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

West Coast Salmon Biological Review Team

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

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

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B.2.6 NORTHERN CALIFORNIA STEELHEAD ESU

Primary contributor: David Boughton

(Southwest Fisheries Science Center – Santa Cruz Lab)

B.2.6.1 Summary of Previous BRT Conclusions

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

Summary of major risks and status indicators

Risks and limiting factors—The previous status review (Busby et al. 1996) identified two major barriers to fish passage: Mathews Dam on the Mad River and Scott Dam on the Eel River. Numerous other blockages on tributaries were also thought to occur. Poor forest practices and poor land use practices, combined with catastrophic flooding in 1964, were thought to have caused significant declines in habitat quality that then persisted up to the date of the status review. These effects include sedimentation and loss of spawning gravels. Non-native Sacramento pikeminnow (*Ptychocheilus grandis*) had been observed in the Eel River basin and could be acting as predators on juvenile steelhead, depending on thermal conditions leading to niche overlap of the two species (see also Brown and Moyle 1981, 1997; Harvey et al 2002, Reese and Harvey 2002).

Status indicators—Historical estimates (pre-1960s) of steelhead abundance for this ESU have been few (Table B.2.6.1). The only time-series data are dam counts of winter-run steelhead in the upper Eel River (Cape Horn Dam, 1933-present), winter-run steelhead in the Mad River (Sweasey Dam, 1938-1963), and combined counts of summer-run and winter-run steelhead in the South Fork Eel River (Benbow Dam, 1938-75; see Figure B.2.6.1A). More recent data are snorkel counts of summer-run steelhead that were made in the middle fork of the Eel since 1966 (with some gaps in the time-series) (Scott Harris and Wendy Jones, CDFG, personal communication). Some "point" estimates of mean abundance exist—in 1963, the California

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

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

Department of Fish and Game made estimates of steelhead abundance for many rivers in the ESU (Table B.2.6.2). An attempt was made to estimate a mean count over the interval 1959 to 1963, but in most cases 5 years of data were not available and estimates were based on fewer years (CDFG 1965); the authors state that "estimates given here which are based on little or no data should be used only in outlining the major and critical factors of the resource" (CDFG 1965). The previous BRT (Busby et al. 1996) considered the above datasets in making their risk assessment.

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

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

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

Listing status

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

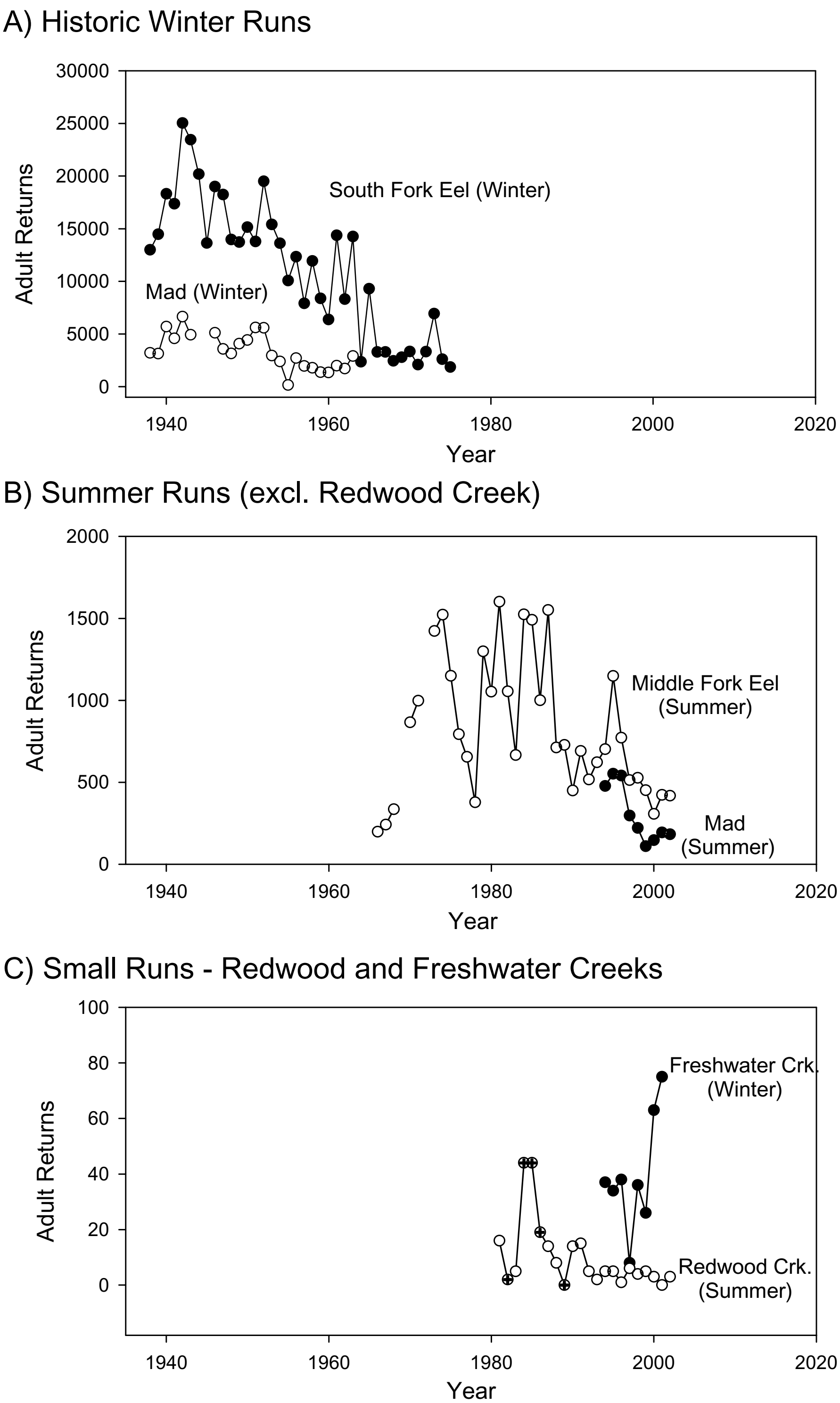

Figure B.2.6.1. Time-series data for the North-Central California Steelhead ESU. A) Historical data from winter runs on the Mad River and South Fork Eel. B) Summer-run on the Middle Fork Eel and Mad River. C) Summer-run steelhead in Redwood Creek, and winter-run steelhead in Freshwater Creek, Humboldt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

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

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

B.2.6.2 New Data and Updated Analyses

There are four significant sets of new information regarding status: 1) Updated time-series data exist for the middle fork of the Eel River (summer-run steelhead; snorkel counts. See Figure B.2.6.1B); 2) There are new data-collection efforts initiated in 1994 in the Mad River (summer-run steelhead; snorkel counts--Figure B.2.6.1B) and in Freshwater Creek (winter-run steelhead; weir counts--Figure B.2.6.1C; Freshwater Creek is a small stream emptying into Humboldt Bay; 3) Numerous reach-scale estimates of juvenile abundance have been made extensively throughout the ESU; and 4) Harvest regulations have been substantially changed since the last status review. Analyses of this information are described below.

Updated Eel River data

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

New time-series

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

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

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

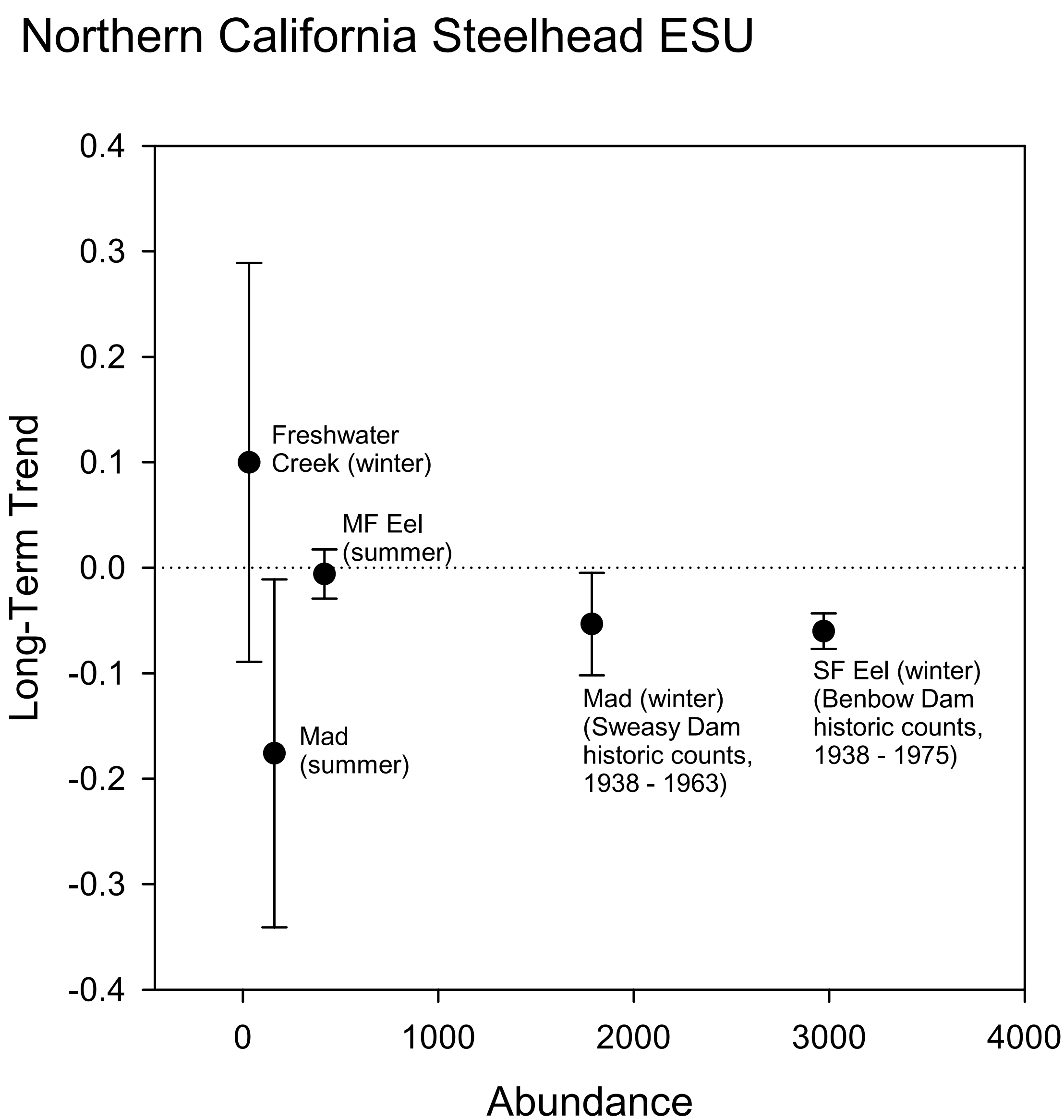

Figure B.2.6.2. Trends versus abundance for the time-series data from Figure B.2.6.1. Note that neither set of dam counts (Sweasy Dam, Benbow Dam) has any recent data. Vertical bars are 95% confidence intervals.

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

Population	Span of time series	5-Year Means[5]			Lambda[6]	Long-term trend (95% conf. int.)	Short-term trend (95% conf. int.)
		Rec.	Min.	Max.			
Northern California ESU (threatened)							
M.Fk. Eel Riv. (summer-run)	’66-’02	418	384	1,246	0.98 (0.93, 1.04)	-0.006 (-0.029, 0.017)	-0.067 (-0.158, 0.024)
Mad River (summer-run)	’94-’02	162	162	384	Insufficient data	-0.176 (-0.341, -0.012)	-0.176 (-0.341, -0.121)
Freshwater Crk. (winter-run)	’94-’01	32	25	32	Insufficient data	0.099 (-0.289, 0.489)	0.099 (-0.289, 0.489)
Redwood Crk. (summer-run)	’81-’02	3	Fig. B.2.6.1[7]		Insufficient data	See Fig. B.2.6.1	-0.775 (-1.276, -0.273)
S.Fk. Eel Riv. (winter-run)[8]	’38-’75		2,743	20,657	0.98 (0.92, 1.02)	-0.060 (-0.077, -0.043)	No recent data
Mad Riv. (winter-run)[9]	’38-’63		1,140	5,438	1.00 (0.93, 1.05)	-0.053 (-0.102, -0.005)	No recent data
Central California ESU (threatened)							
No data							
South-Central California ESU (threatened)							
Carmel River (winter-run)	’62-’02	611	1.13	881	Insufficient data	0.488 (0.442, 0.538)[10]	0.488 (0.442, 0.538)
Southern California ESU (endangered)							
Santa Clara R. (winter-run)[11]	’94-’97	1.0			Insufficient data		

[5] Geometric means. The value 0.5 was used for years in which the count was zero.
[6] Lambda calculated using the method of Lindley (In press). Note that a population with lambda greater than 1.0 can nevertheless be declining, due to environmental stochasticity.
[7] Certain years have minimum run sizes, rather than unbiased estimates of run size, rendering the time series unsuitable for some of the estimators.
[8] Historical counts made at Benbow Dam.
[9] Historical counts made at Sweasy Dam.
[10] Early data (pre 1988) have exceptionally high observation error and were not used in calculations.
[11] Recent abundance is a 4-year mean.

Juvenile data

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

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

To estimate a trend from the juvenile data, the data within each time-series were log-transformed and then normalized, so that each datum represented a deviation from the mean of that specific time-series. The normalization is intended to prevent spurious trends that could arise from the diverse set of methods used to collect the data. Then, the time-series were grouped into units thought to plausibly represent independent populations; the grouping was based on watershed structure. Finally, within each population a linear regression was done for the mean deviation versus year. The estimator for time-trend within each grouping is the slope of the regression line. The minimum number of observations per time-series is 6 years (Other assessments in this status review place the cut-off at 10 years.). The general lack of data on this ESU prompted us to consider these datasets despite their brevity.

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

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

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

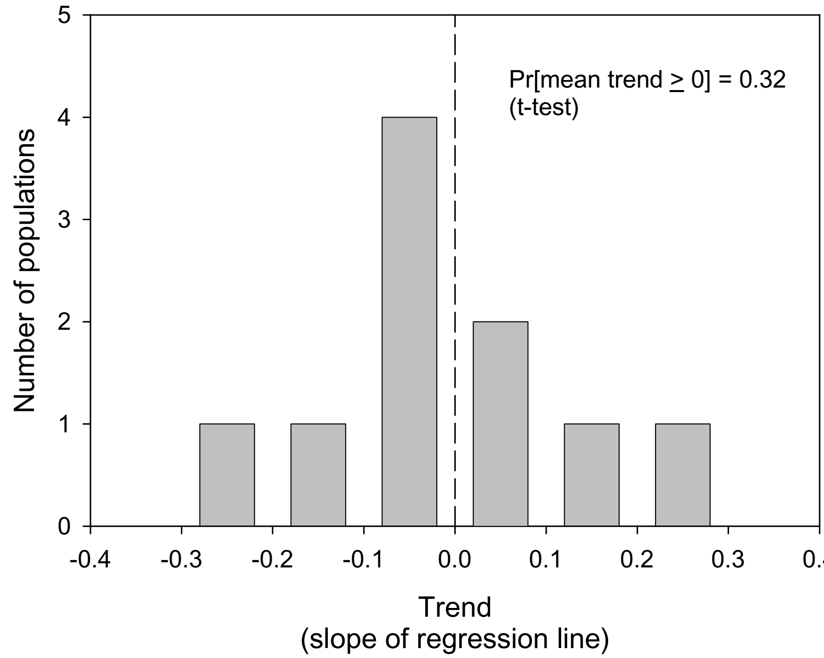

Figure B.2.6.3. Distribution of trends in juvenile density, for 10 "independent" populations within the North Coast steelhead ESU (see text for description of methods). Trend is measured as the slope of a regression line through a time-series; values less than zero indicate decline; values greater than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

Possible changes in harvest impacts

Since the original status review of Busby et al. (1996), regulations concerning sport fishing have been changed in a way that probably reduces extinction risk for the ESU.

Sport harvest in the ocean is prohibited by the California Department of Fish and Game (CDFG 2002a), and ocean harvest is a rare event (M. Mohr, NMFS, pers. comm.), so effects on extinction risk are negligible. For freshwaters (CDFG 2002b), all streams are closed to fishing year round except for special listed streams as follows: Catch-and-release angling is allowed year round excluding April and May in the lower mainstem of many coastal streams. Most of these have a bag limit of one hatchery trout or steelhead during the winter months (Albion River, Alder Creek, Big River, Cottoneva Creek, Elk Creek, Elk River, Freshwater Creek, Garcia River, Greenwood Creek, Little River in Humboldt Co., Gualala River, Navarro River, Noyo River, Ten Mile River, and Usal Creek); in a few the one-fish bag limit extends to the entire season (Bear River and Redwood Creek, both in Humboldt Co.). The Mattole River has a slightly more restricted catch-and-release season with zero bag limit year round.

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

At catch-and-release streams, all wild steelhead must be released unharmed. There are significant restrictions on gear used for angling. The CDFG monitors angling effort and catch-per-unit-effort in selected basins by way of a "report card" system in which sport anglers self-report their catch, gear used, and so forth, and in selected other basins by way of creel censuses.

Although the closure of many areas, and institution of catch-and-release elsewhere, is expected to reduce extinction risk for the ESU, this risk reduction cannot be estimated with existing data (due to the fact that natural abundance is not being estimated). After the Federal listing decisions, NMFS requested that CDFG prepare a Fishery Management and Evaluation Plan (FMEP) for the listed steelhead ESUs in California. This has not yet been done for the northern California ESU.

Resident *O. mykiss* considerations

Resident (non-anadromous) populations of *O. mykiss* were assigned to one of three categories for the purpose of provisionally determining ESU membership (See "Resident Fish" in the introduction for a description of the three categories and default assumptions about ESU membership). The third category consists of resident populations that are separated from anadromous conspecifics by recent human-made barriers such as dams without fish ladders. No default assumption about ESU membership was possible for Category 3 populations, so they are here considered case-by-case according to available information.

As of this writing there are few data on occurrence of resident populations and even fewer on genetic relationships. A provisional survey of the occurrence of Category 3 populations in the ESU (see Appendix B.5.2) revealed the following: In the watersheds inhabited by this ESU, 8% of stream kilometers lie behind two major recent barriers—Scott Dam on the Eel River and Robert Matthews dam on the Mad (Appendix B.5.2; major barriers are defined as blocking access to watersheds with areas of 100 sq. mi. or greater). Category 3 populations are documented to occur above both dams and there is ongoing stocking of hatchery fish in the Mad River above the dam. No such records of stocking were uncovered for the Eel above Scott Dam. There do not appear to be any relevant genetic studies of these Category 3 populations.

B.2.6.3 New Hatchery Information

California hatchery stocks being considered for inclusion in this ESU are those from Mad River Hatchery, Yager Creek Hatchery, and the North Fork Gualala River Steelhead Project. The stocks and their associated hatcheries were assigned to one of three categories for the purpose of determining ESU membership at some future date (See “Artificial Propagation” in the introduction for a description of the three categories and related issues regarding ESU membership). To make the assignments, data about broodstock origin, size, management, and genetics were gathered from fisheries biologists and are summarized below.

Mad River Hatchery (Mad River Steelhead [CDFG])

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

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

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

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

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

Category—The hatchery has been determined to belong in Category 3. There have been no introductions since 1974, and naturally spawned fish are being included in the broodstock. However, there is still an out-of-basin nature to the stock (SSHAG 2003; see Appendix B.5.3).

Yager Creek Hatchery (Yager Creek Steelhead [PalCo])

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

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

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

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

Category—This hatchery was determined to belong to Category 1. The broodstock has had no out-of-basin introductions and hatchery fish are excluded from the broodstock (SSHAG 2003; see Appendix B.5.3).

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

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

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

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

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

Category—Determined to be Category 1. Usually only naturally spawned juveniles are reared at the facility (SSHAG 2003; see Appendix B.5.3).

B.3 STEELHEAD BRT CONCLUSIONS

The ESA (Sec. 3) allows listing of "species, subspecies, and distinct population segments." The option to list subspecies is not available for Pacific salmon, since no formally recognized subspecies exist. However, a number of subspecies have been identified for *O. mykiss*, including two that occur in North America and have anadromous populations. According to Behnke (1992), *O. mykiss irideus* (the "coastal" subspecies) includes coastal populations from Alaska to California (including the Sacramento River), while *O. mykiss gairdneri* (the "inland" subspecies) includes populations from the interior Columbia, Snake and Fraser Rivers. Both subspecies thus include populations within the geographic range of this updated status review, but both also include northern populations outside the geographic range considered here. The BRT did not attempt to evaluate extinction risk to *O. mykiss* at the species or subspecies level; instead, we evaluated risk at the distinct population segment (ESU) level, as for the other species considered in this report.

Snake River steelhead ESU

A majority (over 70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for spatial structure to 3.2 for growth rate/productivity) (Table B.3.2). The continuing depressed status of B-run populations was a particular concern. Paucity of information on adult spawning escapements to specific tributary production areas makes a quantitative assessment of viability for this ESU difficult. As indicated in previous status reviews, the BRT remained concerned about the replacement of naturally produced fish by hatchery fish in this ESU; naturally produced fish now make up only a small fraction of the total adult run. Again, lack of key information considerably complicates the risk analysis. Although several large production hatcheries for steelhead occur throughout this ESU, relatively few data exist regarding the numbers and relative distribution of hatchery fish that spawn naturally, or the consequences of such spawnings when they do occur.

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

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Palouse and Malad Rivers) are not. Recent genetic data suggest that native resident *O. mykiss* above Dworshak Dam on the North Fork Clearwater River should be considered part of this ESU, but hatchery rainbow trout that have been introduced to that and other areas would not. The BRT did not attempt to resolve the ESU status of resident fish residing above the Hell's Canyon Dam complex, as little new information is available relevant to this issue. However, Kostow (2003) suggested that, based on substantial ecological differences in habitat, the anadromous *O. mykiss* that historically occupied basins upstream of Hells Canyon (e.g., Powder, Burnt, Malheur, Owhyee rivers) may have been in a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Upper Columbia River steelhead ESU

A slight majority (54%) of the BRT votes for this ESU fell in the "danger of extinction" category, with most of the rest falling in the "likely to become endangered" category (Table B.3.1). The most serious risk identified for this ESU was growth rate/productivity (mean score 4.3); scores for the other VSP factors were also relatively high, ranging from 3.1 (spatial structure) to 3.6 (diversity) (Table B.3.2). The last 2-3 years have seen an encouraging increase in the number of naturally produced fish in this ESU. However, the recent mean abundance in the major basins is still only a fraction of interim recovery targets (NMFS 2002). Furthermore, overall adult returns are still dominated by hatchery fish, and detailed information is lacking regarding productivity of natural populations. The ratio of naturally produced adults to the number of parental spawners (including hatchery fish) remains low for upper Columbia steelhead. The BRT did not find data to suggest that the extremely low replacement rate of naturally spawning fish (estimated adult: adult ratio was only 0.25-0.3 at the time of the last status review update) has improved substantially.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in the Entiat, Methow, and perhaps Okanogan basins) are not. Resident fish potentially occur in all areas in the ESU used by steelhead. Case 3 resident fish above Conconully Dam are of uncertain ESU affinity. The BRT did not attempt to resolve the ESU status of resident fish residing above Grand Coulee Dam, as little new information is available relevant to this issue. Possible ESU scenarios for these fish include 1) they were historically part of the ESU and many of the remnant resident populations still are part of this ESU; 2) they were historically part of the ESU but no longer are, due to either introductions of hatchery rainbow trout or rapid evolution in a novel environment; or 3) they were historically part of a separate ESU. For many BRT members, the presence of relatively numerous resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Middle Columbia River steelhead ESU

A slight majority (51%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with a substantial minority (49%) falling in the "not likely to become endangered" category (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.5 for diversity to 2.7 for abundance) (Table B.3.2).

This ESU proved difficult to evaluate for two reasons. First, the status of different populations within the ESU varies greatly. On the one hand the abundance in two major basins, the Deschutes and John Day, is relatively high and over the last five years is close to or slightly over the interim recovery targets (NMFS 2002). On the other hand, steelhead in the Yakima basin, once a large producer of steelhead, remain severely depressed (10% of the interim recovery target), in spite of increases in the last 2 years. Furthermore, in recent years escapement to spawning grounds in the Deschutes River has been dominated by stray, out-of-basin (and largely out-of-ESU) fish—which raises substantial questions about genetic integrity and productivity of the Deschutes population. The John Day is the only basin of substantial size in which production is clearly driven by natural spawners. For the other major basin in the ESU (the Klickitat), no quantitative abundance information is available. The other difficult issue centered on how to evaluate contribution of resident fish, which according to Kostow (2003) and other sources are very common in this ESU and may greatly outnumber anadromous fish. The BRT concluded that the relatively abundant and widely distributed resident fish mitigated extinction risk in this ESU somewhat. However, due to significant threats to the anadromous component the majority of BRT members concluded the ESU was likely to become endangered.

Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in Deschutes and John Day basins) are not. Case 3 resident fish above Condit Dam in the Little White Salmon; above Pelton and Round Butte Dams (but below natural barriers) in the Deschutes; and above irrigation dams in the Umatilla Rivers are of uncertain ESU status.

Lower Columbia River steelhead ESU

A large majority (over 79%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT found moderate risks in all the VSP categories, with mean risk matrix scores ranging from 2.7 for spatial structure to 3.3 for both abundance and growth rate/productivity) (Table B.3.2). All of the major risk factors identified by previous BRTs still remain. Most populations are at relatively low abundance, and those with adequate data for modeling are estimated to have a relatively high extinction probability. Some populations, particularly summer run, have shown higher returns in the last 2-3 years. The Willamette Lower Columbia River TRT (Myers et al. 2002) has estimated that at least four historical populations are now extinct. The hatchery contribution to natural spawning remains high in many populations.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of this ESU, while those above long-standing natural barriers (e.g., in upper Clackamas, Sandy, and some of the small tributaries of the Columbia River Gorge) are not. Case 3 resident fish above dams on the Cowlitz, Lewis, and Sandy Rivers are of uncertain ESU status.

Upper Willamette River steelhead ESU

The majority (over 76%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with small minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table B.3.1). The BRT did not identify any extreme risks for this ESU but found moderate risks in all the VSP categories (mean risk matrix scores ranged from 2.6 for diversity to 2.9 for both spatial structure and growth rate/productivity) (Table B.3.2). On a positive note, after a decade in which overall abundance (Willamette Falls count) hovered around the lowest levels on record, adult returns for 2001 and 2002 were up significantly, on par with levels seen in the 1980s. Still, the total abundance is small for an entire ESU, resulting in a number of populations that are each at relatively low abundance. The recent increases are encouraging but it is uncertain whether they can be sustained. The BRT considered it a positive sign that releases of the "early" winter-run hatchery population have been discontinued, but remained concerned that releases of non-native summer-run steelhead continue.

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

Northern California steelhead ESU

The majority (74%) of BRT votes were for "likely to become endangered," with the remaining votes split about equally between "in danger of extinction" and "not warranted" (Table B.3.1). Abundance and productivity were of some concern (scores of 3.7; 3.3 in the risk matrix); spatial structure and diversity were of lower concern (scores of 2.2; 2.5); although at least one BRT member gave scores as high as 4 for each of these risk metrics (Table B.3.2).

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

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Northern California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Robert W. Matthews Dam on the Mad River and Scott Dam on the Eel River--but below natural barriers are of uncertain ESU affinity. In this ESU, the inclusion of resident fish would not greatly increase the total numbers of fish, and the resident fish have not been exposed to large amounts of hatchery stocking.

Central California Coast steelhead ESU

The majority (69%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). Abundance and productivity were of relatively high concern (mean score of 3.9 for each, with a range of 3 to 5 for each), and spatial structure was also of concern (score 3.6) (Table B.3.2). Predation by pinnipeds at river mouths and during the ocean phase was noted as a recent development posing significant risk.

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

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Warm Springs Dam on Dry Creek, Russian River; Coyote Dam on the East Fork Russian River; Seeger Dam on Lagunitas Creek; Peters Dam on Nicasio Creek, Lagunitas Creek; and Standish Dam on Coyote Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, an estimated 22% of historical habitat is behind recent barriers. The only relevant biological information about the populations above these barriers pertains to Alameda Creek, and suggests that some but not all populations above Dam 1 are genetically similar to populations within the ESU. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

South-Central California Coast steelhead ESU

The majority (68%) of BRT votes were for "likely to become endangered," and another 25% were for "in danger of extinction" (Table B.3.1). The strongest concern was for spatial structure (score 3.9; range 3-5), but abundance and productivity were also a concern (Table B.3.2). The cessation of plants to the ESU from the Big Creek Hatchery (Central Coast ESU) was noted as a positive development, whereas continued predation from sport fishers was considered a negative development.

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

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South-Central California Coast Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including San Antonia, Nacimiento, and Salinas dams on the Salinas River; Los Padres Dam on the Carmel River; Whale Rock Dam on Old Creek; and Lopez Dam on Arroyo Grande Creek--but below natural barriers are of uncertain ESU affinity. In this ESU, little of the historical habitat is behind recent barriers and most of that on the Salinas River. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

Southern California steelhead ESU

The majority (81%) of BRT votes were for "in danger of extinction," with the remaining 19% of votes being for "likely to become endangered" (Table B.3.1). Extremely strong concern was expressed for abundance, productivity, and spatial structure (mean scores of 4.8, 4.3, and 4.8, respectively, in the risk matrix), and diversity was also of concern (mean score of 3.6) (Table B.3.2).

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

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the South California Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Twitchell Dam on the Cuyama River; Bradbury Dam on the Santa Ynez River; Casitas Dam on Coyote Creek, Ventura River; Matilija Dam on Matilija Creek, Ventura River; Santa Felicia Dam on Piru Creek, Santa Clara River; and Casitac Dam on Casitac Creek, Santa Clara River--but below natural barriers are of uncertain ESU affinity. In this ESU, a large portion of the original area is behind barriers, and the few density estimates that are available from this ESU indicate that the inclusion of area above recent barriers would substantially increase the number of fish in the ESU. Due to the extremely low numbers of anadromous fish in this ESU, it is possible that above-barrier populations contribute a significant number of fish to the below-barrier population by spill over. For some BRT members, the presence of resident fish mitigated the assessment of extinction risk for the ESU as a whole.

California Central Valley steelhead ESU

The majority (66%) of BRT votes were for “in danger of extinction”, and the remainder was for “likely to become endangered” (Table B.3.1). Abundance, productivity and spatial structure were of highest concern (4.2-4.4), although diversity considerations were of significant concern (3.6) (Table B.3.2). All categories received a 5 from at least one BRT member.

The BRT was highly concerned by the fact that what little new information was available indicated that the monotonic decline in total abundance and in the proportion of wild fish in the ESU was continuing. Other major concerns included the loss of the vast majority of historical spawning areas above impassable dams, the lack of any steelhead-specific status monitoring, and the significant production of out-of-ESU steelhead by the Nimbus and Mokelumne River fish hatcheries. The BRT viewed the anadromous life-history form as a critical component of diversity within the ESU and did not place much importance on sparse information suggesting widespread and abundant *O. mykiss* populations in areas above impassable dams. Dams both reduce the scope for expression of the anadromous life-history form, thereby greatly reducing the abundance of anadromous *O. mykiss*, and prevent exchange of migrants among resident populations, a process presumably mediated by anadromous fish.

Based on the provisional framework discussed in the general Introduction to this report, the BRT assumed as a working hypothesis that resident fish below historical barriers are part of the California Central Valley Steelhead ESU, while those above long-standing natural barriers are not. Historically, resident fish are believed to have occurred in all areas in the ESU used by steelhead, although current distribution is more restricted. Resident fish above recent (usually man-made) barriers--including Shasta Dam on the Upper Sacramento River; Whiskeytown Dam on Clear Creek; Black Butte Dam on Stony Creek; Oroville Dam on the Feather River; Englebright Dam on the Yuba River; Camp Far West Dam on the Bear River; Nimbus Dam on the American River; Commanche Dam on the Mokelumne River; New Hogan Dam on the Calaveras River; Goodwin Dam on the Stanislaus River; La Grange Dam on the Tuolumne River; and Crocker Diversion Dam on the Merced River--but below natural barriers are of uncertain ESU affinity. As noted above, collectively these dams have isolated a large fraction of historical steelhead habitat, and resident fish above the dams may outnumber ESU fish from below the dams.

Table B.3.1. Tally of FEMAT vote distribution regarding the status of 10 steelhead ESUs reviewed. Each of 16 BRT members allocated 10 points among the three status categories.

ESU	Danger of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River[1]	14	103	23
Upper Columbia[1]	75	62	3
Middle Columbia[1]	1	71	68
Lower Columbia[2]	10	110	30
Upper Willamette[2]	7	106	37
Northern California	18	119	23
Central California Coast	40	111	9
South Central California	40	109	11
Southern California	129	31	0
Central Valley	106	54	0

[1] Votes tallied for 14 BRT members
[2] Votes tallied for 15 BRT members

Table B.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 10 steelhead ESUs reviewed. Data presented are means (range).

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

B.4 REFERENCES

Adams, P. 2000. Memorandum to Rodney McInnis: Status review update for the steelhead northern California Evolutionarily Significant Unit. U.S. Dep. Commer., National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz/Tiburon Laboratory, Tiburon, California.

AFS (American Fisheries Society). 1991. Minutes of southern California steelhead meeting, US Fish and Wildlife Service Office, Ventura, California, January 22, 1991. Am. Fish. Soc., California-Nevada Chapter, Environmental Concerns Committee, 9 p. (Available from Trout Unlimited of California, 2530 San Pablo Ave., Suite D, Berkeley, CA 94702).

Alley, D. W., and Associates. 1994. Comparison of juvenile steelhead densities in 1981 and 1994 with estimates of total numbers of mainstem juveniles and expected numbers of adults returning to the San Lorenzo River, Soquel Creek and Corralitos Creek, Santa Cruz County, California. City of Santa Cruz Water Department, City of Watsonville Water Department Lompico County Water District San Lorenzo Valley Water District and Soquel Creek Water District. Project # 122-01, 123-01, 124-01, 125-01, Brookdale, California .

Alley, D. W., and Associates. 1995. Comparison of juvenile steelhead densities in 1981, 1994 and 1995 with an estimate of juvenile population size in the mainstem San Lorenzo River, with expected numbers of adults returning form juveniles reared in the mainstem river, Santa Cruz County, California. City of Santa Cruz Water Department, San Lorenzo Valley Water District and Lompico County Water District. Project # 135-01, 136-01. Brookdale, California.

Alley, D. W., and Associates. 1997. Comparison of juvenile steelhead densities in 1981 and 1994-96 in the San Lorenzo River and tributaries, with an estimate of juvenile population size in the mainstem river and expected adult returns from that production, Santa Cruz County, California. City of Santa Cruz Water Department and the San Lorenzo Valley Water District. Project # 143-01, 144-01. Brookdale, California.

Alley, D. W., and Associates. 1998. Comparison of juvenile steelhead densities in 1981 and 1994-97 in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size in the mainstem river and expected adult returns. City of Santa Cruz Water Department, and San Lorenzo Valley Water District. Project # 150-01. Brookdale, California .

Alley, D. W., and Associates. 1999. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1994-98; with predicted adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-02. Brookdale, California.

Alley, D. W., and Associates. 2000. Comparisons of juvenile steelhead densities, population estimates and habitat conditions for the San Lorenzo River, Santa Cruz County, California, 1995-99; with an index of adult returns. City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. Project #150-03. Brookdale, California.

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Project # 150-06. Brookdale, California .

Alley, D. W., and Associates. 2002. Comparison of juvenile steelhead densities in 1997 through 2001, in the San Lorenzo River and tributaries, Santa Cruz County, California; with an estimate of juvenile population size and an index of adult returns. City of Santa Cruz Water Department, San Lorenzo Valley Water District and NMFS. Draft report Project # 150-06. Brookdale, California .Anonymous. 1994. Oregon salmon and steelhead catch data, 1981-93. Unpublished.

Anonymous. 1995. 1995 Stock status review for winter steelhead, Mid-Willamette district, NW region.

Anonymous. 1997. ODFW Mid-Willamette Fish District unpublished files: winter steelhead Foster dam counts, Minto trap counts and run size estimates; Molalla R. spring chinook run size estimates through 1997.

Anonymous. 1998. Portland General Electric fish facility reports. Unpublished StreamNet Reference.

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

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60), 21 p.

Behnke, R. J. 1992. Native trout of western North America. Am. Fish. Soc. Monog. 6, 275 p. American Fisheries Society, Bethesda, MD.

Berg, L (ed.). 2001. Yakima Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Berry, R. L. 1978. Salmon and steelhead sport catch statistics, 1978. Unpublished.

Bjornn, T. C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. Univ. Idaho, Coll. For., Wildl. Range Sci. Bull. 27, 57 p.

Boughton, D. A. and H. Fish. MS. The current regional distribution of steelhead (*Oncorhynchus mykiss*) in Southern California. Available from NOAA Fisheries, Southwest Science Center, 110 Shaffer Road, Santa Cruz, CA.

Brown, L. R. and P. B. Moyle. 1981. The impact of squawfish on salmonid populations: a review. N. Amer. J. Fish. Man. 1: 104 – 111.

Brown, L. R. and P. B. Moyle. 1997. Invading species in the Eel River, California: successes, failures, and relationships with resident species. Environmental Biology of Fishes 49: 271 – 291.

Bryson, D. 2001. Draft Imnaha Subbasin Summary. Prepared for the Northwest Power Planning Council. 241 p.

Burgner, R. L., J. T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and origins of steelhead trout (*Oncorhynchus mykiss*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 51, 92 p.

Busby, P. J., O. W. Johnson, T. C. Wainwright, F. W. Waknitz, and R. S. Waples. 1993. Status review for Oregon s Illinois River winter steelhead. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-10, 85 p.

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

CACSS (California Advisory Committee on Salmon and Steelhead). 1988. Restoring the balance. Calif. Dep. Fish Game, Sacramento, CA. 84 p.

Cardenas, M. 1996. Upper Sisquoc River survey. CDFG Report.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan. Volume III supporting data: part B, inventory salmon-steelhead and marine resources. California Department of Fish and Game, Sacramento, California.679 p.

CDFG (California Department of Fish and Game). 1979. Nelson Creek wild trout management plan. California Department of Fish and Game, Sacramento, CA, 27 p.

CDFG (California Department of Fish and Game). 1982. 1982 status report of California wild and scenic rivers salmon and steelhead fisheries. Calif. Dept. Fish Game, Sacramento, CA, 159 p.

CDFG (California Department of Fish and Game). 1995. Letter to M. Schiewe for the ESA Administrative Record for west coast steelhead, dated 30 March 1995, 10 p. plus attachments. (Avail. from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

CDFG (California Department of Fish and Game). 2000. Fishery management and evaluation plan, south-central California coast evolutionarily significant unit, steelhead, draft document. CDFG, Fisheries Programs Branch, 1416 Ninth Street, Sacramento, CA.

CDFG (California Department of Fish and Game). 2000. Fishery management plan for the Upper Sacramento River (Box Canyon Dam to Lake Shasta) 2000 to 2005. California Department of Fish and Game, Sacramento, CA, 52 p.

CDFG (California Department of Fish and Game). 2001. Fishery management plan, Central Valley, California Evolutionary Significant Unit, Steelhead. California Department of Fish and Game, Sacramento, CA, 59 p.

CDFG (California Department of Fish and Game). 2001a. Fishery management and evaluation plan, Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2001b. Fishery management and evaluation plan, South-Central California Coast Evolutionarily Significant Unit, draft.

CDFG (California Department of Fish and Game). 2002. 2002 Freshwater sportfishing regulations booklet. Available from CDFG, 1416 Ninth Street, Room 1320, Sacramento, CA 95814. 70 pp.

CDFG (California Department of Fish and Game). 2003. Letter from D. Marston (CDFG) to M. Martinez (NMFS), dated January 9, 2003.

Chilcote, M. W. 1998. Conservation Status of Steelhead in Oregon. Information Report 98-3. Oregon Department of Fish and Wildlife.

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

Chilcote, M. W. 2002. Spreadsheet with 2002 Oregon steelhead escapement updates.

Cichosz, T., D. Saul, A. Davidson, W. Warren, D. Rollins, J. Willey, T. Tate, T. Papanicolaou and S. Juul. 2001. Clearwater Subbasin Summary. Draft submitted to the Northwest Power Planning Council. Nov. 2001. 477 p.

Clanton, D. A. and J. F. Jarvis. 1946. Memorandum to Bureau of Fish Conservation re: field inspection trip to the Matilija-Ventura watershed in relation to the construction of the proposed Matilija Dam, dated 8 May 1946. Calif. Dep. Nat. Resources., Div. Fish Game, 3 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Comstock, R. 1992. Santa Clara River steelhead restoration assessment. US Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington, 10 pp. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

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

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

Cramer, D. 2002b. Portland General Electric - sandy winter steelhead adults. Portland General Electric. Data delivered via e-mail from Kathryn Kostow, Oregon Dept of Fish and Wildlife.

Cramer, S. P., and 12 co-authors. 1995. The status of steelhead populations in California in regards to the Endangered Species Act. Document prepared for Association of California Water Agencies, 167 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Cramer, S., R. Beamesderfer, P. Monk, K. Witty, A. Kalin, B. Lister & C. Akerman. 2002. Mid-Columbia steelhead trout population viability assessment. S.P. Cramer & Assoc. Progress Rept. Submitted to NMFS. April 2002.

CRFMP TAC (Columbia River Fisheries Management Plan Technical Advisory Committee). 1991. Summer steelhead. In Columbia River fish management plan: 1991 All species review. Technical Advisory Committee, U.S. v. Oregon. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

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

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

Deinstadt, J. M., and Berry, M. A. 1999. California wild trout program, Hat Creek wild trout management plan, 1998 - 2003. California Department of Fish and Game, Sacramento, CA, 51 p.

Engblom, S. 1997. Compilation report for the 1996-97 Santa Ynez River Memorandum of understanding. SYRTAC.

Engblom, S. 1999. Compilation report for the 1998-99 Santa Ynez River Memorandum of understanding.

Engblom, S. 2001. 2001 Lower Santa Ynez River steelhead studies – annual report, Santa Barbara County, California.

Entrix. 1995. Historical steelhead run in the Santa Ynez River. Project No. 374100, prepared for Price Postel and Parma, 200 E. Carillo St., Santa Barbara, CA 93102.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, 48 p.

Foerster, R. E. 1947. Experiment to develop sea-run from land-locked sockeye salmon *(Oncorhynchus nerka kennerlyi*). J. Fish. Res. Board Can. 7(2):88-93.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and homing experiments on salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, in the Columbia River system: fish of the 1939-1944 broods. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC 12, 97 p.

Gephart, L. & D. Nordheim (eds) 2001. Tucannon Subbasin Summary. Prepared for the Northwest Power Planning Council. 222 pages.

Gorman, L. 2001. Hood steelhead at Powerdale dam. StreamNet Excel workbook provided to Paul McElhany from Leah Gorman 10/16/2001. This workbook is based on data provided by Rod French to ODFW/NMFS in the Microsoft Word file Data2000.doc on 7/31/2001.

Grass, A. 1995. Annual Report: Van Arsdale Fisheries Station, 1993-94. California Department of Fish and Game, Inland Fisheries. Administrative Report Number 95-5, 10p.

Griswold, K. E. 1996. Genetic and meristic relationships of coastal cutthroat trout (*Oncorhynchus clarki clarki*) residing above and below barriers in two coastal basins. M.S. Thesis, Oregon State Univ., Corvallis, OR, 83 p.

Hannon, J. and M. Healey. 2002. American River Steelhead Redd Surveys, 2001-2002. U. S. Bureau of Reclamation and California Department of Fish and Game. 19 p.

Hanson, C. H., J. Hagar, S. Englom, and B. Bemis. 1996. Synthesis and analysis of information collected on the fishery resources and habitat conditions of the lower Santa Ynez River: 1993 – 1996.

Harvey, B. C., J. L. White and R. J. Nakamoto. 2002. Habitat relationships and larval drift of native and nonindigenous fishes in neighboring tributaries of a coastal California river. Trans. Amer. Fish. Soc. 131: 159 – 170.

Henke, E. 1994. Letters to G. Bryant re: information on steelhead for the Administrative Record for west coast steelhead. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

Hulett et al. 1995. Studies of hatchery and wild steelhead in the lower Columbia basin. Washington Department of Fish and Wildlife. Report #RAD 95-3.

Hunt, W. 1999. Calapooia River St W Spawning Surveys, Winter Steelhead Counts Upper Willamette River, Late-Run Winter Steelhead Run Size Estimates and St W Returns to Minto Trap. ODFW.

Hunt, L. E., P. E. Lehman, and M. H. Capelli. 1992. Vertebrate resources at Emma Wood State Park and the Ventura River estuary, Ventura County, California: Inventory and management. Calif. Dep. Parks Rec., document dated 6 November 1992, 107 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.)

IEP (Interagency Ecological Program Steelhead Project Workteam). 1998. Monitoring, assessment, and research on Central Valley steelhead: status of knowledge, review of existing programs, and assessment of needs. Available online at: http://calfed.ca.gov/programs/cmarp/a7a11.html

IDFG (Idaho Department of Fish and Game). 1994. Documents submitted to the ESA Administrative Record for west coast steelhead by E. Leitzinger, 18 October 1994. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

IDFG (Idaho Department of Fish and Game). 2002. Written comments submitted to National Marine Fisheries Service regarding status review.

James, G. and C. Scheeler. 2001. Walla Walla Subbasin Summary (Draft). Northwest Power Planning Council, Portland, OR.

Johnson, T. H. and R. Cooper. 1995. Anadromous game fish research and planning, July 1 1993-December 31, 1994. Washington Dept of Fish and Wildlife. Streamnet.org Reference.

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A. M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-37, 292 p.

Jonsson, B. 1985. Life history patterns of freshwater resident and sea-run migrant brown trout in Norway. Trans. Am. Fish. Soc. 114:182-194.

Kaeriyama, M., S. Urawa, and T. Suzuki. 1992. Anadromous sockeye salmon (*Oncorhynchus nerka*) derived from nonanadromous kokanees: Life history in Lake Toro. Sci. Rep. Hokkaido Salmon Hatchery 46:157-174.

Kennedy, T. 2002. Stanislaus River anadromous fish surveys 2000-2001. Report from Fisheries Foundation to A. Hamilton, USFWS, Sacramento, CA.

Kesner, W. D., and R. A. Barnhart. 1972. Characteristics of the fall-run steelhead trout *(Salmo gairdneri gairdneri*) of the Klamath River system with emphasis on the half-pounder. California Fish and Game 58(3):204-220.

Kier & Associates. 2001. Battle Creek salmon and steelhead restoration project. Draft Adaptive Management Plan. Sausalito, CA. 79 p.

Killam, D. 2002. Field notes for Thomes Creek 2002. California Department of Fish and Game, Red Bluff CA.

Kostow, K. 2002. Leaburg and McKenzie abundance. Data delivered via e-mail, September 2002.

Kostow, K. 2003. The biological implications of non-anadromous *Oncorhynchus mykiss* in Columbia basin steelhead ESUs. Report to NOAA Fisheries & ODFW. Draft report to NMFS. Jan. 13, 2003. 90 p.

Mallet, J. 1974. Inventory of salmon and steelhead resources, habitats, use and demands. Job Performance Report. Proj. F-58-R-1. Idaho Dept. of Fish and Game. Boise. Idaho.

Maslin, P. E., M. Lennox, and J. Kindopp. 1998. Intermittent streams as rearing habitat for Sacramento River chinook salmon (*Oncorhynchus tshawytscha*). CSU Chico unpublished report. 51 p.

McClure, M. M., E. E. Holmes, B. L. Sanderson & C. E. Jordan. In press. A large-scale multi-species assessment: Anadromous Salmonids in the Columbia River Basin. 45 p + figures and tables. Ecological Applications.

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

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

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D. R. 2001. Steelhead rainbow trout. Pages 418-425 *in* W. S. Leet, C. M. Dewees, C. M Klingbeil, and E. J. Larson, editors. California's living marine resources: a status report. University of California, Agriculture and Natural Resources, Publication SG01-11.

McEwan, D. R. 2001. Central Valley steelhead. In R. L. Brown, editor, *Fish Bulletin 179*, pages 1-43. California Department of Fish and Game, Sacramento, CA.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Dep. Fish Game, 234 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Meyer Resources. 1988. Benefits from present and future salmon and steelhead production in California. Report to the California Advisory Committee on Salmon and Steelhead, 78 p. (Available from California Advisory Committee on Salmon and Steelhead Trout, 120 Schoonmaker Point, Foot of Spring Street, Sausalito, CA 94965.)

Monterey Peninsula Water Management District (MPWMD). 2001. Executive summary, 2000-20001, MPWMD Mitigation Program and Water Allocation Program Environmental Impact Report.

Moore, M. R. 1980. An assessment of the impacts of the proposed improvements to the Vern Freeman Diversion on anadromous fishes of the Santa Clara River System, Ventura County, California.

Moore, T. L. 2001. Steelhead Survey Report for Antelope, Deer, Beegum and Mill Creeks, 2001. CDFG Sacramento River Salmon and Steelhead Assessment Program. California Department of Fish and Game. 8 p.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I, U.S. Fish and Wildlife Service, Box 549, Leavenworth, WA 98826, 489 p.

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

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

Nielsen, J. L., E. A. Heine, C. A. Gan and M. C. Fountain. 2000. Molecular analysis of population genetic structure and recolonization of rainbow trout following the Cantara spill. California Fish and Game 88:21-40.

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

NMFS (National Marine Fisheries Service). 1993. Endangered and threatened species; Illinois River winter steelhead in Oregon. Federal Register [Docket 930517-3117, 20 May 1993] 58(96): 29390-29392.

NMFS (National Marine Fisheries Service). 1997. Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon, and California. Memorandum from the Biological Review Team to the NMFS Northwest Regional Office. July 7, 1997, 72 p.

NMFS (National Marine Fisheries Service). 1998*a*. Status review update for deferred and candidate ESUs of west coast steelhead (Lower Columbia River, Upper Willamette River, Oregon Coast, Klamath Mountains Province, Northern California, Central Valley, and Middle Columbia River ESUs). Pre-decisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1998*b*. Status review update for deferred ESUs of west coast steelhead: hatchery populations (Lower Columbia River, Klamath Mountains Province, Northern California, and Central Valley). Predecisional ESA document, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1999. Updated Review of the Status of the Upper Willamette River and Middle Columbia River ESUs of Steelhead. Memorandum for W. Stelle and W. Hogarth from M. Schiewe. January 12, 1999, 49 p.

NMFS (National Marine Fisheries Service). 2002. Memorandum for Frank L. Cassidy, Jr. (Northwest Power Planning Council) from Bob Lohn (NMFS), April 2002. (Available at http://www.nwr.noaa.gov/occd/InterimTargets.pdf)

Nobriga, M. 1995. Cosumnes River study. California Department of Fish and Game, Rancho Cordova, CA. 10 p.

Nobriga, M. and P. Cadrett. 2001. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. IEP Newsletter 14: 30-38.

Nordeng, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40:1372-1387.

Nowak, M.C. 2001. Draft Grande Ronde Subbasin Summary. Prepared for the Northwest Power Planning Council. 385 pages.

ODFW (Oregon Department of Fish and Wildlife). 1990. Santiam and Calapooia Rivers: Willamette River subbasin : salmon and steelhead production plan. Oregon Department of Fish and Wildlife. Northwest Power Planning Council.

ODFW (Oregon Department of Fish and Wildlife). 1991. Grand Ronde River subbasin salmon and steelhead plan. Prepared for Northwest Power Planning Council. 129 pp.

ODFW (Oregon Department of Fish and Wildlife). 1999. Personal communications for reconstructed run year estimates from punch cards for steelhead, 1956-1970. Unpublished.

ONRC (Oregon Natural Resources Council), Siskiyou Regional Education Project, Federation of Fly Fishers, Kalmiopsis Audubon Society, Siskiyou Audubon Society, Klamath/Siskiyou Coalition, Headwaters, The Wilderness Society, North Coast Environmental Center, Oregon Chapter of The Sierra Club, and The National Wildlife Federation. 1992. Petition for a rule to list the Illinois River winter steelhead as threatened or endangered under the Endangered Species Act and to designate critical habitat. Unpubl. manuscr., 16 p. (Document submitted to USDOC NOAA NMFS Northwest Region, Seattle, Washington, May 1992).

Puckett, L. K. 1969. Fisheries surveys on Thomes and Stony Creeks, Glenn and Tehama Counties, with special emphasis on their potentials for King Salmon spawning. California Department of Fish and Game, Water Projects Branch Administrative Report No. 69-3. 24 p.

Rawding, D. 2002a. Lower Columbia River summer-run steelhead. Excel Workbook sent from Dan Rawding (WDFW) to Paul McElhany via e-mail to Paul McElhany and Sarah Sydor, NWFSC.

Rawding, D. 2001b. Simsam (Steelhead). Unpublished data and documentation sent from Dan Rawding (WDFW) to Paul McElhany on 5/16/2001 as Excel file and Word document, via e-mail.

Reavis, B. 1991. Status of California steelhead stocks. In Pacific States Marine Fisheries Commission and Association of Northwest Steelheaders (organizers), International Symposium on Steelhead Trout Management, January 3-5, 1991, Portland, OR, p. 57 – 63.

Reese, C. D. and B. C. Harvey. 2002. Temperature-dependent interactions between juvenile steelhead and Sacramento pikeminnow in laboratory streams. Trans. Am. Fish. Soc. 131: 599 – 606.

Reynolds, F. L., T. J. Mills, R. Benthin and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Sacramento, CA, 184 p.

Robertson, S. R. 1985. Clavey River wild trout habitat management plan. Stanislaus National Forest, Sonora, CA, 14 p. (from CV steelhead; not in master list)

Rode, M., and Weidlein, W. D. 1986. California wild trout management program, Fall River management plan. California Department of Fish and Game, Inland Fisheries Admin. Rpt. 86-2. 55 p. (from CV steelhead; not in master list)

Roelofs, T. D. 1983. Current status of California summer steelhead (*Salmo gairdneri*) stocks and habitat, and recommendations for their management. Submitted to USDA Forest Service, Region 5, 77 p. (Available from Environmental and Technical Services Division, Natl. Mar. Fish. Serv., 525 N.E. Oregon Street, Suite 500, Portland, OR 97232.).

Ruiz-Campos, G. and E. P. Pister. 1995. Distribution, habitat, and current status of the San Pedro Martir rainbow trout, *Oncorhynchus mykiss nelsoni* (Evermann). Bulletin of the Southern California Academy of Sciences, 94(2): 131 – 148.

Schill, D. J. and R. L. Scarpella. 1997. Barbed hook restrictions in catch-and-release trout fisheries: a social issue. N. Am. J. Fish. Man. 17: 873 – 881.

Servheen, G. Draft Salmon Subbasin Summary. Prepared for the Northwest Power Planning Council. 481 p. + app.

Shapovalov, L. 1944. Preliminary report on the fisheries of the Santa Ynez River System, Santa Barbara County, California. CDFG Report, 22 pp.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dep. Fish Game Fish Bull. 98, 375 pp.

Sharp, B. 2001. Klickitat Subbasin Summary. Northwest Power Planning Council, Portland, OR.

Shea, K., and M. Mangel. 2001. Detection of population trends in threatened coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 58: 375-385.

Smith, J. J. 1994. Abundance of coho and steelhead in Redwood Creek in 1994. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1992. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1992. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Gazos Creeks in 1993. Department of Biological Sciences, San Jose State University. San Jose, CA.

Smith, J. J. 1994. Distribution and abundance of juvenile coho and steelhead in Scott and Waddell Creeks in 1988 and 1994: Implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1995. Distribution and abundance of juvenile coho and steelhead in Waddell, Scott and Gazos Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of coho and steelhead in Redwood Creek in November 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1995. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1996. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1996. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1997. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1997. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of coho and steelhead in Redwood Creek in fall 1998. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1997 and the implications for status of southern coho. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1998. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1998. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 1999. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 1999. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2000. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2000. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2000. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Gazos, Waddell and Scott Creeks in 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2001. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2001. Department of Biological Sciences, San Jose State University. San Jose, California.

Smith, J. J. 2002. Distribution and abundance of juvenile coho and steelhead in Redwood Creek in fall 2002. Department of Biological Sciences, San Jose State University. San Jose, California.

Snider, B., and R. G. Titus. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; November 1995 - July 1996. California Department of Fish and Game, Stream Evaluation Program Technical report 98-5.

Snider, B., and R. G. Titus. 2000a. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1996 - September 1997. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-4.

Snider, B., and R. G. Titus. 2000b. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing October 1997-September 1998. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical Report 00-5.

Snider, B., and R. G. Titus. 2000c. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing; October 1998 - September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program Technical report 00-6.

Snider, W. M. 1983. Reconnaissance of the steelhead resource of the Carmel River drainage, Monterey County. Calif. Dep. Fish Game, Environmental Services Branch Admin. Rep. 83-3., 41 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814.)

Snyder, J. O. 1925. The half-pounder of Eel River, a steelhead trout. Calif. Fish Game 11(2): 49-55.

Stephens, S. J., Christenson, D. P., Lechner, M., and Werner, H. 1995. Upper Kern Basin fishery management plan. California Department of Fish and Game, Sacramento, CA, 86 p.

Stoecker, M.W. and CCP (Conception Coast Project). 2002. Steelhead assessment and recovery opportunities in Southern Santa Barbara County, California. Conception Coast Project, Santa Barbara.

Titus, R. G., D. C. Erman, and W. M. Snider. MS. History and status of steelhead in California coastal drainages south of San Francisco Bay.

Titus, R. G. and C. D. Vanicek. 1988. Comparative hooking mortality of lure-caught Lahontan cutthroat trout at Heenan Lake, California. Calif. Fish Game 74: 218 – 225.

USFWS (U.S. Fish and Wildlife Service). 2000. Anadromous fish restoration actions in the Butte Creek Watershed. Programmatic Environmental Assessment. Sacramento, CA.

Waples, R. S. 1998. Willamette Steelhead. Memorandum to Mike Delarm and Garth Griffin, NMFS Regional Office, Portland, 2 July 1998. 2 p.

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

WDFW ((Washington Department of Fisheries and Wildlife). 1997. "Preliminary stock status update for steelhead in the Lower Columbia River, Washington (WDFW Kalama Research)." Data via Michelle McClure; references from Eli Holmes.

Withler, R. E. 1988. Genetic consequences of fertilizing chinook salmon (*Oncorhynchus tshawytscha*) eggs with pooled milt. Aquaculture 68: 15-25.

Workman, M. L. 2001. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam, August 2000 through April 2001. East Bay Municipal Utility District, Lodi, CA. 21 p.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. N. Am. J. Fish. Man. 18:487-521.

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