts likely provide some indication of total population abundance, though these counts do not include fish spawning below the counting facility. The remaining sampling efforts either provide only indices of relative abundance and not population estimates (e.g., Mad and Eel river sites), or sample only a portion of the population (e.g., Prairie Creek, Freshwater Creek, and Van Arsdale Station).

Population estimates for Chinook salmon adults in Prairie Creek (part of the Redwood Creek population) have been made annually since 1998. During that time, estimates have averaged 212 adults (range 27 to 531) and the population has experienced a significant ($p = 0.0008$) decline over the 12-year period of record (Figure 12a; Table 11). Spawner surveys had been performed on Cannon Creek, tributary to the Mad River, since 1981, with data expressed as maximum live/dead counts (Figure 12b). Both the 16-yr and 29-yr trend are slightly positive, though not significantly so ($p = 0.738$ and $p = 0.203$, respectively). There has also been a downward trend since 2005. Chinook salmon have been counted at the Freshwater Creek weir since 1994 (Figure 12c). These counts are partial counts, as fish can fish pass over the weir during high flows and smaller jacks may pass through the weir. Additionally, Freshwater Creek represents only one of several Chinook-bearing streams that make up the Humboldt Bay population defined by the TRT. Counts at the weir indicate the wild population has declined ($p = 0.054$) over the 16 years of record (Table 11), a trend that is largely driven by the fact that only two adults were counted at the weir in both 2008 and 2009.

For the Lower Eel River population, spawner surveys have been conducted annually since the mid-1970s at Sproul Creek, a tributary to the South Fork Eel River, with data expressed as maximum live/dead counts. Over the past 16 years, Sproul Creek shows a slight positive trend, though it is not significant ($p = 0.232$); the longer-term trend, however, remains negative, though again the trend is not significant ($p = 0.148$; Figure 12d; Table 11). As Sproul Creek represents only a small fraction of the total spawning habitat available to the Lower Eel River population, these patterns may not necessarily reflect overall trends in the population.

For the Upper Eel River population, two time series of abundance are available: maximum live-dead counts from Tomki Creek, and counts at the Van Arsdale fish station. Returns to both Tomki Creek and Van Arsdale Station appear influenced by stream flows in the mainstem, which in turn are affected by water releases from Cape Horn and Scott dams upriver. In years of lower flow, fish may be less inclined to enter Tomki Creek or to ascend the mainstem Eel River as far as Van Arsdale Station, instead spawning in areas downstream; thus, there is some uncertainty as to the reliability of these data sets for inferring population trends (S. Harris, California Department of Fish and Game, personal communication). Beginning in 2004, mandated increases in minimum flow releases from Cape Horn Dam have been implemented (NMFS 2002; J. Jahn, NMFS Southwest Region, Santa Rosa, personal communication, 1 September 2010), resulting in a general increase in the amount of water available in the mainstem Eel River below the dam. The increase in flow has likely influenced the distribution of spawners in the Eel River, possibly drawing more fish as far as Van Arsdale Station. With that caveat in mind, Tomki Creek Chinook maximum live/dead counts have trended downward, though only the long-term trend is significant ($p = 0.0001$), primarily because of high numbers that prevailed from the late 1970s to mid 1980s (Figure 12e; Table 11). Counts at Van Arsdale Station have shown considerable variation (Figure 12f). Over the last 14 years, during which wild fish were counted separately from hatchery fish, the number of wild fish has trended upward ($p = 0.016$). However, interpretation of these data is complicated by the fact that an average of 38,822 hatchery Chinook salmon were released annually between 1996-1997 and 2003-2004 seasons. Although hatchery fish are not included in the trend analysis, an unknown proportion of wild fish returning are likely progeny of hatchery parents that spawned on natural spawning grounds. The potential influence of hatchery plantings, coupled with the changed in flow regime discussed above, makes it difficult to determine if the recent increase in numbers of fish reaching Van Arsdale Station represents an increase in wild population size or the combined effect of hatchery activities and redistribution of spawners.

Spawner surveys have also been conduction on the Mattole River since the 1994-1995 spawning season by the Mattole Salmon Group (MSG 2010). Because the number of stream kilometers and the frequency of surveys has gradually increased over time, MSG has developed a redd index, which is the total number of Chinook redds observed, divided by the accumulated distance surveyed over all surveys (this includes repeated surveys of the same reach in some instances). Since 1994, the redd index has shown a slight downward trend (Figure 12g).

Finally, video counts of adult Chinook salmon in the Russian River indicate that an average of just over 3000 adults have passed upstream in the last 10 years (range 1125-6103) (Figure 12h). The trend in numbers during this time has been negative but not significant ($p = 0.564$) (Table 11).

Discussion

The lack of population-level estimates of abundance for Chinook salmon populations in the CC ESU continues to hinder assessment of status. The available data, a mixture of partial population estimates and spawner/redd indexes show somewhat mixed patterns, with some showing slight increases and others slight decreases, and few of the trends being statistically significant (Table 11). Further, it is difficult to interpret the available numbers in the context of population viability criteria developed by the TRT. For example, the only available time series from the Upper Eel River are from Tomki Creek and Van Arsdale Station, which together represent only a fraction of the total habitat available to Chinook salmon in this population. These data indicate a minimum combined spawner abundance averaging 469 individuals over the past 16 years. However, the Upper Eel River population is likely substantially larger. For example, in the 2009-2010 spawning season, spawner surveys were conducted on the mainstem Eel River from Dos Rios to Van Arsdale Station, as well as in Outlet Creek and one of its major tributaries, Long Valley Creek. These surveys covered about 40% of the available spawning habitat in these reaches and resulted in a population estimate of just over 3,000 fish (Harris 2010c). Adding to this number the Tomki Creek maximum live/dead count and the Van Arsdale Chinook count (534 fish) and the total exceeds 3,500 for those portions of the Upper Eel River that were surveyed this year, which does not include the Middle Fork Eel River, or the mainstem Eel River and its tributaries from Dos Rios downstream to the confluence of the South Fork of the Eel River. This example highlights the difficulty in interpreting index reach counts that cover only a small fraction of the available spawning habitat. Until more exhaustive and spatially representative surveys of the available habitat are done on a consistent basis, the status of Chinook salmon in these watersheds will remain highly uncertain.

At the ESU level, several areas of concern remain. Within the North-Coastal and North Mountain Interior strata, all independent populations continue to persist, though there is high uncertainty about current abundance in all of these populations. The loss of the spring Chinook life-history type from these two strata represents a significant loss of diversity within the ESU. Additionally, the apparent extirpation of all populations south of the Mattole River to the Russian River (exclusive) means that one diversity stratum (North-Central Coastal) currently does not support any populations of Chinook salmon, and a second stratum (Central Coastal Stratum) contains only one extant population (Russian River) that, while it remains relatively abundant, has shown a declining trend since 2003. The significant gap in distribution diminishes connectivity among strata across the ESU.

In summary, it is difficult to characterize the status of this ESU based on the available data. Although we do not find evidence of a substantial change in conditions since the last status review (Good et al. 2005), when viewed in the context of the TRT's viability criteria, the loss of representation from one diversity stratum, the loss of the spring-run life history type (two diversity substrata), and the diminished connectivity between populations in the northern and southern half of the ESU are troubling. Further complicating matters is the fact that the historical occurrence of persistence populations in the region from Cape Mendocino to Point Arena, which includes the two southern-most diversity strata, is also highly uncertain (Bjorkstedt et al. 2005).

We conclude that there is no evidence to suggest any significant improvement in the status of this ESU. New and additional information available since Good et al. (2005) does not appear to suggest a change in extinction risk.

2.2.3 Northern California Steelhead

DPS Boundary Delineation

The Northern California steelhead DPS comprises winter- and summer-run steelhead populations from Redwood Creek (Humboldt County) south to the Gualala River (Mendocino County). Extant summer-run populations are found in Redwood Creek, Mad River, Eel River (Middle Fork), and Mattole River. The Central California Coast steelhead DPS begins at the Russian River and extends south to Aptos Creek. This leaves several *O. mykiss* populations in small watersheds between the Gualala and Russian rivers that are not currently assigned to either DPS.

Since publication of the last status review (Good et al. 2005), significant new genetic data are available for populations across much of coastal California. These data consist of primarily microsatellite data, but also SNP and mtDNA data (Clemento et al. 2009; Garza et al. 2004; Aquilar et al. unpublished; Pearse et al. 2010). These data have been discussed in greater detail previously in this document (see Section 1.2), and suggest that boundaries, not only for the NC steelhead DPS, but other coastal DPSs within the state, warrant re-examination. The status update below is based on the existing DPS boundaries.

Summary of Previous BRT Conclusions

Busby et al. (1996) and Good et al. (2005) concluded that the Northern California steelhead ESU was not presently in danger of extinction, but was likely to become endangered in the foreseeable future. The BRTs major concerns included low population abundance relative to historical estimates, recent downward trends in most stocks for which data were available, and the low abundance of summer steelhead populations. They also cited continued habitat degradation, the increasing abundance of a nonnative predator (Sacramento pikeminnow) in the Eel River, the influence of artificial propagation on certain wild populations, and the lack of data for this DPS as concerns and sources of risk (Busby et al. 1996; Good et al. 2005).

Brief Review of TRT Documents and Findings

Bjorkstedt et al. (2005) concluded that the NC-Steelhead DPS historically comprised 42 independent populations (19 functionally independent and 23 potentially independent) populations of winter-run steelhead, and as many as 10 independent populations (all functionally independent) of summer-run steelhead. In addition, this DPS likely contained a minimum of 65 (and likely more) dependent populations of winter-run steelhead in smaller coastal watersheds, as well as small tributaries to the Eel River. Steelhead populations were assigned to five geographically based diversity strata, with two of these strata further subdivided into winter-run and summer-run life history types (Bjorkstedt et al. 2005; modified in Spence et al. 2008). For winter-run populations, viability targets based on density criteria developed by Spence et al. (2008) are shown in

Table 12. Such targets were not developed for summer-run populations because availability of over-summering habitat for adults is more likely to limit abundance than either spawning or juvenile rearing habitat.

Spence et al. (2008) concluded that adult abundance information for independent populations of steelhead were insufficient to rigorously evaluate the viability of any of the 42 independent populations of winter-run steelhead in the Northern California DPS using criteria developed by the TRT. Fish counts at Van Arsdale Fish Station in the Upper Eel River basin, which represent the longest time series of adult abundance in the DPS, collects fish from three separate populations upstream: Bucknell Creek, Soda Creek, and the Upper Mainstem Eel River. The TRT concluded that populations in Bucknell Creek and Soda Creek are at moderate/high risk of extinction based on low adult counts at Van Arsdale Fish Station and the fact that these counts were dominated by hatchery fish (i.e., >90%) from 1997-2007. The Upper Eel River was deemed at high risk of extinction due to the loss of the majority of historical habitat (above Scott Dam) and the high proportion of hatchery fish returning to Van Arsdale. Shorter time-series of adult abundance from the Pudding Creek, Noyo River, Caspar Creek, and Hare Creek in the Mendocino Coast suggested that all four of these populations would be considered at moderate risk of extinction should abundances stay about the same (Spence et al. 2008). All other winter-run populations were deemed data deficient.

Summer-run populations have been sampled somewhat more regularly, as these can be quantified during summer months as adult fish can be counted in holding pools. The largest summer-run steelhead population in the DPS spawns in the Middle Fork Eel River and has been surveyed annually since the 1960s. This population was deemed at moderate risk due primarily the fact that, although population numbers continued to be slightly above low-risk thresholds established by the TRT, the long-term trend continued to be downward. Based on less consistent and comprehensive surveys, the TRT concluded that the Mad River summer-run population was likely at least at moderate risk of extinction, and that two other summer-run populations, Redwood Creek and Mattole River, were deemed to be at high risk of extinction based on very low adult counts (Spence et al. 2008).

New Data and Updated Analyses

Population-level abundance estimates for independent populations of NC steelhead continue to be extremely limited, particularly for winter-run populations. Monitoring efforts have produced population abundance estimates for winter-run populations in several streams and rivers along the Mendocino Coast (Pudding Creek, Noyo River, Caspar Creek, Hare Creek), but these time series are relatively short (7-9 years) and so of limited use in evaluating population trends. Although risk metrics are computed for these short time series, they are intended only to provide a general frame of reference and not a rigorous assessment of status. Additionally, monitoring of winter-run steelhead populations has occurred in recent years in Prairie Creek, Freshwater Creek, South Fork Noyo River, Little River (Mendocino Co.), and the Wheatfield Fork of the Gualala River;

in all of these cases, spawner surveys cover only a portion of the total watershed and so constitute partial population estimates. Steelhead counts also continue to be made at Van Arsdale Fish station, though this count represents a composite of three independent populations. Summer-run populations have been monitored using dive counts in four watersheds, including Redwood Creek, Mad River, Middle Fork Eel River, and Mattole River. Only the Middle Fork Eel River counts are likely a reasonable estimate of population-level abundance.

Figure 13 shows time series of abundance for winter- and summer-run steelhead populations in the NC Steelhead DPS. Within the Northern-Coastal stratum, population estimates have been generated for Prairie Creek (part of the Redwoood Creek population) for the past five years, during which estimates have averaged 64, though in the past two years, estimates were just 12 and 4 fish, respectively (Table 14). In Freshwater Creek (part of the Humboldt Bay population), population estimates over the last nine years have averaged 212 fish (range 50-434), with a slight negative but non-significant ($p = 0.602$) trend driven by decreasing numbers over the last 5 years (Figure 13a; Table 14). Winter steelhead abundance data are not available for the Mad River basin except for counts of hatchery fish at the Mad River Hatchery. These counts indicate average returns of more than 2,300 fish annually since the 2000-2001 season. Average releases of juvenile steelhead from the hatchery during this period have averaged over 226,000 (J. Urrutia, CDFG, Sacramento, unpublished data)[6]. Although estimates of the fraction of hatchery fish on natural spawning grounds are not available, the substantial hatchery production suggests artificial propagation as a significant risk for the wild population in the Mad River.

There are essentially no data available for winter-run populations in the Lower Interior stratum, and in the North Mountain Interior diversity strata, the only available data are the Van Arsdale Fish Station counts, which represent a composite of the Upper Eel River, Bucknell Creek, and Soda Creek populations. These counts are strongly influenced by hatchery production. Hatchery and wild fish have been reported separately since the 1996-1997 spawning season. Despite the fact that hatchery steelhead have been released only once (2004-2005) since the 1997-1998 season, hatchery fish have made up 81% of fish returning to Van Arsdale since 1996. This reflects the extraordinarily large number of hatchery fish returning (as many as 7,300) relative to the number of wild fish, which has averaged about 250 fish per year (Figure 13i). The trend in abundance of wild fish has been positive ($p = 0.048$) over the last 14 years (Table 14); however, because of the large hatchery fraction, all three populations represented by these counts are likely at least at moderate risk, with the Upper Eel population likely at high risk due to the loss of the majority of the historical habitat.

In the North-Central Coastal stratum, population-level estimates for four independent populations (Pudding Creek, Noyo River, Caspar Creek, and Hare Creek) all indicate non-significant negative trends ($p = 0.057$, $p = 0.804$, $p = 0.126$, and $p = 0.589$,

[6] Hatchery release and return data supplied by CDFG is preliminary and subject to change. The data may contain inaccuracies for which the Department of Fish and Game should not be held liable.

respectively; Table 13), though we again note that these time series are all of short duration (Figures 13b,c,e,f). Of these populations, the Noyo River population appears the largest, with an estimated average of 302 spawners (range 186-476). A longer time series (11 yrs) is available for the South Fork Noyo River, which over the seven years in common accounted for about 20-25% of the total Noyo River population, showed no trend (Figure 13d; Table 14). Pudding Creek averaged 133 spawners (range 10-265) over eight years, Caspar Creek 64 spawners (range 6-145) over 9 years, and Hare Creek 90 spawners (range 43-162) over five years. Though none of these time series meets the minimum length for applying the TRT's viability criteria, should current patterns continue, the Pudding Creek and Noyo River populations would likely be considered at moderate risk, with Caspar and Hare creek population possibly being considered at high risk based on the effective population size criterion. Little River, a dependent population in the Mendocino Coast area, has recently declined to extremely low levels (Figure 13g), with estimates of just 4 and 2 fish in the last two years.

The only ongoing monitoring effort in the Central Coastal stratum is on the Wheatfield Fork of the Gualala River (part of the Gualala River population). Counts of adult steelhead have averaged 1915 adults (range 369-5843), and there has been no discernable trend in abundance over the 8 years of surveys ($p = 0.999$; Figure 13h; Table 14).

Summer diver surveys have been used to enumerate summer-run steelhead populations in four watersheds within the NC-Steelhead DPS, three of which are in the Northern Coastal Diversity stratum, and on of which is in the North Mountain Interior stratum (Middle Fork Eel River). Dive surveys covering an index reach of approximately 25.9 km of Redwood Creek have been conducted annually since 1981. Mean counts have averaged only 10 fish during the period of record (range 0-44), during which there has been a negative but non-significant ($p = 0.547$) trend. The recent (16-year) trend has been positive ($p = 0.029$); however, the critically low abundance overshadows this recent trend (Figure 13j; Table 14). Diver counts of summer steelhead in different reaches of the Mad River have been conducted by three different entities (CDFG, U.S. Forest Service, and Green Diamond Resource Co.) in the last two decades. CDFG and USFS counts were discontinued in the early 2000s, thus the Green Diamond counts, which ran from 1994 through 2005 and cover several reaches between the confluence of Deer Creek and Mad River Hatchery are the most consistent among years. These counts averaged 252 fish (range 78-501) over the period of record (Figure 13k), but should be viewed as minimum estimates, as not all reaches were surveyed during the period 2001-2005. Because of the inconsistency in survey effort, we did not estimate a trend for this time series.

The longest and most comprehensive time series of abundance for a summer steelhead population is that for the Middle Fork Eel River, which has been monitored since the mid-1960s (Figure 13l). The count has averaged 780 fish over the period of record and 609 fish in the past 16 years (Table 13). Both the short-term (16-year) and long-term (44-year) trends are negative, though not significantly so ($p = 0.507$ and $p = 0.424$, respectively). Lastly, summer dive counts have been made annually on the Mattole River since 1996 by the Mattole Salmon Group (MSG unpublished data). Because survey effort varies among years, the number of fish per km provides the best index of abundance (Figure 13m). These indices suggest negative but only marginally significant trends in the number of both adults (slope = -0.013; p=0.072) and half-pounders (slope = 0.044; p =0.093) over the period of record.

Discussion

The scarcity of time series of abundance at the population level spanning more than a few years continues to hinder assessment of the status of the NC Steelhead DPS. Population-level estimates of abundance are available for only 4 of the 42 independent populations of winter-run steelhead identified by the TRT; all are from the same diversity stratum and none of these time series spans more than 9 years. Similarly, population-level estimates of abundance are available for only 1 of 10 summer-steelhead populations in the DPS. All remaining time series are partial population estimates (except one composite), and so must be viewed with appropriate caution.

With those caveats in mind, trend information from the available datasets suggests a mixture of patterns, with slightly more populations showing declines than increases. Few of these trends are statistically significant, though many populations show declining numbers over the last 5 years. This is not surprising, given the recent drought that affected all of coastal California from 2007 to 2009, as well as what appear to have been unfavorable conditions in the marine environment, which affected other salmonids during the last 5 years. Of the population for which population-level estimates of abundance are available, only the Middle Fork Eel River summer steelhead population approaches low-risk thresholds established by the TRT, failing to satisfy only the effective population size criterion. The remaining populations for which adult abundance has been estimated (i.e., those on the Mendocino Coast) appear to be at either moderate or high-risk of extinction. Of continued concern is the depressed status of at least two of the remaining summer-run populations in the DPS, Redwood Creek and Mattole River. Although surveys within these watersheds do not typically encompass all available over-summering habitats, the chronically low numbers seen during surveys in these rivers suggest that both populations are likely at high risk of extinction. In the Mad River, the high number of hatchery fish in the basin, coupled with the uncertainty about the relative abundance of hatchery and wild spawners is also of concern. For all remaining populations, there is little information from which to assess status. It is generally believed that winter steelhead continue to inhabit most of the watersheds in which they historically occurred. Thus, all diversity strata within the DPS appear to be represented by extant populations. However, there is little basis for assessing whether conditions have improved or gotten worse in the past 5-8 years.

In summary, we find little new evidence to suggest that the status of the NC Steelhead DPS has changed appreciably in either direction since publication of the last status review (Good et al. 2005). New and additional information available since Good et al. (2005) does not appear to suggest a change in extinction risk.

2.2.4 Central California Coast Steelhead

DPS Boundary Delineation

The Central California Coast steelhead DPS includes winter-run steelhead populations from the Russian River (Sonoma County) south to Soquel Creek (Santa Cruz County) inclusive. The current northern boundary, coupled with the current southern boundary (Gualala River) of the Northern California DPS, leaves a roughly 30 km stretch of coastline that falls outside of either DPS (see section 1.2). Several small streams within this region are known to support steelhead.

As noted above, significant new genetic data are available for populations across much of coastal California. These data consist of primarily microsatellite data, as well as SNP and mtDNA data (Clemento et al. 2009; Garza et al. 2004; Aquilar et al. unpublished; Pearse et al. 2010). These data suggest that boundaries of not only the CCC steelhead DPS, but other coastal DPSs within the state, warrant re-examination.

Summary of Previous BRT Conclusions

The original BRT concluded that the ESU was in danger of extinction (Busby et al. 1996), citing likely extirpation of populations in Santa Cruz County and in tributaries to San Francisco and San Pablo Bays, as well as apparent substantial declines in steelhead number in the Russian River. Subsequent status reviews (NMFS 1997; Good et al. 2005) concluded that the ESU was not presently in danger of extinction, but was likely to become so in the foreseeable future. The general paucity of data was indentified as a continuing source of uncertainty.

Brief Review of TRT Documents and Findings

Bjorkstedt et al. (2005) concluded that the CCC-steelhead DPS historically comprised 37 independent populations (i.e., 11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. These populations were placed in five geographically based diversity strata (Bjorkstedt et al. 2005; modified in Spence et al. 2008). Viability targets based on density criteria developed by Spence et al. (2008) are shown in Table 15.

The lack of time series of population-level estimates of abundance spanning 12 or more years precluded application of viability criteria developed by the TRT to any of the 37 independent populations of CCC-Steelhead. Ancillary data on population abundance (a time series of adult abundance spanning 4 years) and the high proportion of returning fish of hatchery origin (34%) led the TRT to classify the Scott Creek population as at moderate risk. Additionally, the TRT concluded that many of populations in the Coastal San Francisco Bay and Interior San Francisco Bay diversity strata, including Walnut Creek, San Pablo Creek, San Lorenzo Creek, Alameda Creek, and San Mateo Creek, were likely at high risk of extinction due to the complete loss of the majority of historical spawning habitat behind impassible barriers and the heavily urbanized nature of most of these watersheds downstream of these barriers. The remaining populations were classified as data deficient.

New Data and Updated Analyses

Data from which to assess status of the CCC-Steelhead DPS remains extremely limited. Monitoring of the Scott Creek population has continued, so the time series now includes the past six years. During that time, the total estimated number of steelhead returning to the stream has averaged 275 (range 126-440), with about 35% of these fish being of hatchery origin and the remainder of natural origin (mean 179; range 71-312). Natural-origin spawners have experienced a significant downward trend (slope = -0.220; p = 0.036).

Elsewhere in the DPS, the status of steelhead is highly uncertain. In the North Coastal and Interior strata, there are no population-level estimates of abundance, and ancillary data is also limited. In the Russian River basin, steelhead return in substantial numbers to the Warm Springs Hatchery and Coyote Valley Fish Facility, with an average of just over 7,000 fish returning to these facilities annually in the last 10 years. Juvenile releases during this period have averaged nearly 500,000 fish annually (J. Urrutia, CDFG, Sacramento, CA, unpublished data[7]). However, the lack of spawner surveys on natural spawning grounds within the Upper Russian River basin makes it impossible to assess either population abundance of wild fish or the fraction of hatchery fish occurring on natural spawning grounds. Data for steelhead in the San Francisco Bay region (both Interior SF Bay and Coastal SF Bay strata) remain limited. Recent juvenile surveys in the Santa Cruz Mountain stratum of this DPS indicate that *O. mykiss* remain present in all major watersheds from San Gregorio Creek south to Aptos Creek (B. Spence, NMFS Southwest Fisheries Science Center, unpublished data); however, other than the aforementioned Scott Creek population estimates, little is known about adult population sizes in this diversity stratum.

Discussion

The scarcity of information on steelhead abundance in the CCC DPS makes it difficult to assess whether conditions have changed appreciably since the previous status review of Good et al. (2005), when the BRT concluded that the population was likely to become endangered in the foreseeable future. In the North Coastal, Interior, and Santa Cruz Mountain strata, most watersheds still appear to still support some steelhead production, but there is high uncertainty about population abundance of almost all independent populations. The high numbers of hatchery fish in the Russian River suggest that risks associated with hatchery production are a significant concern. The status of populations in the two San Francisco Bay strata is likewise highly uncertain, though many

[7] Hatchery release and return data supplied by CDFG is preliminary and subject to change. These data may contain inaccuracies for which the Department of Fish and Game should not be held liable.

populations, particularly those where historical habitat is now inaccessible, are likely at high risk of extinction.

In summary, we find little new evidence to suggest that the status of the DPS has changed appreciably in either direction since publication of the last status review (Good et al. 2005). New and additional information available since Good et al. (2005) does not appear to suggest a change in extinction risk.

2.3 South-Central/Southern California Coast Domain[8]

The South-Central/Southern California Coast (SCSCC) Domain is inhabited by two Distinct Population Segments of steelhead. The South-Central California Coast Steelhead DPS inhabits coastal stream networks from the Pajaro River system in Monterey Bay south to, but not including, the Santa Maria River system in Santa Barbara County. It is currently listed as Threatened. The Southern California Steelhead DPS inhabits coastal stream networks from the Santa Maria River system south to the US border with Mexico. It is currently listed as Endangered.

Freshwater-resident *O. mykiss* also occur in the same geographic region, frequently co-occurring in the same river systems as steelhead, which is the vernacular name for the anadromous form of the species. Anadromous and/or freshwater forms of the species also occur in some basins south of the US border, on the Baja California Peninsula (Ruiz-Capos and Pister 1995).

Summary of Previous BRT Conclusions

Busby et al. (1996) described the first comprehensive status review of steelhead in this domain. Data on run sizes were sparse, but suggested that run sizes had declined quite dramatically over the course of the 20th Century, from the thousands or 10s of thousands to the hundreds or dozens for many of the larger river systems. Consistent with declines was the progressive development of factors for decline over the same period, such as the dewatering of stream systems due to water diversions; the construction of dams with no provision for fish passage; extreme levels of channelization of streams for flood control; and introduction of exotic species that modified the freshwater habitats of steelhead.

Busby et al. (1996) also concluded that the southern range limit of anadromous *O. mykiss* occurred in this domain, at the southern end of the Santa Monica Mountains just north of Los Angeles. Data on mitochondrial DNA suggested that unique steelhead haplotypes were present in this domain, and that a genetic transition occurred in the vicinity of Monterey Bay. Based on these data, and the occurrence of ecological and biogeographic transitions in the vicinity of Monterey Bay and of Point Conception, Busby et al. (1996) concluded that *O. mykiss* populations comprised three evolutionarily significant units (ESUs) along the coast between the Golden Gate and the species' southern range limit. The geographic locales of the transition zones between the ESUs were thought to lie 1) in the vicinity of Monterey Bay, roughly marking the transition from coastal redwood forest to chaparral; and 2) the transition from the Coast Mountain Ranges to the Transverse Mountain Ranges in the vicinity of the Santa-Barbara/San Luis Obispo county line.

Good et al. (2005) updated the status of Pacific coast steelhead populations. In the time period between Busby et al. (1996) and Good et al. (2005), the southern California ESU was listed as endangered and the south-central California coast ESU was listed as threatened. The southern range limit of anadromous fish was found to occur further

[8] Section prepared David A. Boughton

south than previously believed, at least as far as the Tijuana River system at the US border, and possibly further south in Baja California. Run sizes continued to be monitored in one river system, the Carmel River, and were observed to rebound somewhat during the benevolent environmental conditions of the late 1990s and early 2000s, probably aided by intense fisheries management efforts in that basin. However, run sizes were still very low both by historical standards, and in terms of absolute numbers (well under 1000); and the benign environmental conditions were thought to be due to normal fluctuations in climate and ocean conditions, and thus were likely unreliable over the long term.

Run sizes for other stream systems continued to be poorly characterized, but such reports as there were gave no indication of robust runs. However, extensive surveys of the domain indicated that the species *O. mykiss* was still present in most of the basins in which it historically occurred, though in many systems the species was only found above impassable dams, and thus was composed entirely of the resident form of the species. During this time period, NMFS refined the listing status to explicitly apply only to the anadromous form of the species, now designated a DPS, or distinct population segment.

Brief Review of TRT Documents and Findings

After the listing, a technical recovery team (TRT) was convened to formulate a biological and ecological basis for recovery. The team summarized available information and characterized population structure (Boughton et al. 2006), and formulated viability criteria (Boughton et al. 2007). Viability criteria are measurable traits of a DPS that, if achieved, would indicate that the DPS was no longer at risk of extinction. These criteria were intended to serve as the scientific basis for recovery goals and the recovery plan.

The TRT inferred that each coastal basins inhabited by *O. mykiss* probably supported a demographically independent population, but that relevant information was sparse and better information might require revision of this assumption. One system, the Salinas River system, was thought to support three demographically independent populations. Ecologically, the populations could be broadly divided into coastal populations, which inhabit small stream systems on the western slopes of coastal mountains, and thus experience a strong maritime climate; and inland populations, which inhabit a series of stream systems smaller in number, but larger in extent, that drain more inland areas with a weaker influence of maritime climate.

The TRT concluded that two factors complicate the formulation of viability criteria. The first is the variability of climate, and especially precipitation, in the domain. The variable climate (and ocean conditions) probably drive the large fluctuations in run sizes that is reported anecdotally for steelhead runs in the domain. Theoretical models indicated that extinction risk of populations would be highly sensitive to the magnitude of run-size fluctuations, necessitating large average run sizes to achieve viability. Inference from salmonid runs in other parts of the state indicated that a mean annual run size of at least 4150 adults per population would generally be sufficient for viability, but might not always prove necessary. Case-by-case data on the magnitude of fluctuations might reveal smaller mean run sizes to be sufficient for viability in some basins.

The second factor that complicated the formulation of viability criteria was the potential role of resident (i.e., non-anadromous) fish in supporting anadromous runs. Elsewhere in its range, resident *O. mykiss* are sometimes observed to produce anadromous *O. mykiss* among their progeny, and vice versa. If these sorts of reciprocal life-history "crossovers" occur in the SCSCC domain, it would suggest that resident *O. mykiss* might be necessary for the long-term persistence of steelhead; and also that viable (i.e., persistent) steelhead runs could be sustained at more modest levels than an average of 4150 spawners per year per population.

On balance a variety of evidence suggested that life-history crossovers must occur at some level in the domain, but their frequency and quantitative affect on viability could not be determined given information available at the time. The TRT thus recommended a risk-averse approach: viability would be assured if 1) the population produced both the resident and anadromous forms of the species, and 2) the population produced an anadromous run averaging 4150 spawners per year. This dual-prong approach is risk-averse because it essentially covered both the possibility that resident fish are necessary for persistent steelhead runs, and the possibility that they offer no support and that steelhead runs must be large in and of themselves. The TRT concluded that another condition for viability was that anadromous forms include both fish that reared in lotic habitats, and fish that reared in the estuary/lagoon, based on findings by Bond (2006) and Smith (1990).

A summary of viability criteria for the population- and DPS-levels of organization is in Table 16. At the population-level, the prescriptive criteria encompass the precautionary assumptions that were thought to be sufficient for viability. Because it was recognized that less stringent criteria might also be sufficient, but would require additional information to formulate, the TRT also described a more general set of "performance-based criteria" that provide a framework for revised criteria that might be developed in the future. The most useful information for revising criteria was thought to be 1) quantitative information on the magnitude of annual fluctuations in run size, and 2) quantitative information on the abundance of the freshwater-resident form of the species, anadromous/resident "crossover" rates, and spawner size/age/fecundity classes for each form (see Figure 3 and Table 3 in Boughton et al. 2007).

New Data and Updated Analyses

Genetic

Clemento et al. (2009) described the genetic relationships for *O. mykiss* sampled above and below impassable dams, in a series of basins in this domain. The basins were the Salinas River system; the Arroyo Grande River basin in San Luis Obispo County; the Santa Ynez River system; the Ventura River system, and the Santa Clara River system. Also included in the analysis were *O. mykiss* sampled from Fillmore Hatchery strains.

Fillmore Hatchery is located on a tributary of the Santa Clara River, and has been the origin of trout planted in many reservoirs of the domain over the years.

Juvenile fish from 20 locations and hatchery strains were evaluated from neutral alleles at 24 microsatellite loci. Phylogeographic trees and analysis of molecular variance showed that subpopulations within a basin, both above and below dams, were generally each other's closest relatives. Data showed the absence of hatchery fish or their progeny in the tributaries above dams, which indicate that hatchery fish did not commonly spawn in the wild, and that above-barrier fish were descended from coastal steelhead trapped above the dams when they were originally constructed. Finally, although samples from each individual basin had distinctive gene frequencies, there was little evidence for broader-scale genetic structure in the domain. In particular, the analysis of neutral alleles provided no evidence for a genetic transition between the Coast Range and Transverse Range (i.e., the current DPS boundary), or anywhere else for that matter.

2.3.1 South-Central California Coast Steelhead DPS

DPS Boundary Delineation

Since publication of the last status review (Good et al. 2005), significant new genetic data are available for populations across much of coastal California. These data consist of primarily microsatellite data, but also SNP and mtDNA. These data have been discussed in greater detail previously in this document (Section 1.2), and suggest that boundaries for this and other coastal DPSs within the state warrant re-examination.

Recent Run Sizes

<u>Carmel River</u>
Steelhead have been counted at the San Clemente Dam fish ladder since the early 1990s, when the runs rebounded following changes in water-management practices, the end of a regional drought, and the improvement of ocean conditions in the late 1990s. Since a peak around the turn of the millennium, the number of adult steelhead migrating through the fish ladder appears to have undergone a steady decline (Figure 14).

The fisheries staff of the Monterey Peninsula Water Management District (MPWMD) consider the apparent decline to be partly due to mortality from various sources, and partly due to increased numbers of fish spawning before they reach the fish ladder, in response to improved habitat conditions downstream of the dam (MPWMD 2009a; MPWMD 2009b). If true, the decline in run size is less steep than the decline in fish numbers at the ladder.

Staff have periodically surveyed occurrence of redds and adults in the mainstem between the ladder and the ocean; the most extensive observations were made in the springs of 2007 and 2008, covering most of the mainstem but omitting tributaries and only making one survey per season. These data certainly show substantial numbers of fish are omitted from the ladder-counts (see entries in Figure 14).

To calibrate these findings, we draw on information from Gallagher and Gallagher (2005), who conducted extensive redd surveys in Mendocino County streams, and estimated redd-detection rates to be 0.67 – 0.75 per person-redd encounter, and redds per female to be 1.93 – 3.46. Assuming that similar rates apply to the surveys in the Carmel River, and that the sex ratio of the run is 1:1 (both of these assumptions are at best only approximately correct), the redd data imply that somewhere between 162 and 324 migrants spawned in the lower mainstem in 2007, and somewhere between 104 and 208 spawned there in 2008. For comparison the ladder counts of those two years are 222 and 412 adults, respectively, suggesting that about 20% to 60% of adults stayed below the ladder.

<u>San Luis Obispo Creek</u>
Alley and Steiner (2008) electrofished a stratified-random sample of pools from the San Luis Obispo Creek system during June 2007. Although the intent of the sampling was to estimate juvenile abundances and distribution of habitat quality, Alley and Steiner (2008) also observed three adult steelhead in their sample, oversummering in freshwater pools (oversummering of adults steelhead in freshwater was widely reported in the summer of 2007, a very dry year, presumably with restricted opportunities for migration). These data indicate a run of at least 3 anadromous fish for at least one year, but a time-series of steelhead runs is not yet available.

2.3.2 Southern California Coast Steelhead DPS

DPS Boundary Delineation

Since publication of the last status review (Good et al. 2005), significant new genetic data are available for populations across much of coastal California. These data consist of primarily microsatellite data, but also SNP and mtDNA. These data have been discussed in greater detail previously in this document (Section 1.2), and suggest that boundaries for this and other coastal DPSs within the state warrant re-examination.

Recent Run Sizes

<u>Santa Ynez River</u>
Staff of the Cachuma Conservation Release Board have monitored anadromous adults in the Santa Ynez River system since 2000 (Tim Robinson, personal communication), primarily through trapping efforts on two tributaries, Salsipuedes Creek and Hilton Creek, and a section of the mainstem just downstream of Cachuma Dam in the mid-basin. Cachuma Dam is a complete passage barrier. Salsipuedes Creek (and tributaries) is in the lower basin, just upstream of the Santa Ynez River confluence with the ocean. Hilton Creek is a small tributary just downstream of Cachuma Dam.

The number of anadromous adults observed each year varied between zero and four, except for the year 2008, when 16 anadromous adults were observed (Figure 15). Resident fish were commonly caught in traps as well, indicating the co-occurrence of the anadromous and resident forms in the same tributaries.

<u>Ventura River</u>

A fish ladder on the Robles Diversion Dam was completed in 2006, and since that time upstream migrants through the ladder have been monitored using a VAKI River Watcher, considered by staff of Casitas Municipal Water District to obtain observation probabilities effectively equal to 1.0 (Scott Lewis, personal communication). The Dam occurs about 14 miles from the ocean, and the counts made there omit spawning in this portion of the mainstem as well as an important tributary, San Antonio Creek. Redd surveys were conducted in 2009 and 2010 to estimate the entire spawning run, but these estimates are not yet available.

The annual number of upstream migrants observed at Robles Diversion Dam from 2006 through 2009 was 4, 0, 6, and 0 fish, for a mean annual run of 2.5 fish (not including fish spawning downstream of the dam and in San Antonio Creek). Most of these fish were judged anadromous based on their size, but the 4 fish observed in 2006 were relatively small and possibly freshwater residents.

<u>Santa Clara River</u>

Anadromous *O. mykiss* migrating upstream have been monitored, with uncertain observation probabilities, since 1995 at the Freeman Diversion Dam on the mainstem of the Santa Clara River. With the exception of the estuary, most spawning and rearing habitat occurs upstream of this dam, so few if any steelhead are missed because they spawn downstream of the dam. Figure 15 shows that counts ranged from 0 to 2 anadromous adults per year between 1995 and 2009. However, the counts suffer from various technical difficulties in operating the passage facility and/or observing fish in it.

The active upstream migrant trap was decommissioned in 1997, and counting methods and staff expertise were variable through 2002. A passive upstream migrant counter was installed in 2003 or 2004, but was thought to be inefficient, and a more complete counting system was put on line for the 2010 season (S. Howard, personal communication). Thus, the anadromous run through the facility is somewhat larger than implied by the counts. At this writing, data for the 2010 season are not yet available. Numerous resident *O. mykiss* passed through the facility during the period of observation, in numbers ranging from 0 to 68 per year. The total resident population, mostly resident to the lower mainstem, Santa Paula, Sespe, Hopper, and Piru creeks, and their tributaries, has not been estimated but is presumably much larger.

<u>Topanga Creek</u>

Stillwater Sciences et al. (2010) describe observations of *O. mykiss* in Topanga Creek, a small system in the Santa Monica Mountains just north of Los Angeles. Snorkel-counts have been conducted monthly since 7 June 2001. In addition, tagging and recapture efforts using PIT tags were conducted in fall of 2008 and 2009, and migrant trapping was conducted opportunistically for a total of 27 days from February 2003 through March 2010.

Trapping efforts over the years documented downstream migrants of age 1+ and 2+, and a total of three upstream migrants, size and age not given in the report. Snorkel counts indicate the persistent occurrence of juvenile and freshwater-resident *O. mykiss*. The authors consider fish with fork length greater than 50 cm (20”) to be anadromous adults; and consider fish with fork length between 25 cm and 50 cm to be resident adults (R. Dagit, personal communication). These assumptions allow a rough estimate for the lower bound of abundance of the two life-history types (Figure 16).

The number of anadromous adults is likely undercounted relative to resident adults, because conditions for observation are worse during the spring migration season than in the summer and fall, when many of the largest counts of resident adults were made. Observed numbers of anadromous fish ranged between zero and 4 annually. Even with observation probabilities as low as 10%, the largest run would have been about 40 fish at the most.

According to the authors, mark-recapture data from 2007-08 indicate a population of resident fish whose abundance is on the order of 500 individuals, including all size and age classes. The authors observed very little use of lagoon habitat; and a trend toward broader freshwater habitat use during the study period. An unusually large number of juveniles was observed in summer 2008, suggestive that at least one anadromous (i.e., high-fecundity) female spawned the previous spring.

<u>Malibu Creek</u>
Snorkel surveys have been conducted in Malibu Creek downstream of Rindge Dam, and one anadromous adult has been reported in each of the summers of 2007 through 2010 (R. Dagit, personal communication). These surveys typically commence in May or June and so the bulk of the run (expected to occur February through April) is over prior to the count.

Discussion

The picture emerging from these data are very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored. Unusually strong runs emerged in the year 2008, perhaps because it occurred two years after a long wet spring that presumably gave smolts ample opportunity to migrate to the ocean late in the spring. Though here “strong” is an appropriate term only within the context of the domain, since elsewhere such runs would be considered quite weak. Some of the strength of the 2008 season may be an artifact of conditions that year: low rainfall appears to have caused many spawners to get trapped in freshwater, where they were observed during the summer; in addition, low rainfall probably improved conditions for viewing fish during snorkel surveys, and for trapping fish in weirs.

The Carmel River continues to support the largest documented run, and its long-term decline is somewhat worrying, though not unexpected due to normal fluctuations of both freshwater and marine conditions. In addition, at least some of the decline appears to be an artifact of improved spawning and rearing conditions downstream of the ladder, which is surely a positive development in terms of recovery of the DPS.

The question begged by the observations is: How can such small runs of anadromous fish (single digits) persist, even over the short term (1 decade). These small runs could be maintained either by strays from some source population somewhere, and/or by consistent production of smolts by the local population of trout (freshwater non-anadromous *O. mykiss*).

Genetic assignment tests can be used to assess the likelihood that anadromous fish are strays from other basins. Of the 16 anadromous fish captured in the Santa Ynez system in 2008, data from tissue samples assigned 6 (38%) to origins outside the basin, and 10 to origins within the basin (T. Robinson, personal communication). Assignment tests on juveniles and resident adults from Topanga Creek in 2008 and 2009 assigned to Topanga Creek, though earlier years had evidence of hatchery origin (Stillwater Sciences et al. 2010). The broader-scale study of Clemento et al. (2009) tended to indicate that populations in different basins are linked by frequent straying, although "frequent" should be understood here in a genetic sense rather than a demographic sense: frequent enough so that family structure dominated the genetic distinctions among basins.

There is a variety of anecdotal evidence that freshwater resident populations of *O. mykiss* can produce smolts (reviewed in previous status reviews and TRT reports). More recently, Satterthwaite and coauthors (Mangel and Satterwaite 2008; Satterthwaite et al. 2009; Satterthwaite et al. 2010) have argued, using state-dependent optimality models, that the evolutionarily optimal strategy for individual *O. mykiss* is to delay committing to either the anadromous or resident life-history strategy until its first or second year of life. At that point, its realized size and growth rate provide valuable information as to whether the anadromous or freshwater-resident strategy would provide greater reproductive potential. If this model is generally applicable, then fish with this plastic strategy should generally outcompete either a purely resident or purely andromous strategy over the long term. However, conditions particular to a given basin and time period may select for a pure strategy in the short term. One would expect that if such a situation persisted long enough, the ability to express the plastic strategy would become vestigial, like the eyes of cave-dwelling fish.

The Satterthwaite model postulates a "decision window," a seasonal time period when the life-history commitment is physiologically determined by the fish. This has yet to be empirically demonstrated in *O. mykiss*, though a comparable decision window has been observed in the extensively-studied Atlantic salmon, *Salmo salar*.

2.3.3 Summary – Status of SCC and SC Steelhead DPSs

In summary, we find little new evidence to suggest that the status of the South-central Coast California Steelhead DPS and the Southern California Steelhead DPS has changed appreciably in either direction since publication of the last status review (Good et al. 2005). New and additional information available since Good et al. (2005) does not appear to suggest a change in extinction risk.

2.4 Central Valley Recovery Domain[9]

2.4.1 Sacramento River Winter-run Chinook Salmon ESU

ESU Boundary Delineation

The Sacramento River winter-run Chinook salmon (SRWRC) ESU includes winter-run Chinook salmon spawning in the mainstem Sacramento below Keswick Dam and Livingston Stone National Fish Hatchery (LSNFH). No new information suggests that the boundary of this ESU should change or that its status as an ESU should change.

Summary of Previous BRT Conclusions

Good et al. (2005) found that the SRWRC ESU was endangered. The major concerns of the biological review team (BRT) were that there is only one extant population, and it is spawning outside of its historical range in artificially-maintained habitat that is vulnerable to drought.

Brief Review of TRT Documents and Findings

The CVTRT delineated four historical independent populations of SRWRC. The spawning areas of three of these historical populations are above the impassable Keswick and Shasta dams, while Battle Creek (location of the fourth population) is presently unsuitable for winter-run Chinook salmon due to high summer water temperatures.

Lindley et al. (2007) developed viability criteria for Central Valley salmonids, summarized in Table 17[10] and Figure 17. Using data through 2004, Lindley et al. (2007) found that the mainstem Sacramento River population was at low risk of extinction. The ESU as a whole, however, could not be considered viable because there is only one naturally-spawning population, and it is not within its historical range. An emerging concern was rising levels of LSNFH-origin fish spawning in natural areas was, although the duration and extent of this introgression was still consistent with a low extinction risk as of 2004.

New Data and Updated Analyses

Since the 2005 status review, routine escapement data have continued to be collected, allowing viability statistics to be updated. Figure 18 shows the escapement of Sacramento River winter-run Chinook salmon to the Sacramento River and LSNFH, and

[9] Section prepared Steven T. Lindley

[10] To maximize consistency with previous BRT reports and with other sections of this document, the rate of population growth or decline is estimated from log-transformed counts, rather than a running sum of log-transformed counts as suggested by Lindley et al. (2007).

Table 18 shows abundance and trend statistics related to the viability criteria. Like many other populations of Chinook salmon in the Central Valley, SRWRC have declined in abundance since 2005, and the point estimate for the 10-year trend is negative. Current population size still satisfies the low risk criterion, and abundance has not declined enough over the last 10 years to trigger the population decline criterion. Since 2000, the proportion of SRWRC spawning in the river that are of hatchery origin has mostly been between 5 and 10%, but reached 20% in 2005 (Figure 19). The average over the last 10 years (approximately three generations) has been 8%, still below the low-risk threshold for hatchery influence.

Discussion

The status of SRWRC is little changed since the last status review, and new information available since Good et al. (2005) does not appear to suggest a change in extinction risk. The Sacramento River population did increase in abundance in the first half of the decade, but these increases have reversed during the more recent period of unfavorable ocean conditions (2005-06) and drought (2007-09). One should note that while continued operation of LSNFH may result in the Sacramento River population being classified as at moderate risk of extinction, the status of the ESU will not change. The ESU is likely at lower extinction risk with a sustainable LSNFH population and naturally-spawning population than it would be with just the single naturally-spawning population, at least in the near term. Improvement in the status of the ESU depends on re-establishing a low-risk population in a historically-used area (e.g., Battle Creek). Fish passage projects in the planning phase, if successful, would also significantly benefit SRWRC.

2.4.2 Central Valley Spring-run Chinook Salmon DPS

ESU Boundary Delineation

The Central Valley spring-run Chinook salmon (CVSRC) ESU includes spring-run Chinook salmon populations spawning in the Sacramento and San Joaquin rivers and their tributaries, and spring-run Chinook salmon in the Feather River Hatchery (FRH). No new information suggests that the boundary of this ESU should change or that its status as an ESU should change.

Summary of Previous BRT Conclusions

Good et al. (2005) found that the CVSRC was likely to become endangered. The major concerns of the BRT were the low diversity, poor spatial structure and low abundance of this ESU.

Brief Review of TRT Documents and Findings

The CVTRT delineated 18 or 19 independent populations of CVSRC, along with a number of smaller dependent populations, and four diversity groups (Lindley et al. 2004). Of these 18 populations, only three are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) and they represent only the Northern Sierra Nevada diversity group. All populations in the Basalt and Porous Lava group and the Southern Sierra Nevada group were extirpated, and only a few dependent populations persist in the Coast Range group.

Using data through 2005 and the criteria in Table 17, Lindley et al. (2007) found that the Mill Creek, Deer Creek, and Butte Creek populations were at or near low risk of extinction. The ESU as a whole, however, could not be considered viable because there were no extant populations in the three other diversity groups. In addition, Mill, Deer and Butte creeks are close together, decreasing the independence of their extinction risks due to catastrophic disturbance.

New Data and Updated Analyses

Figure 20 shows the escapement of Central Valley spring-run Chinook salmon to various areas of the Central Valley, and Table 19 shows abundance and trend statistics related to the viability criteria. With a few exceptions, escapements have declined over the past 10 years, in particular since 2006. The recent declines in abundance place the Mill and Deer Creek populations in the high extinction risk category due to their rate of decline, and in the case of Deer Creek, also the level of escapement. Butte Creek continues to satisfy the criteria for low extinction risk, although the rate of decline is close to triggering the population decline criterion for high risk. Overall, the recent declines have been significant but not severe enough to qualify as a catastrophe under the criteria of Lindley et al. (2007). On the brighter side, spring-run Chinook salmon appear to be repopulating Battle Creek, home to an historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the spring-run Chinook salmon population in Clear Creek has been increasing, although Lindley et al. (2004) classified this population as a dependent population, and thus is not expected to exceed the low-risk population size threshold of 2500 fish.

Until recently, we were unaware of any reports of hatchery-origin fish spawning in the higher elevation areas of Butte, Deer or Mill creeks utilized by spring-run Chinook. In 2010, 10 coded-wire tags of Feather River spring Chinook salmon were recovered from a sample of 1,113 carcasses in the upper reached of Butte Creek (T. McReynolds, CDFG, pers. comm., 15 December 2010). As 100% of FRH spring Chinook salmon production is marked and tagged, this translates into slightly less than 1% of the Butte Creek returns being comprised of hatchery strays. This is well below the 10% allowable stray rate for out-of-diversity-group-origin fish within one generation (Figure 17). Prolonged influx of

FRH strays at even this low level is undesirable, as it would cause the receiving population to shift to a moderate risk level after four generations of such impact.

Discussion

The status of Central Valley spring-run Chinook salmon has probably deteriorated on balance since the 2005 status review and Lindley et al.'s (2007) assessment, with two of the three extant independent populations of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Butte Creek remains at low risk, although it is on the verge of moving towards high risk. Counteracting these developments, spring-run Chinook salmon in Battle and Clear creeks have increased in abundance over the last decade, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have increased at least in part due to extensive habitat restoration, although in the case of Clear Creek, it is not yet clear the degree to which strays, as opposed to local production, have driven this dramatic increase. With the recent implementation of mass marking of FRH spring-run Chinook salmon, this question may be answered.

The time since 2005 has been a period of widespread declines in the abundance of Chinook in the Central Valley, including Central Valley spring-run Chinook salmon. In an analysis focused on Sacramento River fall Chinook salmon, Lindley et al. (2009) found that unusual ocean conditions in the spring of 2005 and 2006 led to poor growth and survival of juvenile salmon entering the ocean in those years. From 2007-2009, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon. There is a possibility that with the recent cessation of the drought and a return to more typical patterns of upwelling and sea-surface temperatures that declining trends in abundance may reverse in the near future.

At the ESU level, the reintroduction of spring-run Chinook salmon to Battle Creek and increasing abundance of spring-run Chinook salmon in Clear Creek is benefiting the status of Central Valley spring-run Chinook salmon. Further efforts, such as those underway to get some production in the San Joaquin River below Friant Dam and to facilitate passage above Englebright Dam on the Yuba River, will be needed to make the ESU viable.

To conclude, the status of Central Valley spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review. Improvements, evident in the status of two populations, are certainly not enough to warrant a downgrading of the ESU extinction risk. The degradation in status of the three formerly low- or moderate- risk independent populations is cause for concern. New information available since Good et al. (2005) indicates an increased extinction risk.

2.4.3 Central Valley Steelhead DPS

DPS Boundary Delineation

This DPS includes steelhead populations spawning in the Sacramento and San Joaquin rivers and their tributaries. Hatchery stocks within the DPS include Coleman National Fish Hatchery (CNFH) and Feather River Hatchery (FRH); steelhead in the Nimbus Hatchery (NH) and Mokelumne River Hatchery (MRH) are not included in the DPS. No new information suggests that the boundary of this DPS should change or that its status as an ESU should change.

Summary of Previous BRT Conclusions

Good et al. (2005) found that Central Valley steelhead was in danger of extinction, with a minority of the BRT viewing the ESU as likely to become endangered. The BRT's major concerns were the low abundance of naturally-produced anadromous fish at the ESU level, the lack of population-level abundance data, and the lack of any information to suggest that the monotonic decline in steelhead abundance evident from 1967-1993 dams counts has stopped.

Brief Review of TRT Documents and Findings

The CVTRT delineated more than 80 independent populations of Central Valley steelhead, along with a number of smaller dependent populations. Many of these historical populations are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Impassable dams also block significant portions of habitat for many other populations within watersheds even when not all habitat is blocked.

Lindley et al. (2007) developed viability criteria for Central Valley salmonids, summarized in Table 17. Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the status of any of the naturally-spawning populations of Central Valley steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

New Data and Updated Analyses

Population trend data remain extremely limited for Central Valley steelhead. The best population-level data come from Battle Creek, where Coleman National Fish Hatchery operates a weir. In 2002, 2000 fish passed the weir, but abundance has since declined to 330-650 fish per year (Figure 21, Table 20). The 10-year trend is -0.17, placing the population in the high extinction risk category. The percentage of fish passing the weir that were of hatchery origin has been highly variable, ranging from 5% to 70%, with an average of 29% over the 2002-2010 period. This level of hatchery influence corresponds to a moderate risk of extinction, according to panel D of Figure 17.

Redd counts are conducted in the America River and in Clear Creek, but there are not yet enough data to compute all risk metrics. An average of 154 and 116 redds have been counted each year since 2003 on the American River and Clear Creek, respectively.

The Chipps Island midwater trawl dataset of USFWS provides information on the trend in abundance for the Central Valley steelhead ESU as a whole. Updated through 2010, the trawl data indicate that the decline in natural production of steelhead has continued unabated since the 2005 status review (Figure 22). Catch per unit effort has fluctuated but remained level over the past decade, but the proportion of the catch that is ad-clipped (100% of hatchery steelhead production have been ad-clipped starting in 1998) as risen steadily, exceeding 90% in recent years and reaching 95% in 2010. Because hatchery releases have been fairly constant, this implies that natural production of juvenile steelhead has been falling.

Discussion

The status of Central Valley steelhead appears to have worsened since the 2005 status review (Good et al. 2005), when the BRT concluded that the DPS was in danger of extinction. New information available since Good et al. (2005) indicates an increased extinction risk.

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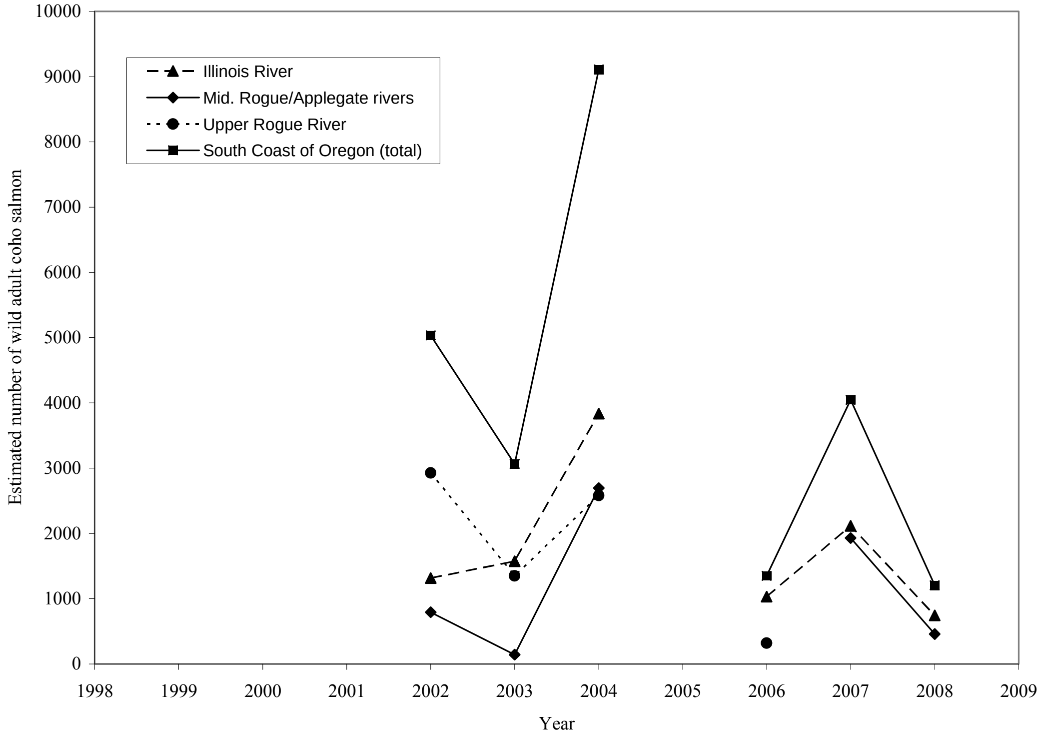


Figure 1. Wild adult coho salmon abundance estimates from selected independent populations in the Oregon portion of the SONCC Coho Salmon ESU (data from ODFW 2010).

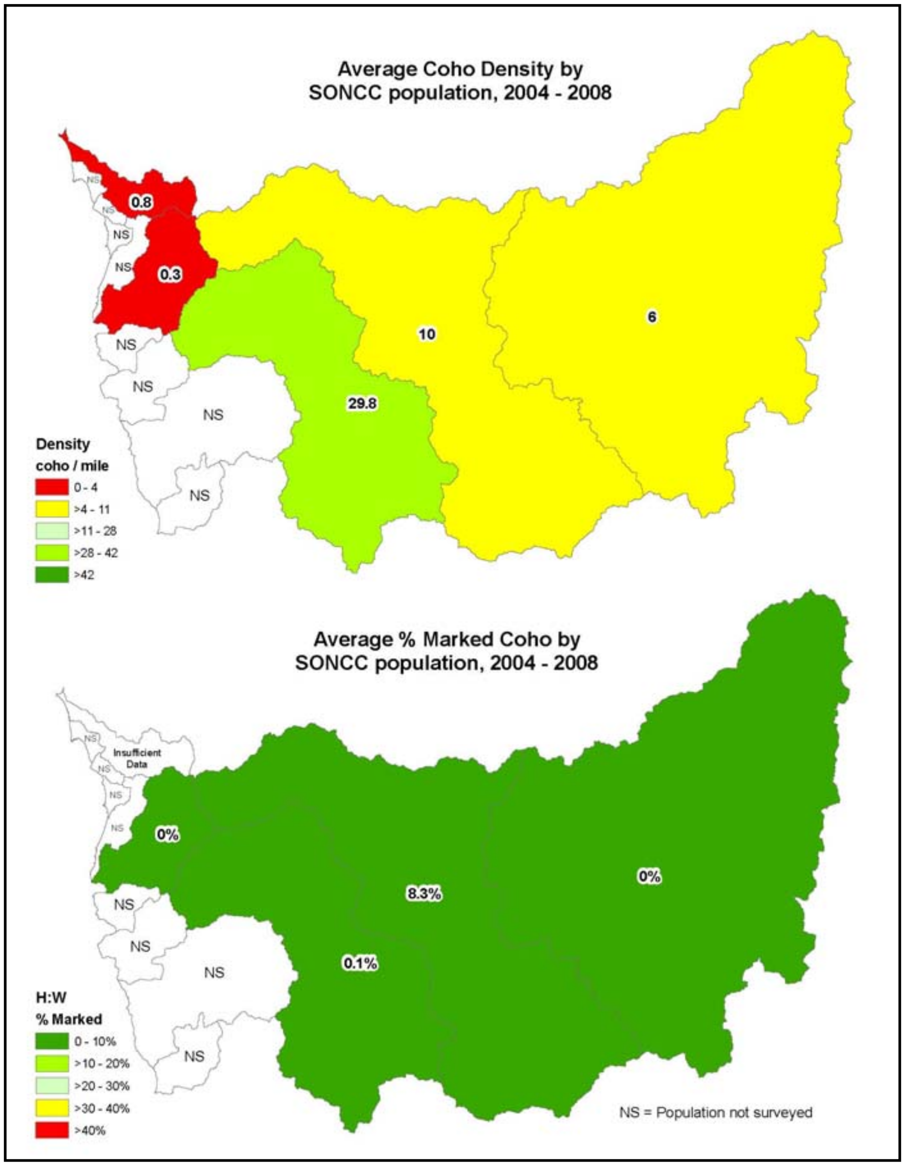


Figure 2. Wild adult coho salmon density estimates and percent of adult fish marked (i.e., hatchery origin) from selected independent populations in the Oregon portion of the SONCC Coho Salmon ESU (ODFW 2010).

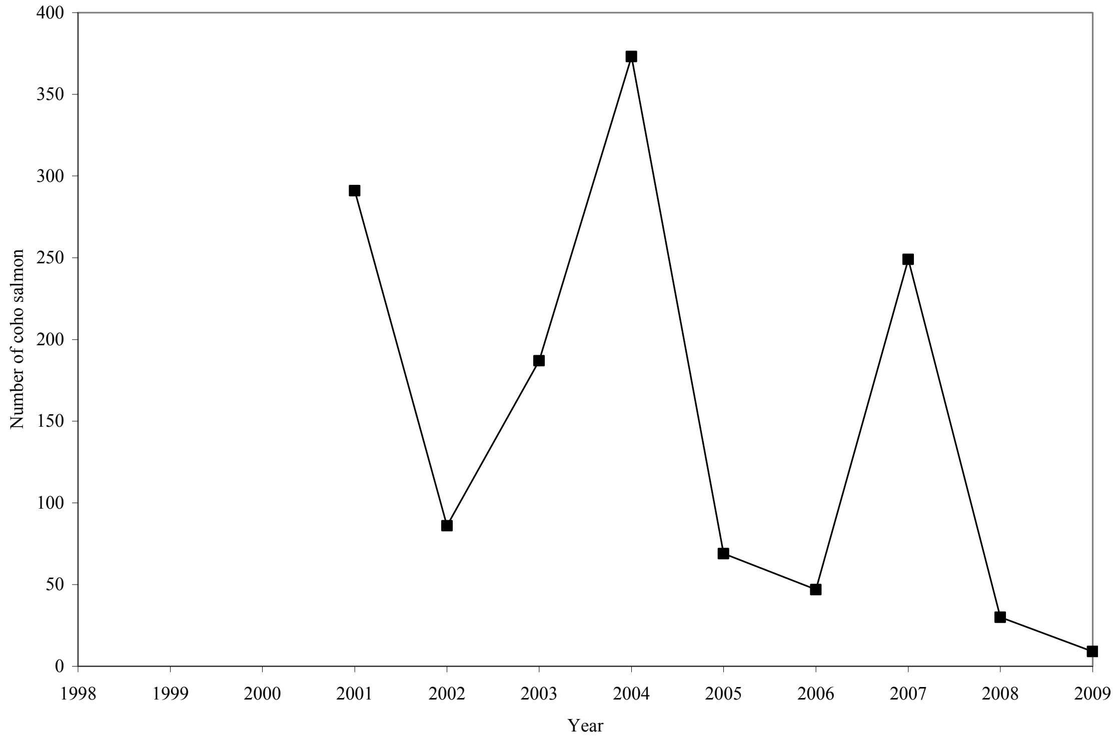


Figure 3. Video weir estimates of adult coho salmon in the Shasta River independent population, 2001 – 2009 (data from M. Knechtle, California Department of Fish and Game).

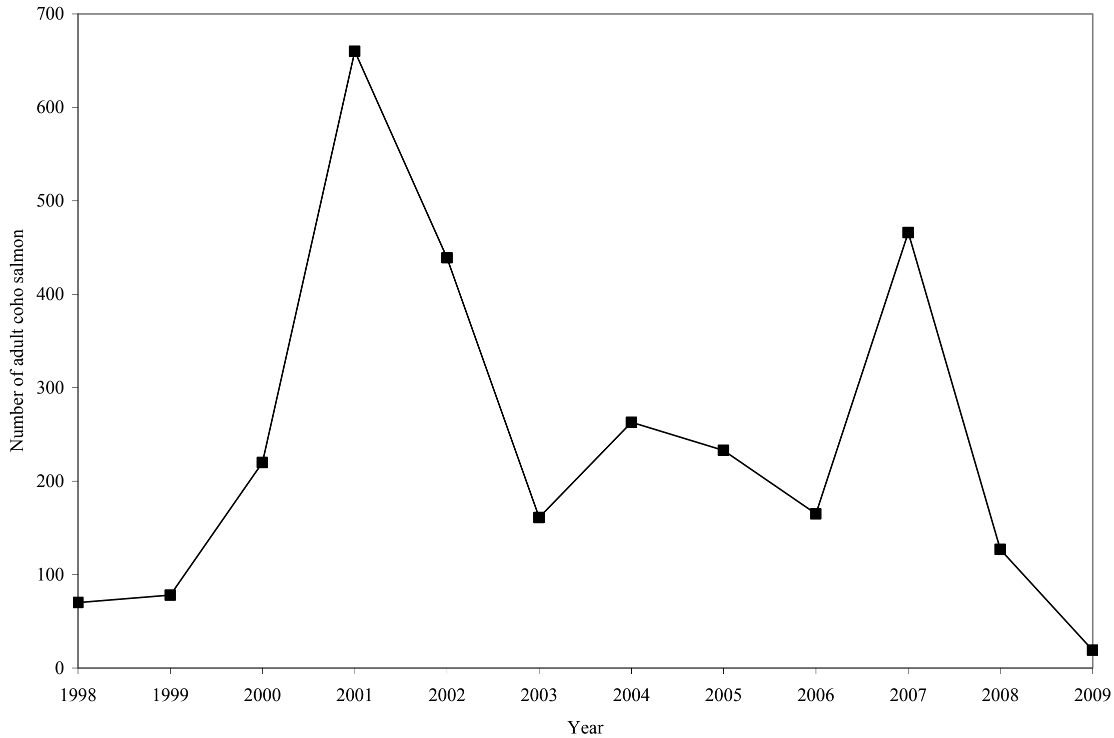


Figure 4. Estimate of spawning coho salmon in Prairie Creek, tributary to Redwood Creek (Humboldt County, California) based on AUC estimate, 1998 – 2009 (data from W. Duffy, California Cooperative Fishery Research Unit, USGS).

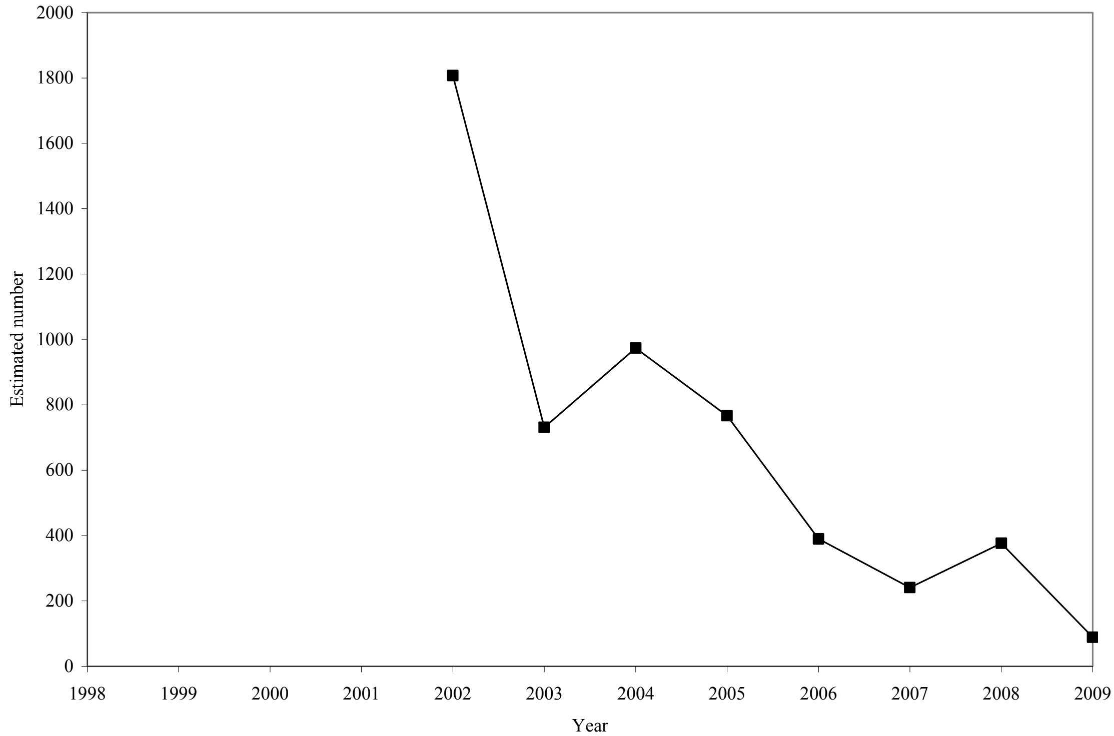


Figure 5. Adult coho salmon estimate for Freshwater Creek, tributary to Humboldt Bay, 2002 – 2009 (data from S. Ricker, California Department of Fish and Game).

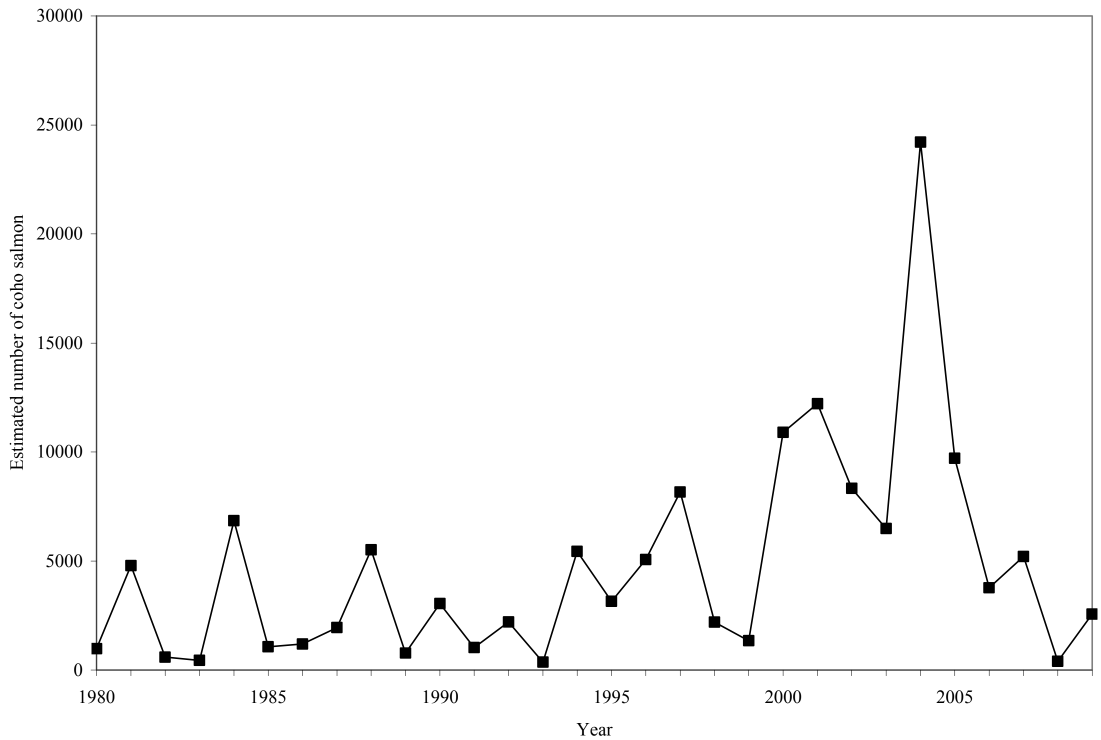


Figure 6. Estimated number of wild adult coho salmon in the Rogue River basin (Huntley Park sampling), 1980 – 2009 (data from ODFW).

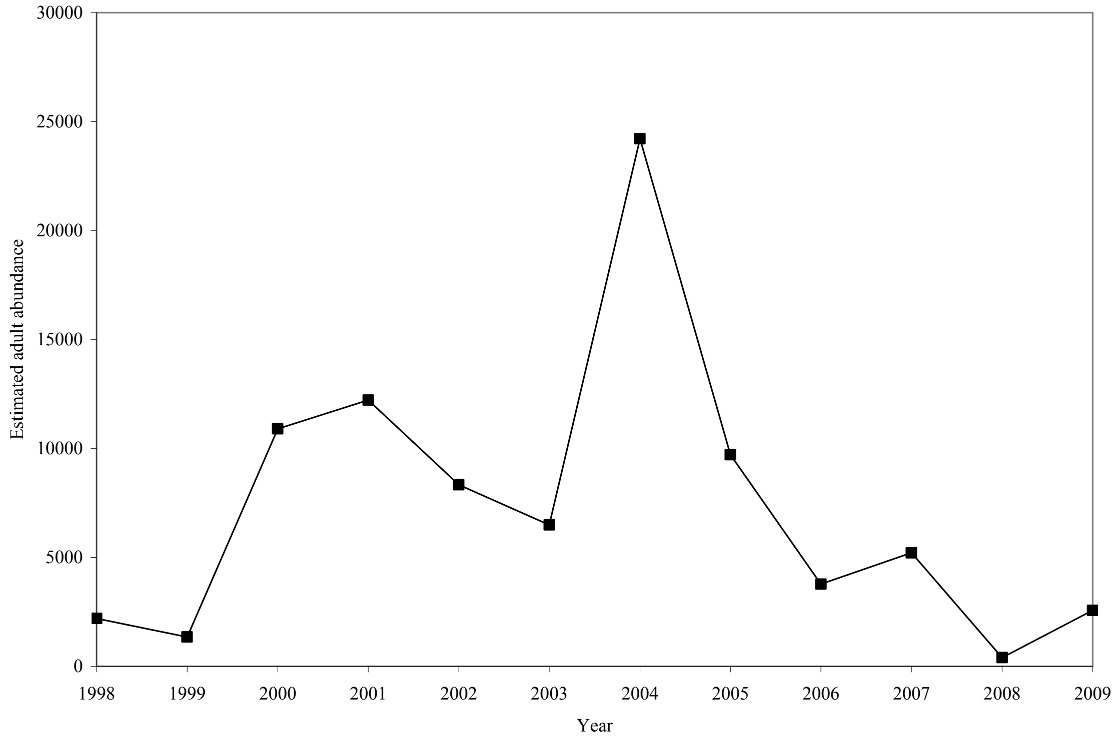


Figure 7. Estimated number of wild adult coho salmon in the Rogue River basin (Huntley Park sampling), 1998 – 2009 (data from ODFW).

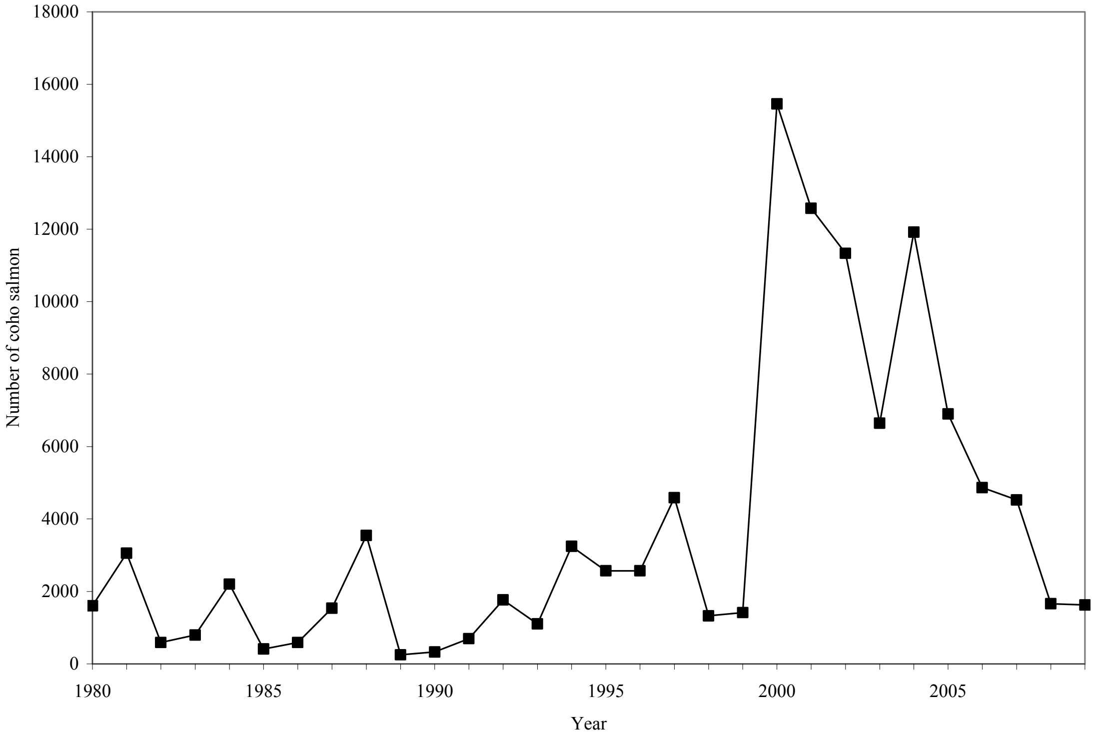


Figure 8. Passage estimates of wild adult coho salmon at Gold Ray Dam, Oregon, 1980 – 2009 (data from ODFW).

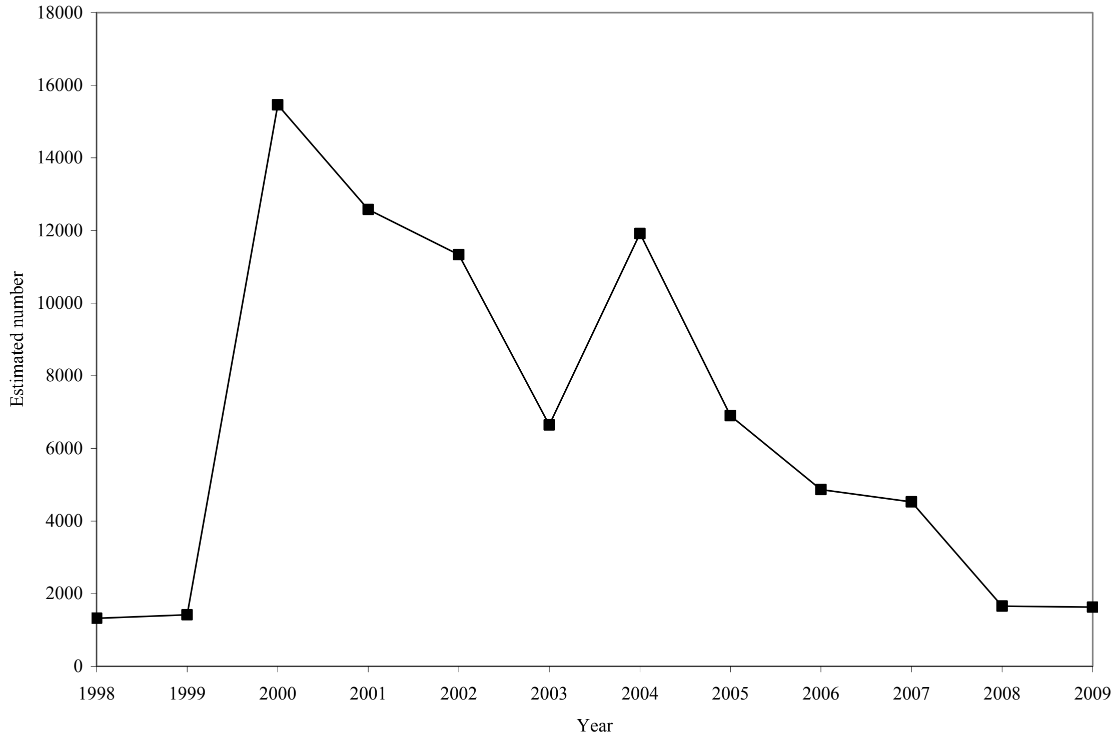


Figure 9. Passage estimates of wild adult coho salmon at Gold Ray Dam, Oregon, 1998 – 2009 (data from ODFW).

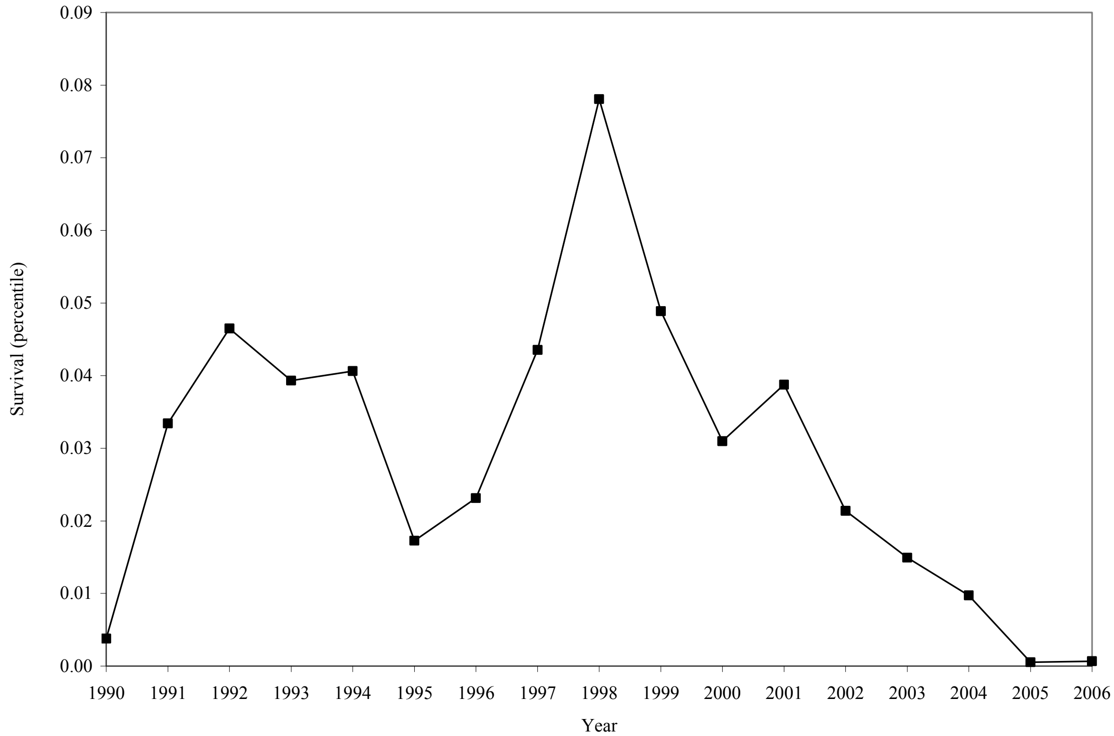


Figure 10. Survival (percentile) of hatchery fish returning to Cole Rivers Hatchery (Rogue River) based on coded-wire-tag returns, broodyears 1990 – 2006 (data from ODFW).

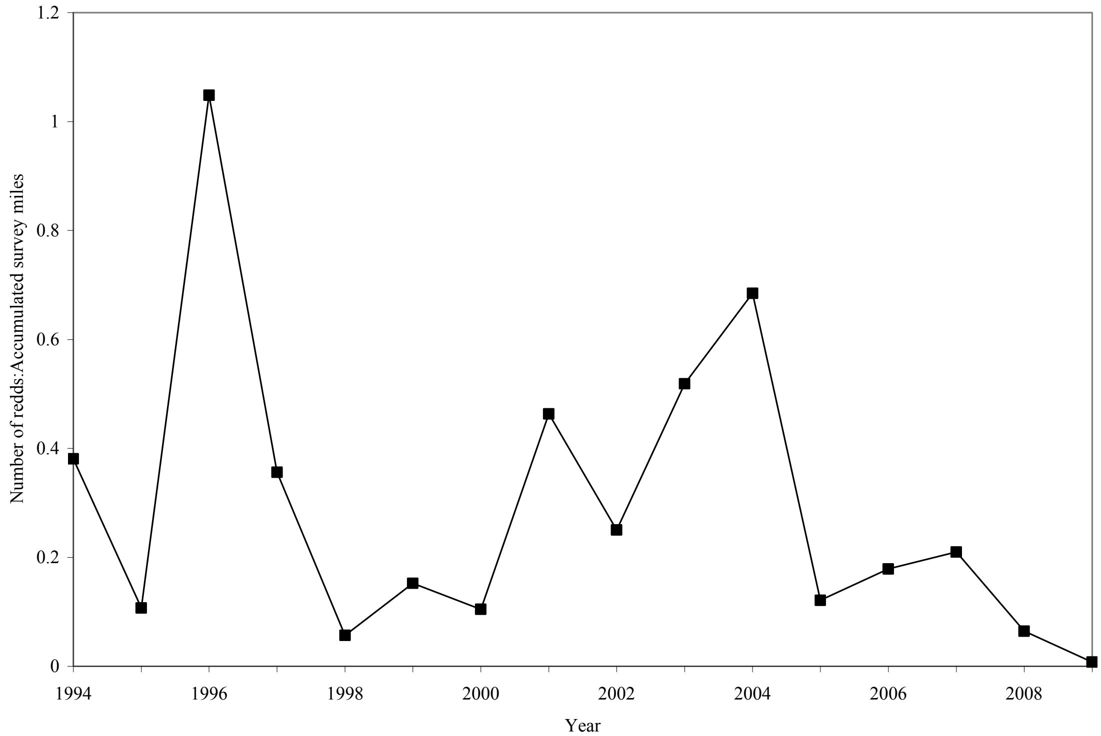


Figure 11. Index of coho salmon spawners in Mattole River based on "escapement index", 1994 – 2009 (data from Mattole Salmon Group).

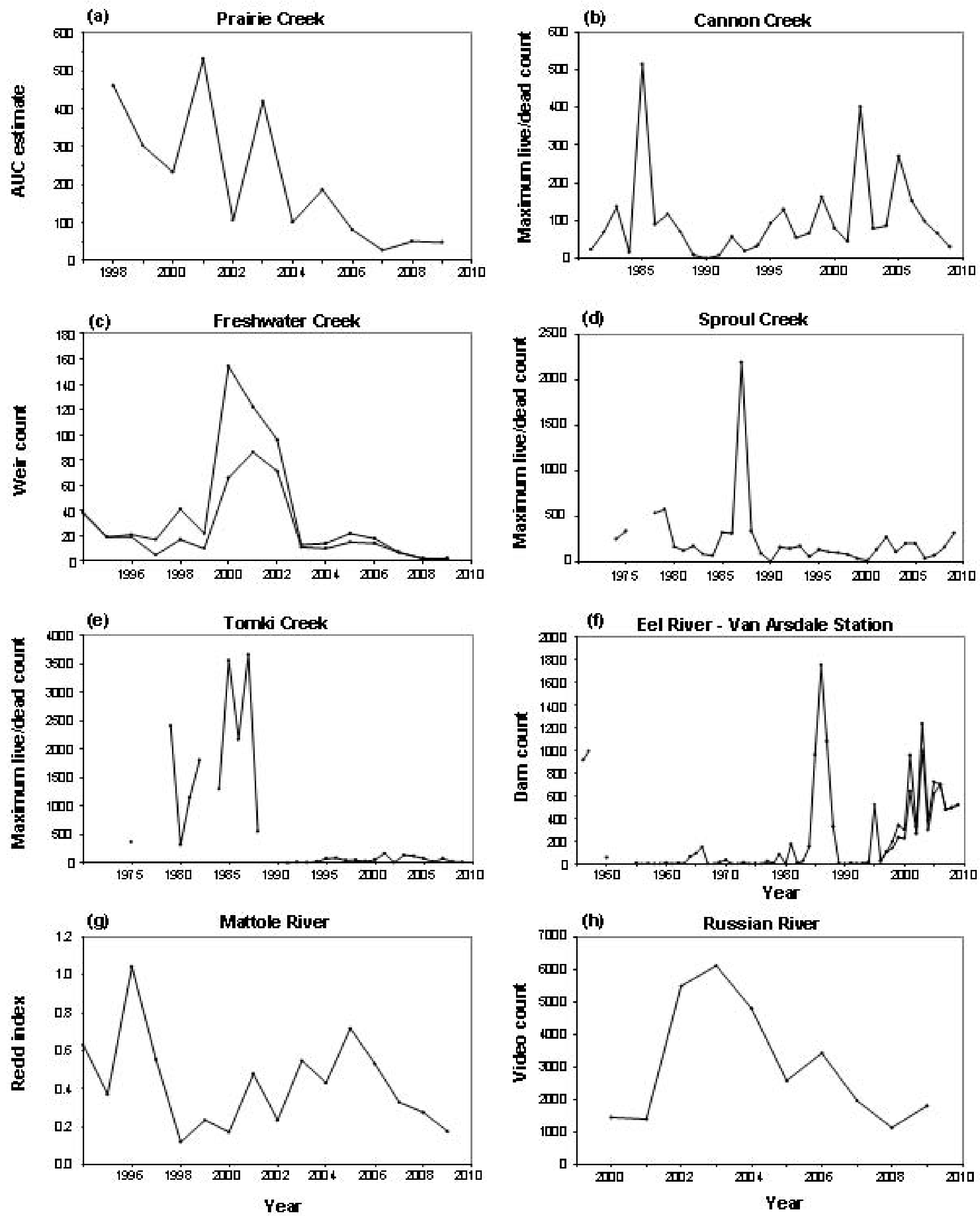


Figure 12. Chinook salmon population estimates, counts, and indices for populations in the CC-Chinook Salmon ESU.

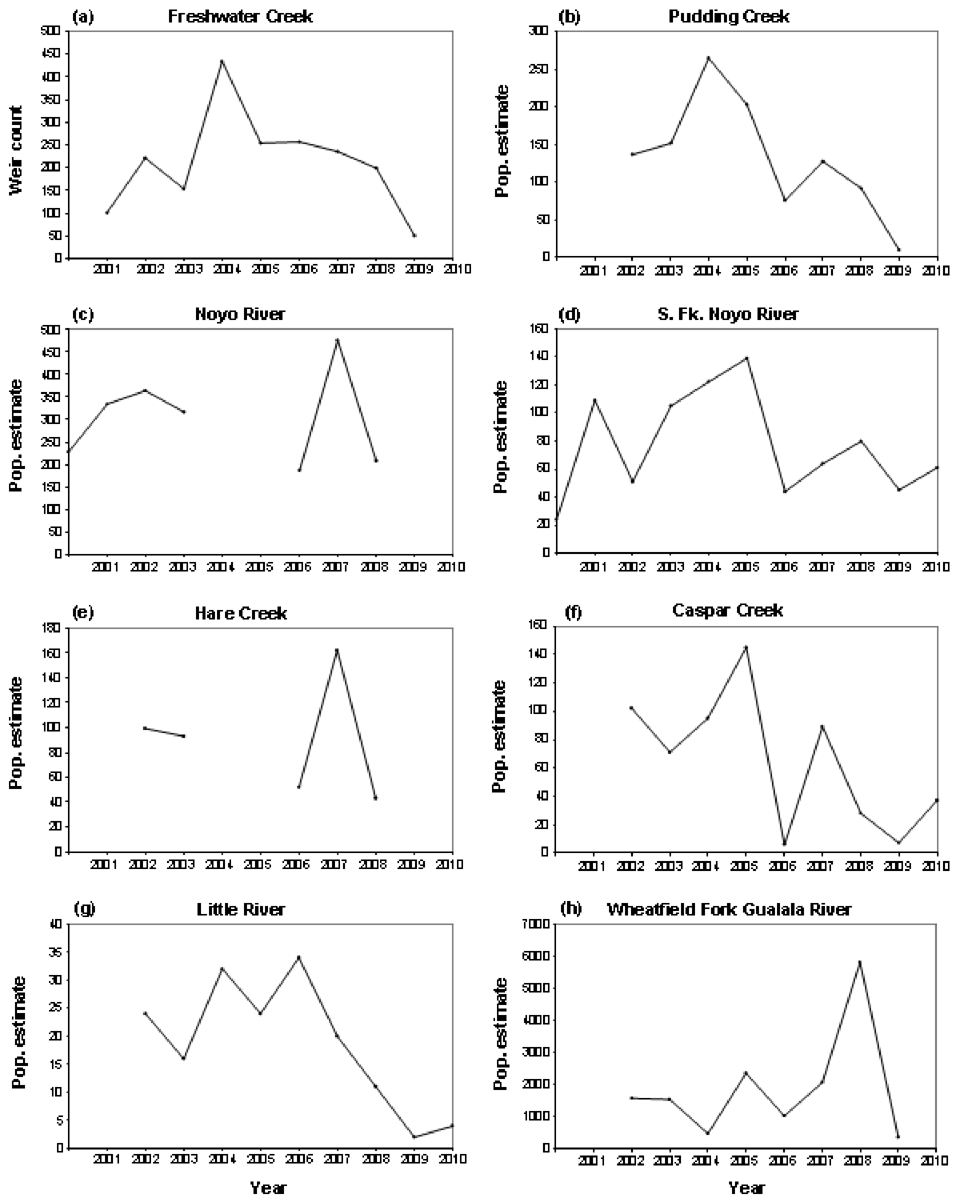
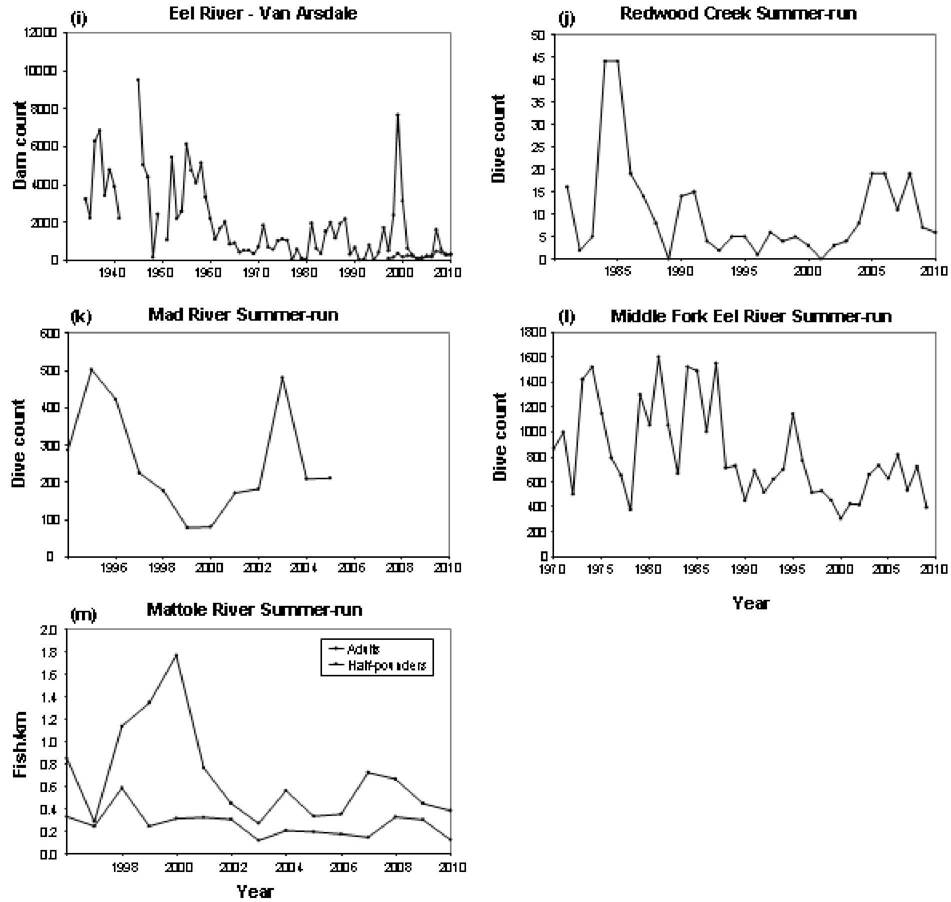


Figure 13. Population estimates, indices, weir counts and dive counts for NC-Steelhead. Populations are winter-run unless otherwise noted. Note: for winter-run, year 2010 indicates the 2009-2010 spawning season. For summer-run, year is the year of survey.



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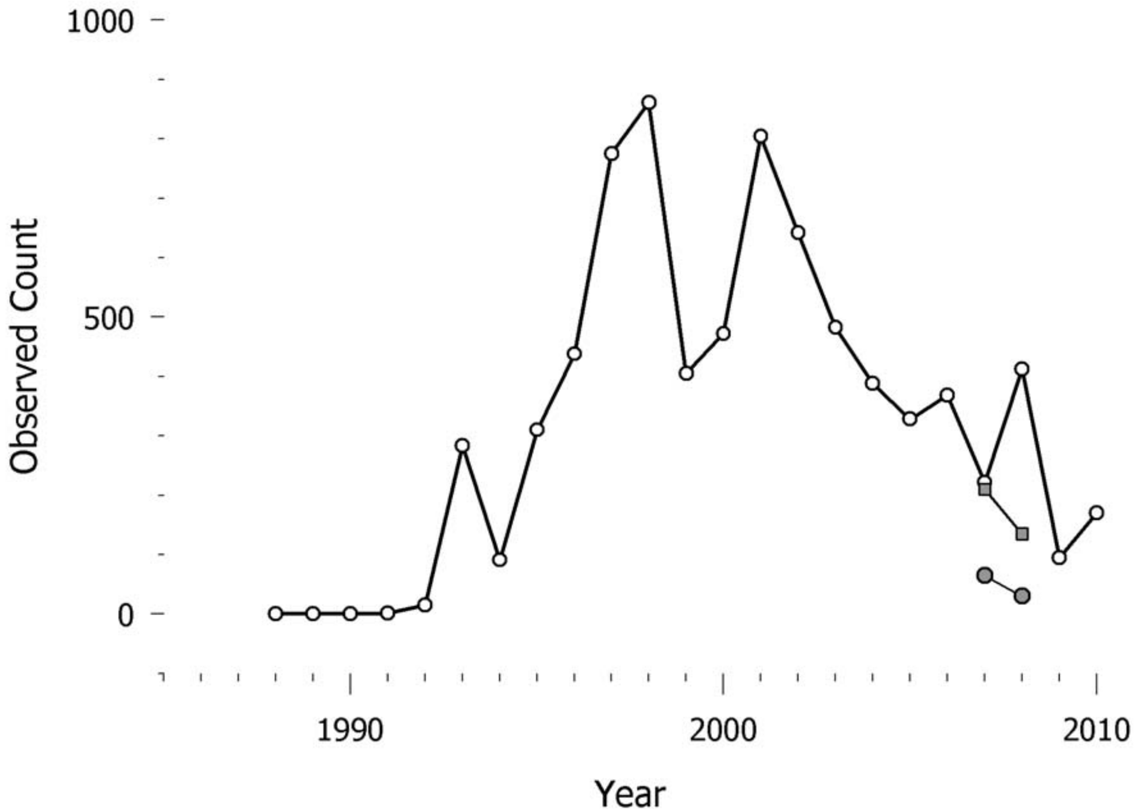

Figure 14. Open symbols: recent steelhead counts at the San Clemente Dam fish ladder at river mile 18.6 of the Carmel River. Gray symbols: high and low estimates of the number of steelhead spawning downstream of the San Clemente Dam.

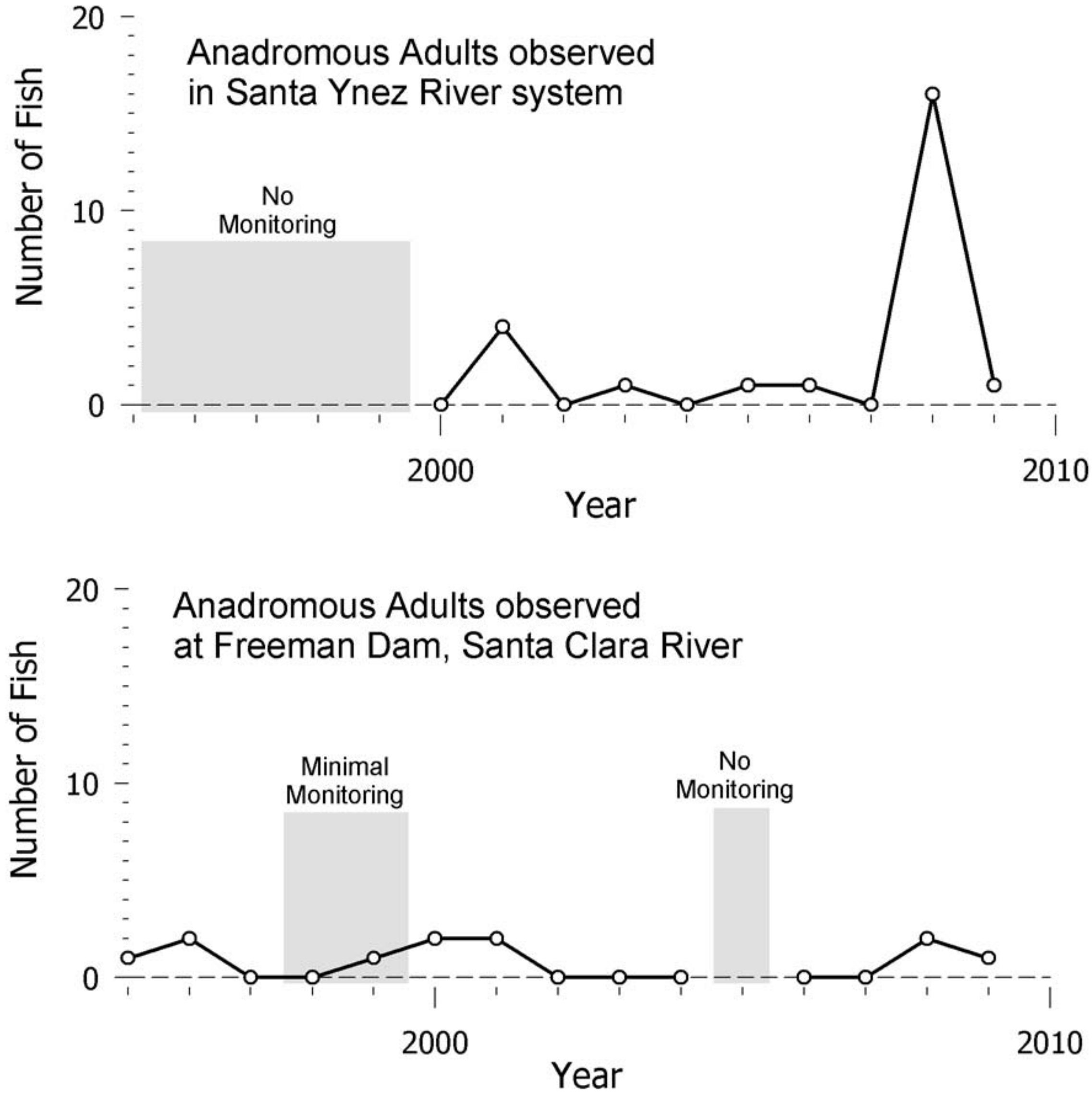

Figure 15. Anadromous *O. mykiss* observed in the Santa Ynez River system, by staff of the Cachuma Conservation Release Board; and at the fish-passage facility for the Freeman Dam on the Santa Clara River, by staff of the United Water District. Numbers are incomplete counts, unadjusted for observation probabilities; see text for details.

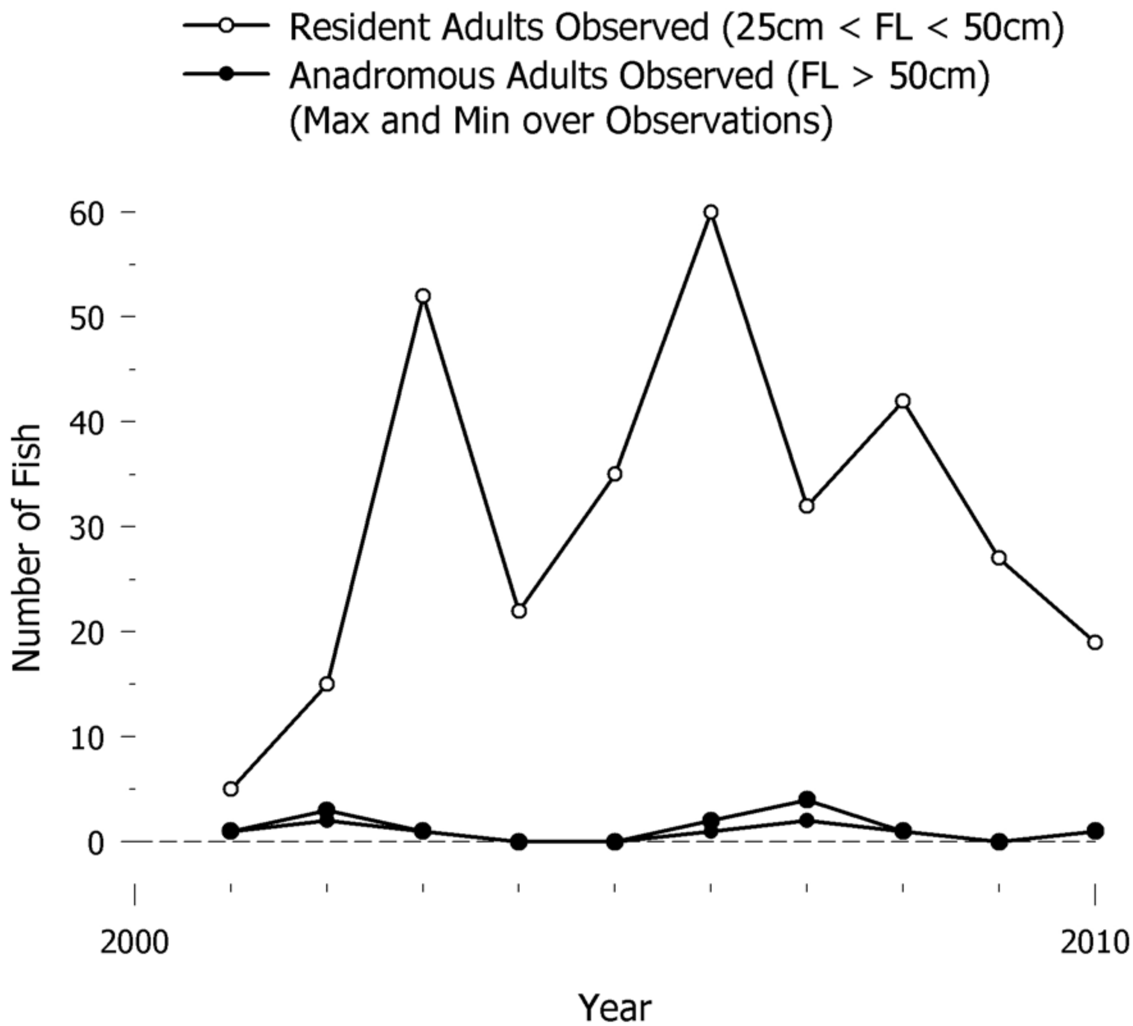

Figure 16. Summary of *O. mykiss* observations in Topanga Creek since initiation of monitoring in 2001. *O. mykiss* with fork length between 25 and 50cm were assumed to be non-anadromous (resident) adults; *O. mykiss* with fork length greater than 50cm were assumed to be anadromous adults (R. Dagit, personal communication). Observations of residents are the maximum of monthly counts over a calendar year, based on the assumption that the maximum count represented the survey with the highest observation probabilities. The observation probability was not estimated, but is almost certainly less than 1.0, so the counts represent a minimum estimate of the population of resident adults. Observations of anadromous fish is the range over alternative assumptions about observations. The maximum assumes each observation was of a unique individual; the minimum assumes that observations on different dates were repeat observations of the same individuals. A series of observations of 1 fish repeatedly made during the summer of 2001 was assumed to be one individual, so no maximum was estimated for that year. The counts are not corrected for observation probabilities less than 1.0, and thus are minimum estimates of the run size.

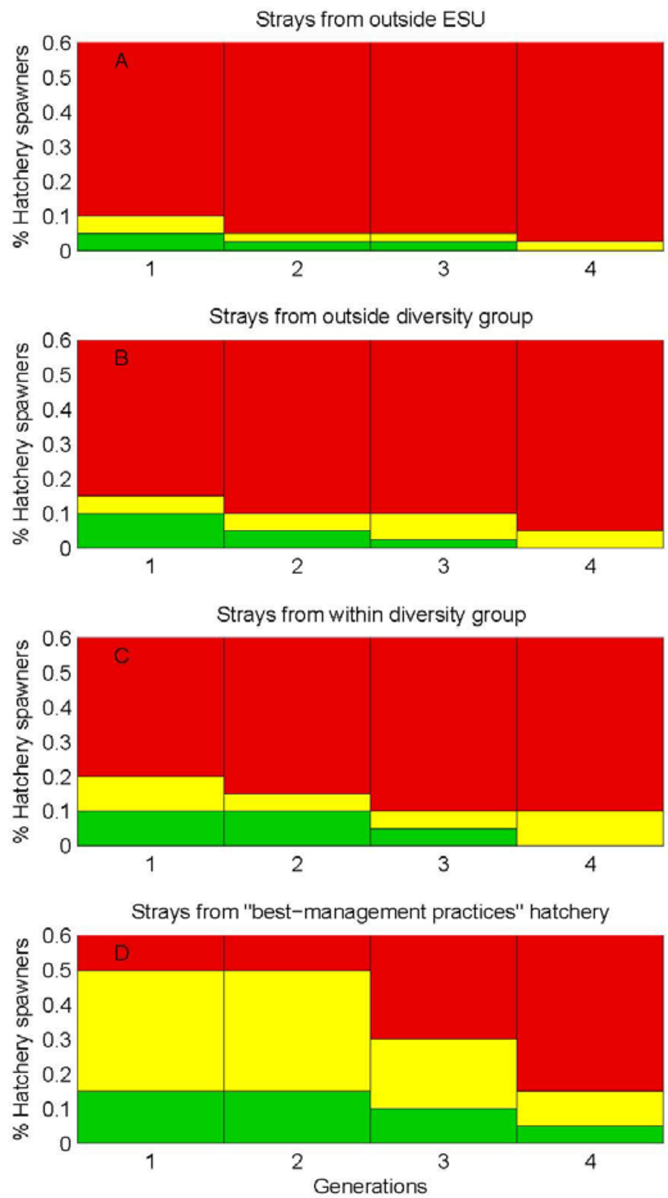

Figure 17. Extinction risk levels corresponding to different amount, duration and source of hatchery strays. Green bars indicate the range of low risk, yellow bars moderate risk, and red areas indicate high risk. Which chart to use depends on the relationship between the source and recipient populations. A: hatchery strays are from a different ESU than the wild population. B: Hatchery strays are from the same ESU but from a different diversity group within the ESU. C: Hatchery strays are from the same ESU and diversity group, but the hatchery does not employ "best management practices". D: Hatchery strays are from the same ESU and diversity group, and the hatchery employs "best management practices". From Lindley et al. (2007).

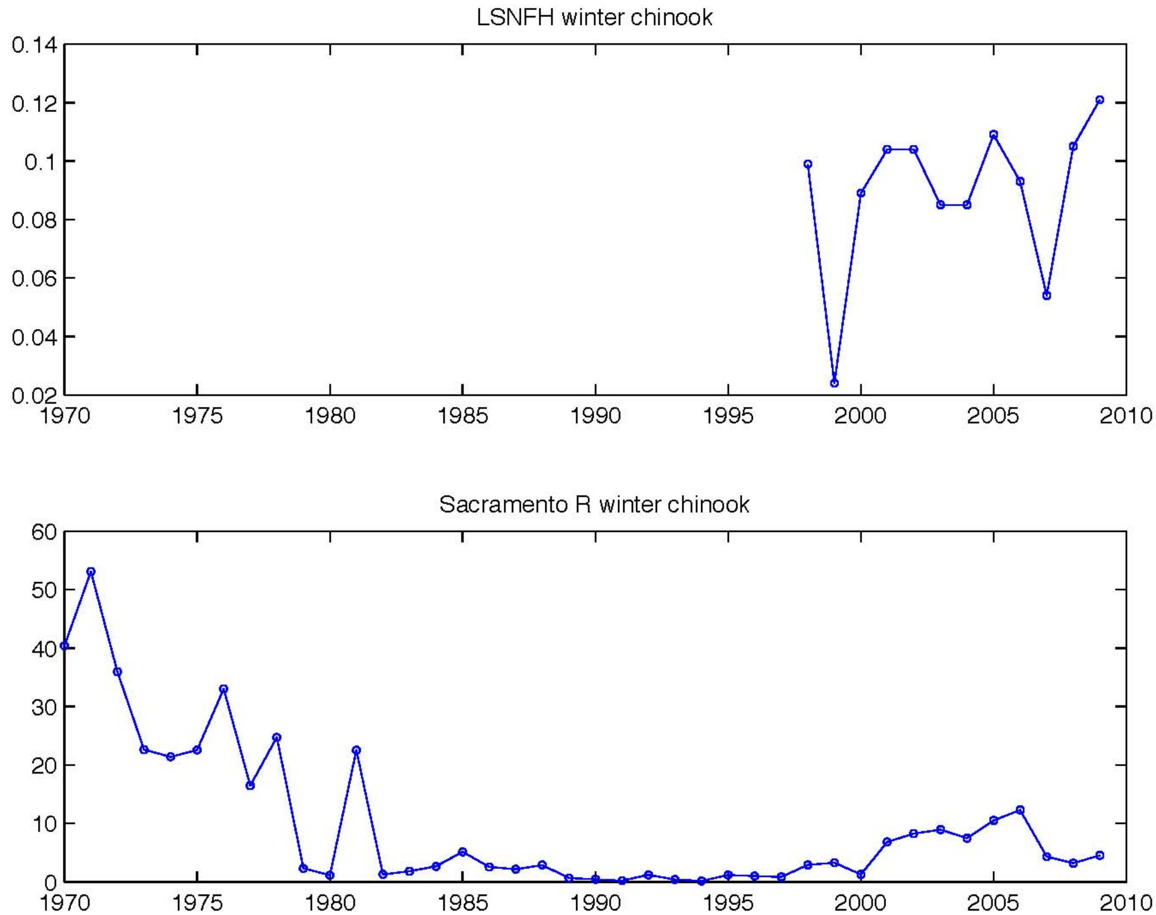

Figure 18. Time series of escapement for SRWRC salmon populations. Counts of the natural spawners is the average of the dam counts at Red Bluff and the carcass survey mark-recapture estimate (when available).

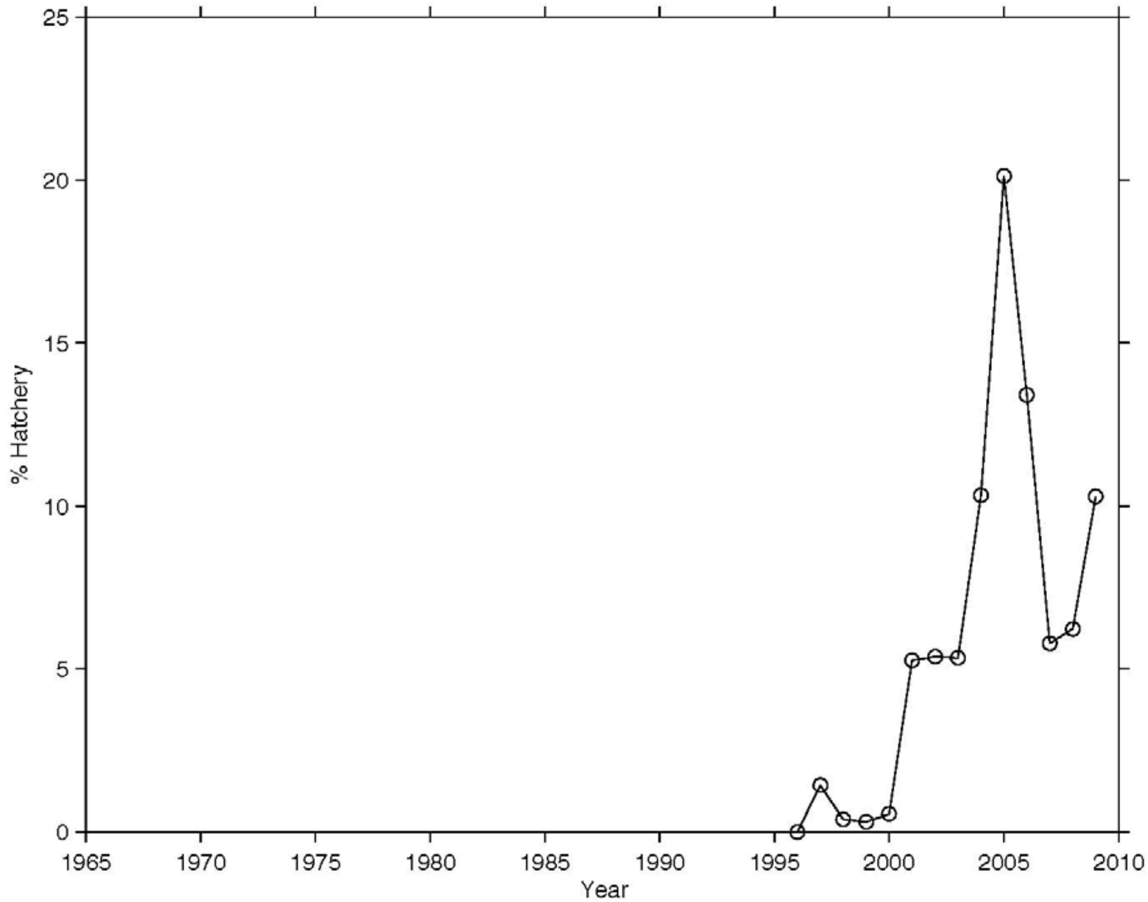

Figure 19. Percentage of winter-run Chinook salmon spawning in the river that are of hatchery origin.

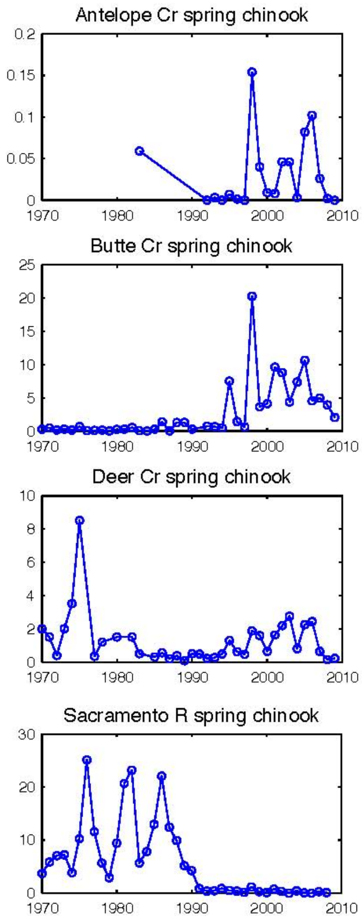

Figure 20. Time series of escapement for Central Valley spring-run Chinook salmon populations. Y axis is in thousands of fish.

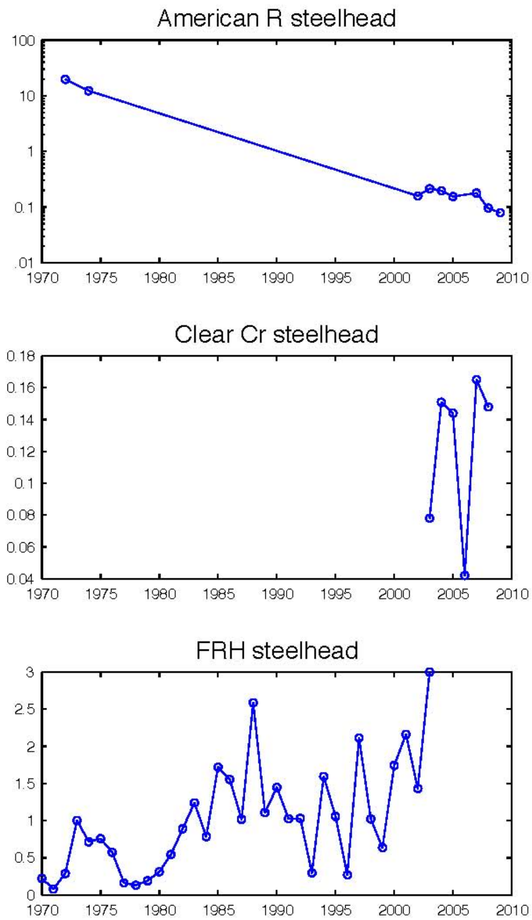

Figure 21. Time series of escapement for Central Valley steelhead populations. Y axis is in thousands of fish. Note that the y-axis of plot for American River steelhead is on a logarithmic scale.

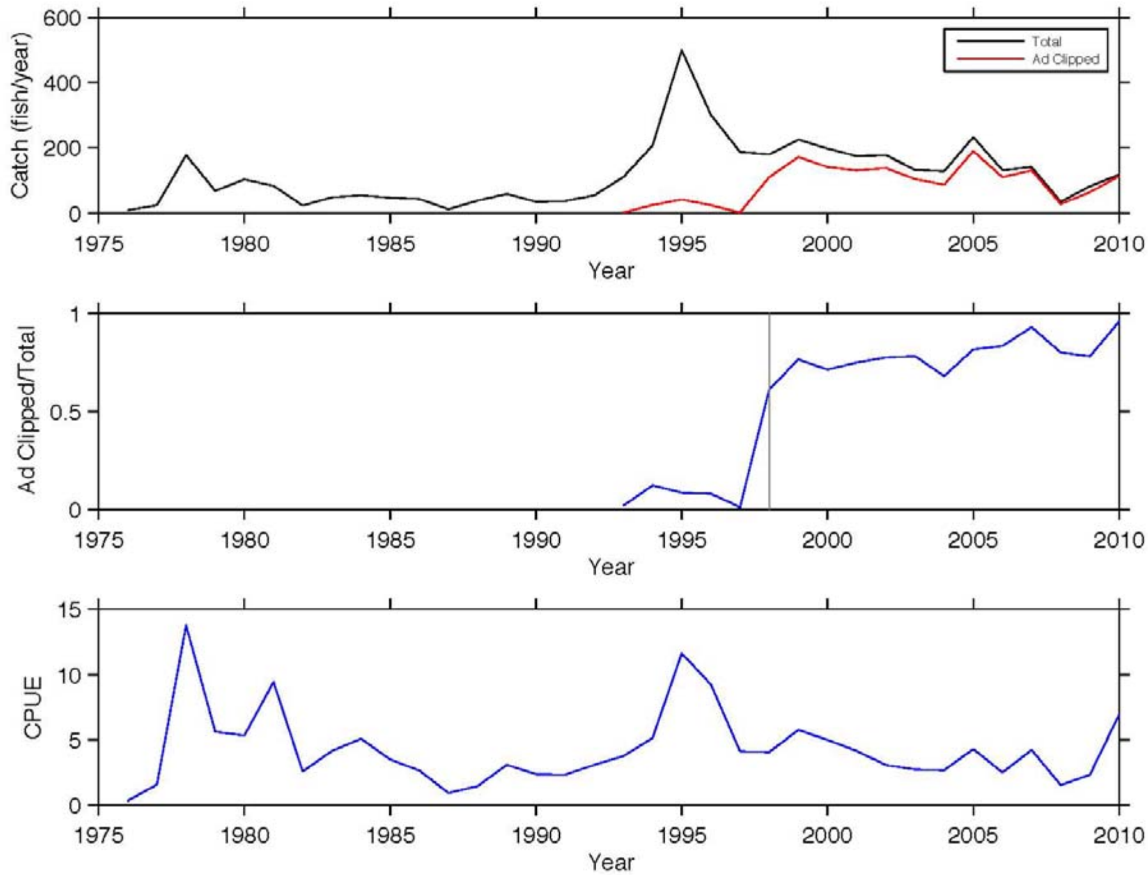

Figure 22. Top: Catch of steelhead at Chipps Island by the USFWS midwater trawl survey. Middle: Fraction of the catch bearing an adipose fin clip. 100% of steelhead production has been marked starting in 1998, denoted with the vertical gray line. Bottom: Catch per unit effort in fish per million m-3 swept volume. CPUE is not easily comparable across the entire period of record, as over time, sampling has occurred over more of the year and catches of juvenile steelhead are expected to be low outside of the primary migratory season.

Table 3. Viability criteria for assessing extinction risk for populations of coho salmon in the Southern Oregon/Northern California Coast ESU. For a given population, the highest risk score for any category determines the populations overall extinction risk. Modified from Allendorf et al. (1997) and Lindley et al. (2007). See table footnotes for definitions of N_e, N_g, and N_a.

	Extinction risk		
Criterion	High	Moderate	Low
	- any One of -	- any One of -	- all of -
Effective population size[a]	$N_e \leq 50$	$50 < N_e < 500$	$N_e \geq 500$
- or -	*- or -*	*- or -*	*- or -*
Population size per generation	$N_g \leq 250$	$250 < N_g < 2500$	$N_g \geq 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophic decline	Order of magnitude decline within one generation	Smaller but significant decline[d]	Not apparent
Spawner density (adults/IP km)	$N_a/IP\ km \leq 1$	$1 < N_a/IP\ km <$ MRSD[e]	$N_a/IP\ km \geq$ MRSD[e]
Hatchery influence			Hatchery fraction <5%
			- in addition to above -
Extinction risk from PVA	≥20% within 20 yrs	≥5% within 100 yrs but <20% within 20 yrs	< 5% within 100 yrs[f]

[a] The effective population size (N_e) is the number of breeding individuals in an idealized population that would give rise to the same variance in gene frequency under random genetic drift or the same rate of inbreeding as the population under consideration (Wright 1931); total number spawners per generation (N_g), for SONCC coho salmon the generation time is approximately three years therefore $N_g = 3\ N_a$.
[b] Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size of $N_a \leq 500$ spawners (historically small but stable populations not included) **or** $N_a > 500$ but declining at a rate of ≥10% per year over the last two-to-four generations.
[c] Annual spawner abundance N_a has declined to ≤500 spawners, but now stable **or** number of adult spawners (N_a) > 500 but continued downward trend is evident.
[d] Annual spawner abundance decline in one generation < 90% but biologically significant (e.g., loss of year class).
[e] MRSD = minimum required spawner density is dependent on the amount of potential habitat available. Figure 5 summarizes the relationship between spawner density and IP km.
[f] For population to be considered at low-risk of extinction, all criteria must be satisfied (i.e., not just a PVA). A population viability analysis (PVA) can be also included for consideration, but must estimate an extinction risk <5% within 100 years *and* all other criteria must be met. If discrepancies exist between PVA results and other criteria, results need to be thoroughly examined and potential limitations of either approach are carefully identified and examined.

Table 4. Projected population abundances (N_a) of SONCC Coho Salmon independent populations corresponding to a high-risk (depensation) thresholds of 1 spawner/*IPkm* and low-risk thresholds based on application of spawner density criteria (see Williams et al. 2008).

		High Risk	Low risk	
	Historical	depensation	Density	
Stratum/Population	*IPkm*	N_a	spawner/*IPkm*	N_a
Northern Coastal Basins				
Elk River	62.64	63	38	2400
Lower Rogue River	80.88	81	37	3000
Chetco River	135.19	135	33	4500
Winchuck River	56.50	57	39	2200
Central Coastal Basins				
Smith River	385.71	386	20	7700
Lower Klamath River	204.69	205	29	5900
Redwood Creek	151.02	151	32	4900
Maple Creek/Big Lagoon	41.30	41	39	1600
Little River	34.20	34	41	1400
Mad River	152.87	153	32	4900
Southern Coastal Basins				
Humboldt Bay tributaries	190.91	191	30	5700
Low. Eel/Van Duzen rivers	393.52	394	20	7900
Bear River	47.84	48	40	1900
Mattole River	249.79	250	26	6500
Interior – Rogue River				
Illinois River	589.69	590	20	11800
Mid. Rogue/Applegate rivers	758.58	759	20	15200
Upper Rogue River	915.43	915	20	18300
Interior - Klamath				
Middle Klamath River	113.49	113	34	3900
Upper Klamath River	424.71	425	20	8500
Salmon River	114.80	115	35	4000
Scott River	440.87	441	20	8800
Shasta River	531.01	531	20	10600
Interior - Trinity				
South Fork Trinity River	241.83	242	26	6400
Lower Trinity River	112.01	112	35	3900
Upper Trinity River	64.33	64	37	2400
Interior - Eel				

Stratum/Population	Historical *IPkm*	High Risk depensation N_a	Low risk Density spawner/*IPkm*	Low risk N_a
South Fork Eel River	476.10	476	20	9500
Mainstem Eel River	143.90	144	33	4700
North Fork Eel River	53.97	54	39	2100
Mid. Fork Eel River	77.70	78	37	2900
Mid. Mainstem Eel River	255.50	256	25	6500
Upper Mainstem Eel River	54.11	54	39	2100

Table 5. Summary of ESU viability criteria for SONCC coho salmon.

ESU viability characteristic	Criteria
Representation	1. All diversity strata should be represented by viable populations
Redundancy and Connectivity	2.a. At least fifty percent of historically independent populations in each diversity stratum should be demonstrated to be at low risk of extinction according to the population viability criteria. For strata with three or fewer independent populations, at least two populations must be viable. AND 2.b. Total aggregate abundance of the populations selected to satisfy 2a must meet or exceed 50% of the aggregate viable population abundance predicted for the stratum based on the spawner density
.	3. All dependent and independent populations not expected to meet low-risk threshold within a stratum should exhibit occupancy indicating sufficient immigration is occurring from the "core populations".
	4. The distribution of extant populations, both dependent and independent, needs to maintain connectivity across the stratum as well as with adjacent strata.

Table 6**.** Viability metrics for independent populations of coho salmon in the SONCC ESU. Trends in bold are significantly different from 0 (α = 0.05).

Population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ (95% CI)	$\hat{C}$
Illinois River[a]	6	1770	1532	NA	NA	NA
Middle Rogue/Applegate rivers[a]	5	1204	769	NA	NA	NA
Upper Rogue River[a]	4	1795	1343	NA	NA	NA
Scott River[b]	3	588	201	NA	NA	NA
Shasta River[b]	9	149	90	403	**-0.301** (-0.583,-0.019)	0.49

a – Illinois River: 2002-2004, 2006-2008; Middle Rogue/Applegate rivers: 2002-2004, 2007, 2008; Upper Rogue River: 2002-2004, 2006. Data from ODFW 2010.
b – Scott River: 2007-2009; Shasta River 2001-2009. Data from Morgan Knechtle, California Department of Fish and Game.

Table 7. Short- and long-term trends in SONCC coho salmon abundance (wild fish) based on partial or composite population estimates and population indices. Trends in bold are significantly different from 0 (α = 0.05).

Spawning tributary (Population)	Years	Data type	*Average (range)*	$\hat{T}$ (95% CI)	Data sources
Rogue Basin	12	Composite	7278 (394 - 24208)	-0.065 (-0.281, 0.150)	ODFW
	30		4666 (361 - 24208)	**0.052** (0.007, 0.096)	
Upper Rogue River	12	Partial pop. est.	6688 (1325 - 15460)	-0.037 (-0.22, 0.14)	ODFW Gold Ray Dam counts
	30		3724 (253 - 15460)	**0.072** (0.032, 0.11)	
West Branch Mill Creek (Smith River)	9	Partial pop. est.	35 (3 - 175)	0.103 (-0.086, 0.293)	McLeod and Howard 2010
East Fork Mill Creek (Smith River)	9	Partial pop. est.	16 (1 - 55)	0.103 (-0.072, 0.278)	McLeod and Howard 2010
Prairie Creek (Redwood Creek)	12	Partial pop. est.	242 (19 - 660)	-0.044 (-0.229, 0.141)	Walt Duffy, USGS CCFRU
Canon Creek[a] (Mad River)	12	Max. live/ dead count	1 (0-6)	-0.063 (-0.180, 0.054)	PFMC 2010
	29		3 (0-29)	-0.025 (-0.068, 0.018)	
Freshwater Creek (Humboldt Bay)	8	Partial pop. est.	672 (89-1807)	**-0.3484** (-0.500, -0.196)	S. Ricker, California Department of Fish and Game

a - Maximum live/dead counts do not distinguish between natural and hatchery-origin spawners. Counts may include both, particularly in the early part of the time series.

Table 8. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids. Overall risk is determined by the highest risk score for any category. N_g = generational sum of abundance; N_e = effective population size; and N_a = annual spawner abundance. From Spence et al. (2008).

Population Characteristic	Extinction Risk: High	Extinction Risk: Moderate	Extinction Risk: Low
Extinction risk from population viability analysis (PVA)	≥ 20% within 20 yrs - or any ONE of the following -	≥ 5% within 100 yrs but < 20% within 20 yrs - or any ONE of the following -	< 5% within 100 yrs - or ALL of the following -
Effective population size per generation *-or-* Total population size per generation	$N_e \leq 50$ *-or-* $N_g \leq 250$	$50 < N_e < 500$ *-or-* $250 < N_g < 2500$	$N_e \geq 500$ *-or-* $N_g \geq 2500$
Population decline	Precipitous decline[a]	Chronic decline or depression[b]	No decline apparent or probable
Catastrophic decline	Order of magnitude decline within one generation	Smaller but significant decline[c]	Not apparent
Spawner density	$N_a/IPkm$[d] ≤ 1	$1 < N_a/IPkm <$ MRD[e]	$N_a/IPkm \geq$ MRD[e]
Hatchery influence[f]	Evidence of adverse genetic, demographic, or ecological effects of hatcheries on wild population		No evidence of adverse genetic, demographic, or ecological effects of hatchery fish on wild population

[a] Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size $N_a \leq 500$ spawners (historically small but stable populations not included) *or* $N_a > 500$ but declining at a rate of ≥10% per year over the last two-to-four generations.

[b] Annual run size N_a has declined to ≤ 500 spawners, but is now stable *or* run size $N_a > 500$ but continued downward trend is evident.

[c] Annual run size decline in one generation < 90% but biologically significant (e.g., loss of year class).

[d] *IPkm* = the estimated aggregate intrinsic habitat potential for a population inhabiting a particular watershed (i.e., total accessible km weighted by reach-level estimates of intrinsic potential; see Bjorkstedt et al. [2005] for greater elaboration).

[e] MRD = minimum required spawner density and is dependent on species and the amount of potential habitat available. See Figure 5 in Spence et al. (2008) for illustration of the relationship between spawner density and risk for each species.

[f] Risk from hatchery interactions depends on multiple factors related to the level of hatchery influence, the origin of hatchery fish, and the specific hatchery practices employed.

Table 9. ESU-level criteria for assessing the level of risk of extinction for Pacific salmonid ESUs. From Spence et al. (2008).

Criterion	Description
Representation	All identified diversity strata that include historical functionally or potentially independent populations within and ESU/DPS should be represented by viable populations for the ESU/DPS to be considered viable -AND- Within each diversity stratum, all extant phenotypic diversity (i.e., major life history types) should be represented by viable populations
Redundancy and Connectivity	At least 50% of historically independent populations in each diversity stratum must be demonstrated to be at low risk of extinction according to the population viability criteria outlined in Table 1 -AND- Within each diversity stratum, the total aggregate abundance of independent populations selected to satisfy this criterion must meet or exceed 50% of the aggregate viable population abundance (i.e., meeting density-based criteria for low risk) for all independent populations
	Remaining populations, including historical dependent populations and any historical independent populations that are not expected to attain a viable stats must exhibit occupancy patterns consistent with those expected under sufficient immigration subsidy arising from the “core” independent populations selected to satisfy the preceding criterion
	The distribution of extant populations, regardless of historical status, must maintain connectivity within the diversity stratum, as well as connectivity to neighboring diversity strata

Table 10. Projected population abundances (N_a) of fall-run CC-Chinook Salmon independent populations corresponding to a high-risk (depensation) thresholds of 1 spawner/*IPkm* and low-risk (spatial structure/diversity=SSD) thresholds based on application of spawner density criteria (see Spence et al. 2008). Values listed under "historical" represent criteria applied to the historical landscape in the absence of dams that block access to anadromous fish. Values listed under "current" exclude areas upstream from impassible dams.

			High Risk		Low Risk			
			Historical	Current	Historical SSD		Current SSD	
Stratum/ Population	Historical *IPkm*	Current *IPkm*	Depens. N_a	Depens. N_a	Density spawner/*IPkm*	N_a	Density spawner/*IPkm*	N_a
North Coastal								
Redwood Cr.	116.1	116.1	116	116	29.3	3400	29.3	3400
Little R.	18.6	18.6	19	19	40.0	700	40.0	700
Mad R.	94.0	94.0	94	94	31.8	3000	31.8	3000
Humboldt Bay	76.7	76.7	77	77	33.7	2600	33.7	2600
Lower Eel R.*	514.9	514.9	515	515	20.0	10300	20.0	10300
Bear R.	39.4	39.4	39	39	37.8	1500	37.8	1500
Mattole R.	177.5	177.5	178	178	22.5	4000	22.5	4000
North Mountain Interior								
Lower Eel R.*								
Upper Eel R.	555.9	495.3	556	495	20.0	11100	20.0	11100
North-Central Coastal								
Ten Mile R.	67.2	67.2	67	67	34.8	2300	34.8	2300
Noyo R.	62.2	62.2	62	62	35.3	2200	35.3	2200
Big R.	104.3	104.3	104	104	30.6	3200	30.6	3200
Central Coastal								
Navarro R..	131.5	131.5	132	132	27.6	3600	27.6	3600
Garcia R.	56.2	56.2	56	56	36.0	2000	36.0	2000
Gualala R.	175.6	175.6	176	176	22.7	4000	22.7	4000
Russian R.	584.2	496.4	584	496	20.0	11700	20.0	11700

***** The Lower Eel River population spans portions of two diversity strata, with the South Fork Eel River and lower mainstem lying in the North Coastal stratum and tributaries upstream of the South Fork Confluence, including Van Duzen River and Larabee Creek lying in the North Mountain Interior stratum. The high-risk and low-risk thresholds listed under the North Coastal stratum represent the thresholds for the entire population, including those portions in the North Mountain Interior.

Table 11. Short- and long-term trends in CC-Chinook abundance based on partial population estimates and population indices. Trends in bold are significantly different from 0 at α=0.05.

Spawning tributary (Population)	Years	Data type	*Average (range)*	$\hat{T}$ (95% CI)	Data sources
Prairie Creek (Redwood Creek)	12	Partial pop. est.	212 (27-531)	**-0.225** (-0.331, -0.120)	W. Duffy, Humboldt Cooperative Fisheries Unit, Arcata, CA.
Cannon Creek* (Mad River)	16 29	Max. live/ dead count	115 (30-402) 103 (0-514)	0.013 (-0.070, 0.096) 0.036 (-0.020, 0.091)	PFMC 2010
Freshwater Creek (Humboldt Bay)	16	Partial pop. est.	25 (2-86)	-0.105 (-0.211, 0.002)	S. Ricker, California Department of Fish and Game, Arcata, CA.
Sproul Creek* (Lower Eel R.)	16 36	Max. live/ dead count	125 (12-312) 236 (0-2187)	0.056 (-0.040, 0.151) -0.032 (-0.075, 0.012)	PFMC 2010
Tomki Creek* (Upper Eel R.)	16 34	Max. live/ dead count	59 (5-162) 630 (3-3666)	-0.028 (-0.136, 0.080) **-0.137** (-0.199, -0.075)	PFMC 2010
Van Arsdale Sta.** (Upper Eel R.)	14	Partial pop. est.	410 (26-997)	**0.171** (0.079, 0.264)	Harris 2010b; Grass 1996b-2009b
Russian River	10	Partial pop. est.	3006 (1125-6103)	-0.042 (-0.204, 0.119)	PFMC 2010

* Max. live/dead counts do not distinguish between natural and hatchery-origin spawners. Counts may include both, particularly in the early part of the time series.
** Counts and trends estimated for wild fish only. Prior to 1996, hatchery and wild fish were not distinguished.

Table 12. Projected population abundances (N_a) of winter-run Northern California steelhead independent populations corresponding to a high-risk (depensation) thresholds of 1 spawner/*IPkm* and low-risk (spatial structure/diversity=SSD) thresholds based on application of spawner density criteria (see Spence et al. 2008). Values listed under "historical" represent criteria applied to the historical landscape in the absence of dams that block access to anadromous fish. Values listed under "current" exclude areas upstream from impassible dams.

			High Risk		Low Risk			
			Historical	Current	Historical SSD		Current SSD	
Stratum/ Population	Historical *IPkm*	Current *IPkm*	Depens. N_a	Depens. N_a	Density spawner/*IPkm*	N_a	Density spawner/*IPkm*	N_a
Northern Coastal								
Redwood Cr.*	301.1	301.1	301	301	20.0	6000	20.0	6000
Maple Cr/Big L.	94.7	94.7	95	95	29.1	2800	29.1	2800
Little R.	76.2	76.2	76	76	31.6	2400	31.6	2400
Mad R.*	553.2	351.8	553	352	20.0	11200	20.0	7000
Humboldt Bay	283.0	283.0	283	283	20.0	5700	20.0	5700
Eel R. tribs.								
Price Cr.	20.6	20.6	21	21	39.4	800	39.4	800
S. Fk. Eel R.	1182.1	1182.1	1182	1182	20.0	23600	20.0	23600
Bear R.	114.8	114.8	115	115	26.1	3000	26.1	3000
Mattole R.	613.9	613.9	614	614	20.0	12300	20.0	12300
Lower Interior								
Jewett Cr.	18.2	18.2	18	18	39.7	700	39.7	700
Pipe Cr.	18.2	18.2	18	18	39.7	700	39.7	700
Chamise Cr.	38.0	38.0	38	38	37.0	1400	37.0	1400
Bell Springs Cr.	18.5	18.5	19	19	39.6	700	39.6	700
Woodman Cr.	39.4	39.4	39	39	36.7	1400	36.7	1400
Outlet Cr.	313.8	292.9	314	293	20.0	6300	20.0	5900
Tomki Cr.	131.7	131.7	132	132	23.9	3200	23.9	3200
Bucknell Cr.	21.1	21.1	21	21	39.3	800	39.3	800
Soda Cr.	17.6	17.6	18	18	39.8	700	39.8	700
North Mountain Interior								
Redwood Cr.*								
Mad R.*								
Van Duzen R.	363.8	363.8	364	364	20.0	7300	20.0	7300
Larabee Cr.	101.0	101.0	101	101	28.2	2800	28.2	2800
Dobbyn Cr.	52.5	52.5	52	52	34.9	1800	34.9	1800
Kekawaka Cr.	35.3	35.3	35	35	37.3	1300	37.3	1300
N. Fk. Eel R.	372.8	372.8	373	373	20.0	7500	20.0	7500
M. Fk. Eel R.	584.3	581.4	584	581	20.0	11700	20.0	11700
Upper Eel R.	387.3	2.7	387	3	20.0	7700	-	-
North-Central Coastal								
Usal Cr.	19.0	19.0	19	19	39.6	700	39.6	700
Cottaneva Cr.	26.1	26.1	26	26	38.6	1000	38.6	1000
Wages Cr.	19.9	19.9	20	20	39.5	800	39.5	800
Ten Mile R.	204.7	204.7	205	205	20.0	4100	20.0	4100
Pudding Cr.	32.0	32.0	32	32	37.8	1200	37.8	1200
Noyo R.	199.1	196.7	199	197	20.0	4000	20.0	3900
Hare Cr.	18.1	18.1	18	18	39.7	700	39.7	700

Caspar Cr.	16.0	16.0	16	16	40.0	600	40.0	600
Russian Gulch	19.2	19.2	19	19	39.6	800	39.6	800
Big R.	316.6	312.9	317	313	20.0	6300	20.0	6300
Albion R.	77.1	77.1	77	77	31.5	2400	31.5	2400
Big Salmon Cr.	24.8	24.8	25	25	38.8	1000	38.8	1000
Central Coastal								
Navarro R.	458.2	457.9	458	458	20.0	9200	20.0	9200
Elk Cr.	24.3	24.3	24	24	38.9	900	38.9	900
Brush Cr.	28.3	28.3	28	28	38.3	1100	38.3	1100
Garcia R.	169.0	169.0	169	169	20.0	3400	20.0	3400
Gualala R.	478.0	476.3	478	476	20.0	9600	20.0	9500

Table 13. Viability metrics for independent populations of winter- and summer-run steelhead in the NC steelhead DPS. NA indicates not available or applicable.

Population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ (95% CI)	$\hat{C}$	$\hat{D}_{dep}$	$\hat{D}_{ssd}$
Winter-run								
Pudding Creek*	8	133	100	389	-0.278 (-0.567, 0.011)	NA	2.4	4.2
Noyo River**	7	302	287	NA	-0.013 (-0.136, 0.111)	NA	1.6	1.5
Caspar Creek†	9	64	42	155	-0.224 (-0.529, 0.087)	0.73	1.5	4.0
Hare Creek‡	5	90	80	NA	-0.067 (-0.420, 0.286)	NA	NA	5.0
Summer-run								
M. Fk. Eel R.	16	609	577	2346	-0.013 (-0.052, 0.027)	0.51	NA	NA
	44	780	693	2195	-0.005 (-0.018, 0.008)	0.59	NA	NA

***** Data from S. Gallagher, CDFG, Fort Bragg, unpublished data. Data cover period from 2001-2002 through 2008-2009. First two years are based on fish/redd estimates; remaining years are mark-recapture estimates.
** Data from S. Gallagher, CDFG, Fort Bragg, unpublished data. Data cover period from 1999-2000 through 2007-2008 excluding 2003-2004 and 2004-2005 spawning seasons. All estimates based on mark-recapture.
† Data from S. Gallagher, CDFG, Fort Bragg, unpublished data. Data cover period from 2001-2002 through 2009-2010. Data from 2001-2002 through 2004-2005 are based on fish/redd estimates. Remaining years are based on mark-recapture estimates.
‡ Data from S. Gallagher, CDFG, Fort Bragg, unpublished data. Data cover period from 2001-2002 through 2007-2008, excluding 2003-2004 and 2004-2005 spawning seasons.

Table 14. Short- and long-term trends in NC-steelhead abundance based on partial population estimates, composite population estimates, and population indices, as well as one dependent population. Trends in bold are significantly different from 0 at α=0.05. NA indicates not applicable.

Spawning trib. (Population)	Years	Data type	*Average (range)*	$\hat{T}$ (95% CI)	Data sources
Winter-run					
Prairie Creek	5	Partial pop. est.	64 (4-136)	NA	W. Duffy, Humboldt Coop. Res. Station, Arcata, CA.
Freshwater Creek (Humboldt Bay)	9	Partial pop. est.	212 (50-434)	-0.046 (-0.245, 0.153)	S. Ricker, California Department of Fish and Game, Arcata, CA.
Van Arsdale Sta. (Upper Eel/ Bucknell/Soda)	14	Weir count, composite	251 (99-492)	**0.062** (0.001, 0.123)	Harris 2010, Grass 1997, 1998, 1999b-2009b.
S.Fk. Noyo R. (Noyo R.)	11	Partial pop. est.	77 (24-139)	0.004 (-0.115, 0.123)	S. Gallagher, California Dept. of Fish and Game, Fort Bragg, CA.
Little R.	9	Pop. est. dependent	19 (2-34)	**-0.231** (-0.418, -0.043)	S. Gallagher, California Dept. of Fish and Game, Fort Bragg, CA.
Wheatfield. Fk. Gualala R (Gualala River)	8	Partial pop. est.	1915 (369-5843)	0.000 (-0.361, 0.361)	DeHaven 2009.
Summer-run					
Redwood Creek	16 29	Partial pop. est.	8 (0-19) 10 (0-44)	**0.093** (0.011, 0.175) -0.012 (-0.054, 0.029)	D. Anderson, Redwood National and State Parks, Orick, CA.
Mad River	12*	Partial pop. est.	252 (78-501)	NA	M. House, Green Diamond Resources Co., unpublished data.
Mattole River	15	Partial pop. est.	20 (9-44)	NA**	Mattole Salmon Group, unpublished data.

* surveys discontinued after 2005
** trend discussed in text is for fish/km, not abundance

Table 15. Projected population abundances (N_a) of winter-run Central California Coast steelhead independent populations corresponding to a high-risk (depensation) thresholds of 1 spawner/*IPkm* and low-risk (spatial structure/diversity=SSD) thresholds based on application of spawner density criteria (see Spence et al. 2008). Values listed under "historical" represent criteria applied to the historical landscape in the absence of dams that block access to anadromous fish. Values listed under "current" exclude areas upstream from impassible dams.

			High Risk		Low Risk			
			Historical	Current	Historical SSD		Current SSD	
Stratum/ Population	Historical *IPkm*	Current *IPkm*	Depens. N_a	Depens. N_a	Density spawner/*IPkm*	N_a	Density spawner/*IPkm*	N_a
North Coastal								
Russian R. tribs.								
Austin Cr.	111.9	111.9	112	112	26.7	3000	26.7	3000
Green Valley Cr	61.7	61.3	62	61	33.7	2100	33.7	2100
Salmon Cr.	63.5	63.5	63	63	33.4	2100	33.4	2100
Americano Cr.	64.2	64.2	64	64	33.3	2100	33.3	2100
Stemple Cr.	73.1	73.1	73	73	32.1	2300	32.1	2300
Walker Cr.	134.1	98.9	134	99	23.6	3200	28.5	3200
Lagunitas Cr.	170.7	87.2	171	87	20.0	3400	30.1	2600
Interior								
Russian R. tribs.								
Mark West Cr.	366.5	340.8	367	341	20.0	7300	20.0	6800
Dry Cr.	384.9	167.7	385	168	20.0	7700	20.0	3400
Maacama Cr.	106.9	105.2	107	105	27.4	2900	27.6	2900
Up. Russian R.	892.3	703.5	892	704	20.0	17800	20.0	14100
Santa Cruz Mtn								
Pilarcitos Cr.	41.9	30.6	42	31	36.4	1500	38.0	1200
San Gregorio Cr.	77.6	77.6	78	78	31.4	2400	31.4	2400
Pescadero Cr.	93.8	93.8	94	94	29.2	2700	29.2	2700
Waddell Cr.	16.5	16.5	16	16	40.0	600	40.0	600
Scott Cr.	23.5	23.5	24	24	39.0	900	39.0	900
Laguna Cr.	17.4	17.4	17	17	39.8	700	39.8	700
San Lorenzo R.	225.6	215.3	226	215	20.0	4500	20.0	4300
Soquel Cr.	66.4	66.4	66	66	33.0	2200	33.0	2200
Aptos Cr.	41.0	41.0	41	41	36.5	1500	36.5	1500
Coastal SF. Bay								
Corte Madera Cr	41.3	41.3	41	41	36.5	1500	36.5	1500
Miller Cr.	44.4	44.4	44	44	36.1	1600	36.1	1600
Novato Cr.	78.6	61.5	79	62	31.3	2500	33.7	2100
Guadalupe R.	157.3	124.5	157	125	20.4	3200	24.9	3100
Stevens Cr.	39.6	18.4	40	18	36.7	1500	39.7	700
San Francisquito	59.2	39.8	59	40	34.0	2000	36.7	1500
San Mateo Cr.	57.6	9.9	58	10	34.2	2000	-	-
Interior SF Bay								
Petaluma R.	225.4	223.0	225	223	20.0	4500	20.0	4500
Sonoma Cr.	268.7	268.7	269	269	20.0	5400	20.0	5400
Napa R.	593.9	491.0	594	491	20.0	11900	20.0	9800
Green V./Suisun	164.0	162.2	164	162	20.0	3300	20.0	3200
Walnut Cr.	202.2	7.5	202	8	20.0	4000	-	-
San Pablo Cr.	67.9	18.8	68	19	32.8	2200	39.6	700
San Leandro Cr.	80.5	16.0	81	16	31.0	2500	40.0	600
San Lorenzo Cr.	79.8	41.5	80	42	31.1	2500	36.5	1500
Alameda Cr.	816.6	39.5	817	39	20.0	16300	36.7	1500
Coyote Cr.	498.3	252.7	498	253	20.0	10000	20.0	5100

Table 16. Population viability criteria for the South-Central California Coast Steelhead DPS and the Southern California Steelhead DPS.

Criteria for Population Viability

Prescriptive Criteria

Criterion	Viability Threshold	Notes
Mean Annual Run Size	S > 4,150	Precautionary
Ocean Conditions	Size criterion met during poor ocean conditions	
Population Density	Unknown	Research Needed
Anadromous Fraction	100% of 4,150	Precautionary

Performance-Based Criteria

One or more prescriptive criteria (above) could be replaced by a quantitative risk assessment satisfying the following:
1) Extinction risk of anadromous population less than 5% in the next 100 yr.
2) Addresses each risk that is addressed by the prescriptive criteria it replaces.
3) Parameters are either a) estimated from data or b) precautionary
4) Quantitative methods are accepted practice in risk assessment/population viability analysis
5) Pass independent scientific review

Criteria for DPS Viability

Criterion	Viability Threshold
Biogeographic Diversity	1) Sufficient numbers of viable populations in each biogeographic group (see Table 6 in Boughton et al. 2007) 2) Viable populations inhabit watersheds with drought refugia 3) Viable populations in basins separated by >68km if possible
Life-history Diversity	Viable populations exhibit three life-history types (fluvial-anadromous, lagoon-anadromous, resident)

Table 17. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids in the Central Valley of California. Overall risk is determined by the highest risk score for any category.

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

a - Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
b - Decline within last two generations to annual run size ≤ 500 spawners, or run size > 500 but declining at ≥ 10% per year over the past 10 years. Historically small but stable population not included.
c - Run size has declined to ≤ 500, but now stable.
d - Catastrophes occurring within the last 10 years.
e - Decline < 90% but biologically significant.
f - See Figure CV1 for assessing hatchery impacts.

Table 18. Viability metrics Sacramento River Winter Run Chinook Salmon ESU populations.

Population	Ŝ	N	10-year trend (95% CI)	Recent Decline (%)
LSNFH	93.3	280	0.001 (-0.059, 0.060)	9.8
Sacramento R.	4020	12040	0.026 (-0.156, 0.207)	38.0

Table 19. Viability metrics for Central Valley Spring run Chinook salmon populations. Populations in **bold** are historically independent populations. Data are from the 2010 CDFG Grand Tab database, which generally includes data through 2009. Data from Mill, Deer and Butte creeks includes preliminary data from 2010.

Population	Ŝ	N	10-year trend (95% CI)	Recent Decline (%)
Antelope Creek	9.3	28.0	-0.156 (-0.554, 0.242)	44.2
Battle Creek	198	595	0.119 (0.006, 0.232)	NA
Big Chico Creek	2.0	6.0	-0.186 (-0.749, 0.376)	26.9
Butte Creek	3650	10,900	-0.090 (-0.205, 0.025)	42.5
Clear Creek	171	514	0.373 (0.083, 0.664)	NA
Cottonwood Creek	45.3	136	-0.248 (-0.406, -0.090)	66.7
Deer Creek	332	997	-0.196 (-0.430, 0.037)	58.4
Feather River Hatchery	1760	5290	-0.156 (-0.266, -0.046)	56.8
Mill Creek	501	1500	-0.119 (-0.259, 0.022)	45.3
Sacramento River	100	300	-0.238 (-0.845, 0.369)	60.7

Table 20. Viability metrics for Central Valley steelhead populations.

Population	Ŝ	N	10-year trend (95% CI)	Recent Decline (%)
Battle Creek	469	1410	-0.17 (-0.29, -0.055)	68
Column NFH	1870	5610	0.018 (-0.10, 0.14)	6.6
Feather River Hatchery	2200	6590	0.10 (-0.064, 0.27)	