STATUS REVIEW OF CALIFORNIA COHO SALMON NORTH OF SAN FRANCISCO

Report to The California Fish and Game Commission

April 2002

California Department of Fish and Game
The Resources Agency
State of California

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Report to The California Fish and Game Commission

Prepared by
The California Department of Fish and Game

Candidate Species Status Review Report 2002-3

April 2002

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

ACP	Aquatic Conservation Plan
BKD	Bacterial Kidney Disease
BLM	Bureau of Land Management
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BOF	California Board of Forestry and Fire Protection
CALCC	California Conservation Corps
CCC Coho ESU	Central California Coast Coho Evolutionarily Significant Unit
CCR	California Code of Regulations
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFIP	California Forest Improvement Program
CGS	California Geological Survey (formerly California Division of Mines and Geology)
Commission	California Fish and Game Commission
CRMP	Coordinated Resources Management Planning
CRR	Cohort Replacement Rate
CWA	Clean Water Act
Department	California Department of Fish and Game
DHS	California Department of Health Services
DO	Dissolved Oxygen
DWR	California Department of Water Resources
EEGP	Environmental Education Grant Program
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FEMAT	Forest Ecosystem Management Assessment Team
FERC	Federal Energy Regulatory Commission
FGC	California Fish and Game Code
FPA	Forest Practice Act
FPR	Forest Practice Rules
FRGP	Fishery Restoration Grants Program
GIS	Geographic Information System
HCP	Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plan
IWMA	Interim Watershed Mitigation Addendum
LWD	Large Woody Debris
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NCWAP	North Coast Watershed Assessment Program
NMFS	National Marine Fisheries Service
OC Coho ESU	Oregon Coast Coho Evolutionarily Significant Unit
OCN	Oregon Coastal Natural
OPI	Oregon Production Index
PALCO	Pacific Lumber Company

PFMC	Pacific Fishery Management Council
RCD	Resource Conservation District
R/K	Rogue River/Klamath River
RM	River Mile
RPF	Registered Professional Foresters
RWQCB	California Regional Water Quality Control Board
SEIS	Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forests Related Species With the Range of the Northern Spotted Owl
SMARA	Surface Mine and Reclamation Act
SONCC Coho ESU	Southern Oregon/Northern California Coasts Evolutionarily Significant Unit
SRAC	Smith River Advisory Council
SRP	Scientific Review Panel
SWRCB	State Water Resources Control Board
SYP	Sustained Yield Plans
THP	Timber Harvest Plans
TMDL	Total Maximum Daily Load
TRT	Technical Recovery Team
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WSP	Americorps Watershed Stewards Project

I. EXECUTIVE SUMMARY

Petition History

On July 28, 2000, the Fish and Game Commission (Commission) received a petition to list coho salmon north of San Francisco as an endangered species under provisions of the California Endangered Species Act (CESA). The Commission referred the petition to the Department of Fish and Game (Department) on August 7, 2000, for evaluation.

The Department found that the information in the petition was sufficient to indicate the action may be warranted and recommended the Commission accept the petition. The petition was accepted by the Commission on April 5, 2001. On April 27, 2001 the Commission published a Notice of Findings in the California Regulatory Notice Register declaring coho salmon a candidate species, thereby starting the candidacy period.

The Department solicited information and undertook a status review of the species using the best scientific information available. This report contains the results of the Department's status review and recommendations to the Commission. The Department evaluated the status separately for the two coho salmon Evolutionarily Significant Units (ESU) that occur in California: Southern Oregon/Northern California Coast Coho ESU (SONCC Coho ESU - those populations from Punta Gorda north to the Oregon border) and the Central California Coast Coho ESU (CCC Coho ESU - those populations from San Francisco Bay north to Punta Gorda). This approach is consistent with previous listings, the federal approach to species' evaluation, and the generally accepted biological criterion that a species is "a group of interbreeding organisms that is reproductively isolated from other such groups."

Conclusions

The Department did not find any evidence to contradict the conclusions of previous status reviews that coho salmon populations have suffered declines in California. Conversely, new evidence was found that supports these conclusions. The Department concludes that California coho salmon have experienced a significant decline in the past 40 to 50 years. California coho salmon populations have been individually and cumulatively depleted or extirpated and the natural linkages between them have been fragmented or severed. Previous studies have shown that coho salmon abundance in California, including hatchery stocks, could be six to 15 percent of their abundance during the 1940s, and has experienced a decline of at least 70% since the 1960s.

With two exceptions, California hatchery coho salmon stocks have also experienced drastic reductions in recent years due to low spawner abundance. The two exceptions are the Department's Iron Gate and Trinity River hatcheries. Both of these facilities experienced variable adult returns but generally met production quotas in recent years. Upstream of the South Fork of the Trinity River, natural spawning appears to be low and the proportion of hatchery origin fish seems to be high.

Coho salmon harvest dropped-off considerably in the late 1970s, despite a fairly stable rate of hatchery production. By 1992, ocean stocks were perceived to be so low that the commercial fishery in California was closed. Similarly, coho salmon retention in the ocean sport fishery ended with the 1993 season.

Southern Oregon/Northern California Coast Coho ESU

The analysis of presence-by-brood-year data indicates that coho salmon now occupy only about 61% of the SONCC Coho ESU streams that were previously identified as historical coho salmon streams. However, these declines appear to have occurred prior to the late 1980s and our data does not support a significant decline in distribution between the late 1980s and the present. This analysis and the 2001 presence surveys indicate that some streams in this ESU may have lost one or more brood-year lineages.

The 2001 presence survey data also show a decline in reported distribution in this ESU. These data show a substantial reduction in the number of historical streams occupied by coho salmon, especially for the Mattole, Eel, and Smith river systems, where coho salmon appeared to be absent from 71%, 73%, and 62% of the streams surveyed, respectively. These data should be interpreted with caution, however, because they represent only one year of surveys, and 2001 was a drought year on the north coast. Nevertheless, the inability to detect coho salmon in streams where they were historically documented to occur and that are considered by biologists to contain suitable coho salmon habitat is significant, especially to the high degree that coho salmon were not found in these surveys (59% of all the streams surveyed).

Adult coho salmon counts at Benbow Dam on the South Fork Eel River show a substantial decline in coho salmon abundance in this system starting in the mid-1940s. Most other trend indicators for streams in the area show declining or stable trends.

Although streams supporting coho salmon in the California portion of the SONCC Coho ESU appear to be fewer now in comparison to the 1985-1991 period, the available data suggest that population fragmentation within the larger river systems is not as severe as in the CCC Coho ESU. All major stream systems within the California portion of the SONCC Coho ESU still contain coho salmon populations. Also, the presence-by-brood-year analysis indicates that the decline in the number of streams supporting coho salmon appears to have stabilized since the mid-1980s. For these reasons, the Department concludes that the California portion of the SONCC Coho ESU is not presently threatened with extinction. However, because of the decline in distribution prior to the 1980s, the possibility of a severe reduction in distribution as indicated by the field surveys, and the downward trend of most abundance indicators, the Department believes that coho salmon populations in the California portion of this ESU will likely become endangered in the foreseeable future in the absence of the protection and management required by CESA.

Central California Coast Coho ESU

The 2001 presence surveys in the northern portion of the CCC Coho ESU show a level of occupancy of historical streams that is similar to the SONCC Coho ESU. However, stream systems south of Mendocino County show a much greater proportion of streams in which coho salmon were not found. These surveys and other recent monitoring data indicate that widespread extirpation or near-extinctions have already occurred within some larger stream systems (e.g. Gualala and Russian rivers) or over broad geographical areas (e.g. Sonoma County coast, San Francisco Bay tributaries, streams south of San Francisco).

Most abundance trend indicators for streams in the CCC Coho ESU indicate a decline since the late 1980s. However, some streams of the Mendocino County coast show an upward trend in 2000 and 2001. Time-series analysis for these streams show a declining trend and predict that this trend will continue, despite the recent increases.

There is anecdotal evidence that relatively large numbers of coho salmon adults returned to some Marin County streams in 2001, and some of these streams, such as Lagunitas Creek, appear to have relatively stable populations. However, these populations are more vulnerable to extinction due to their small size, and the spatial isolation of this region due to extirpation of coho salmon populations to the north and south.

Coho populations in streams in the northern portion of this ESU seem to be relatively stable or are not declining as rapidly as those to the south. However, the southern portion, where widespread extirpation and near-extinctions have occurred, is a major and significant portion of the range of coho salmon in this ESU. Small population size along with large-scale fragmentation and collapse of range observed in data for this area indicate that metapopulation structure may be severely compromised and remaining populations may face greatly increased threats of extinction because of this. For this reason, the Department concludes that CCC coho salmon are in serious danger of extinction throughout all or a significant portion of their range

Factors Affecting the Decline

The severity of the decline and number of extirpated populations increases as one moves closer to the historical southern limit of the coho salmon range, indicating that freshwater habitat in these marginal environments is less able to support coho salmon populations than in the past. Freshwater habitat loss and degradation has been identified as a leading factor in the decline of anadromous salmonids in California and coho salmon do not appear to be an exception to this trend. Timber harvest activities, especially past and present road construction, have had deleterious effects on coho salmon habitat. Diversion of water for agricultural and municipal purposes and dams that block access to former habitat have resulted in further reduction of habitat. Water quality in historical coho salmon streams has degraded substantially, as evidenced by the number of north- and central-coast streams that have been placed on the list of impaired water bodies, pursuant to section 303 of the Clean Water Act (CWA).

Recommendations

The Department concludes that the listing of the California portion of the SONCC Coho ESU as endangered is not warranted, but listing as threatened is warranted. The Department recommends that the Commission add coho salmon north of Punta Gorda to the list of threatened species.

The Department concludes that coho salmon in the CCC Coho ESU is in serious danger of becoming extinct throughout all or a significant portion of its range. The Department concludes that listing this species as an endangered species is warranted. The Department recommends that the Commission add coho salmon north of, and including, San Francisco Bay to Punta Gorda to the list of endangered species.

II. INTRODUCTION

Petition History

On July 28, 2000, the Fish and Game Commission (Commission) received a petition from the Salmon and Steelhead Recovery Coalition to list the coho salmon (*Oncorhynchus kisutch*) north of San Francisco as an endangered species under provisions of the California Endangered Species Act (CESA). The Commission reviewed the petition for completeness, and pursuant to Section 2073 of the California Fish and Game Code (FGC), referred the petition to the Department of Fish and Game (Department) on August 7, 2000, for evaluation. The Department had a 90-day period to review the petition and make one of the two following findings:

- Based upon the information contained in the petition, there was sufficient evidence to indicate that the petition action may be warranted and the petition should be accepted and considered; or

- Based upon the information contained in the petition, there was not sufficient evidence to indicate that the petition action may be warranted, and the petition should not be accepted and considered.

On November 9, 2000, the Department requested a 30-day extension to complete the evaluation and recommendation. At the Commission meeting on December 8, 2000, in Eureka, the Department received an extension for consideration of the petition, which postponed the Department's presentation and recommendation, and the public comments at that time. They were rescheduled to be heard at the February 2, 2001, meeting in Sacramento.

On February 2, 2001, the Commission received the Department's evaluation report, recommendation, and public testimony. The Department found that the information in the petition was sufficient to indicate the action may be warranted and recommended the Commission accept the petition. Due to the lack of a quorum, no action was taken, and the matter was rescheduled until the next Commission meeting. The Notice of Receipt of petition was published February 23, 2001, in the California Regulatory Notice Register.

At the Commission meeting in Monterey on April 5, 2001, the Commission again received the Department evaluation report, recommendation, and public testimony, and the petition was accepted by the Commission. On April 27, 2001, the Commission published a Notice of Findings in the California Regulatory Notice Register declaring coho salmon a candidate species, thereby starting the candidacy period. A candidate species is defined as a native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant the Commission has formally noticed as being under review by the Department for addition to either the list of endangered species or the list of threatened species. The Commission also adopted a special order pursuant to FGC Section 2084, to provide for incidental take of coho salmon during the candidacy period.

Department Review

This report contains the results of the Department's review, and its recommendations to the Commission. It is based on the best scientific information available. It also contains the Department's recommendation about whether the petitioned action is warranted. Further, it identifies habitat the may be essential to the continued existence of the species and suggests prudent management activities and other restoration actions.

The Department contacted affected and interested parties, invited comment on the petition, and requested any additional scientific information that may be available, as required under FGC Section 2074.4. The Department produced a public notice (Appendix A1) and distributed it by mail on July 17, 2001, to as many affected and interested parties as was practicable. Appendix A2 contains a list of individuals, organizations, and agencies contacted. Newspapers that published the public notice during August 14-16, 2001, are shown in Appendix A3

A press release was issued by the Department on July 24, 2001 (Appendix A4). To attempt to obtain and review all available information on coho salmon, a letter was drafted and sent by mail on September 24, 2001, to scientific collecting permit holders (Appendix A5). The permit holders contacted (Appendix A6) were those who may have done work on coho salmon, or worked in the area covered by the status review. The information collected assisted greatly in the assessment of the status of coho salmon for this review.

A draft version of this document was provided to several qualified experts for Peer Review. The list of experts and their comments are shown in Appendices B1 and B2.

Previous Coho Salmon Listing Actions

State of California Listing Actions

On February 24, 1993, a petition was received by the Commission from Santa Cruz County Fish and Game Advisory Commission (County) requesting the listing of coho salmon on Waddell and Scott creeks under CESA. The Department recommended rejecting the petition, explaining that the two stocks were not reproductively isolated from the nearby streams, and, therefore, limiting the listing to just these two populations[1] was unwarranted.

On the August 5, 1993 meeting, the Commission requested that the County prepare a draft recovery plan to be submitted at the October 7, 1993, meeting thus postponing any action on the petition until that time.

At the October meeting, the Department stated conditional support for the County's draft recovery plan, but again recommended rejection of the petition for the reasons previously given, and because it would not improve the condition of coho south of San Francisco. The County officially withdrew the petition. They submitted a new, revised petition covering the coho salmon streams south of San Francisco Bay to the Commission on December 16, 1993. After

[1] The term "population" is defined for the purposes of this document on page 35.

review, the Department recommended to the Commission that the new petition be accepted. On April 7, 1994, the Commission designated the coho salmon south of San Francisco Bay a candidate species, starting the one-year review process by the Department. Based on this review, the Department recommended that coho salmon south of San Francisco Bay be listed as endangered. The commission accepted the recommendation and listed those coho salmon as endangered, effective December 31, 1995.

Federal Coho Salmon Listing Actions

Coho salmon in California, Oregon, Washington, and Idaho were petitioned for listing under the federal Endangered Species Act (ESA) by Oregon Trout, Pacific Rivers Council, and others in 1993. National Marine Fisheries Service (NMFS) identified six Evolutionarily Significant Units (ESU) of coho salmon in California, Oregon, and Washington. The ESUs in California are the Central California Coast Coho ESU (CCC Coho ESU) and the Southern Oregon/ Northern California Coasts Coho ESU (SONCC Coho ESU). The CCC Coho ESU extends from the San Lorenzo River in Santa Cruz county north to Punta Gorda in Humboldt county (Federal Register 1996). The SONCC Coho ESU begins at Punta Gorda and extends north into Oregon to Cape Blanco (Federal Register 1997). The CCC Coho ESU and SONCC Coho ESU were listed as threatened on December 2, 1996 and June 5 1997, respectively (Federal Register 1996, 1997).

The status of California coho salmon populations was recently reviewed and updated by NMFS Southwest Fisheries Science Center (NMFS 2001a). This status review update agrees with previous conclusions of the NMFS Biological Review Team: the CCC Coho ESU is presently in danger of extinction[2] and the condition of coho salmon is worse than indicated by previous reviews; and the California portion of the SONCC Coho ESU is likely to become endangered in the foreseeable future. It is important to note that the ESA defines an endangered species as any species "....which is in danger of extinction throughout all or a significant portion of its range....". Thus, the ESA listing decision for the CCC Coho ESU does not reflect the conclusions of the NMFS Biological Review Team or the Southwest Fisheries Science Center.

As a result of a recent court decision and petitions to delist several ESUs, NMFS is presently updating status reviews and revisiting listing determinations for all salmon and steelhead ESUs that have one or more hatchery populations included in the ESU. This includes both the CCC and SONCC Coho ESUs.

[2] Extinction can be used to describe loss of all living members of a species, or more localized losses of geographic units smaller than the entire species. Extinction is used in this document to describe losses at various subspecific levels such as local geographic groups, populations, watersheds, runs, ESUs (or portions of them), and/or across the species range in California. The Department has qualified the term extinction in the text in an effort to make clear which level is being discussed.

III. BIOLOGY

Species Characteristics

Coho salmon, as noted by Moyle (1976), Laufle et al. (1986), and Anderson (1995) are medium to large salmon, with spawning adults typically 40 to 70 cm (15.8 to 27.6 inches) fork length (FL) and weighing 3 to 6 kg (6.6 to 13.2 lbs). Coho salmon as large as 80 cm (31.5 inches) and 10 kg (22 lbs) have been caught in California. Identifying fin characteristics are 9 to12 major dorsal fin rays, 12 to17 anal fin rays, 13 to 16 pectoral fin rays, 9 to 11 pelvic fin rays (with an obvious axillary process at the fin base), a small fleshy adipose fin, and a slightly indented caudal fin. The scales are small and cycloid. The lateral line is complete and almost straight with 121 to 148 pored scales. Pyloric caeca number 45 to 83. There are 11 to15 branchiostegal rays on either side of the jaw. Gill rakers are rough and widely spaced, with 12 to16 on the lower limb (half) and 6 to 9 an the upper limb (half) of the first gill arch.

Spawning adults are generally dark and drab. The head and back are dark, dirty blue-green; the sides are a dull maroon to brown with a bright red lateral streak; and the belly is gray to black (Moyle 1976; Laufle et al. 1986; Sandercock 1991)). Females are paler than males, usually lacking the red streak. Characteristics of spawning males also include: hooked jaw, enlarged and more exposed teeth, slightly humped back and a more compressed head and body. The snout is less deformed than in other salmon species. Both sexes have small black spots on the back, dorsal fin, and upper lobe of the caudal fin. Except for the caudal and dorsal, the other fins lack spots. The gums of the lower jaw are grey, except the upper area at the base of the teeth, which is generally whitish.

Adult coho salmon in the ocean are steel-blue to slightly greenish on the back, silvery on the sides, and white on the belly. They have numerous small, irregular black spots on the back, upper sides above the lateral line, and base of the dorsal fin and upper lobe of the caudal fin. The adults have black mouths with white gums at the base of the teeth in the lower jaw; this is the most reliable physical feature that distinguishes them from chinook salmon (*O. tshawytscha*).

Juvenile coho salmon in inland waters are blue-green on the back, with silvery sides. The parr have 8 to 12 parr marks centered along the lateral line, which are more narrow than the pale interspace between them. The adipose fin is uniformly pigmented, or finely speckled giving it a grey or dusky color. The other fins lack spots and are usually orange tinted; however, the intensity of the orange tint varies greatly. The anal fin is pigmented between the rays, often producing a black and orange banding pattern. The anal fin is large, with the first few anterior rays elongated and white with black behind. The large eye and the characteristic sickle-shape of the anal and dorsal fins are characteristic of coho salmon juveniles that distinguishes them from juveniles of other Pacific salmon species.

Range

The coho salmon is one of seven species of Pacific salmon belonging to the genus *Oncorhynchus*, and one of two native salmon species regularly occurring in California. It occurs naturally in the north Pacific Ocean and tributary drainages. It ranges in freshwater drainages from Hokkaido, Japan and eastern Russian, around the Bering Sea and Aleutian Islands to mainland Alaska, and south along the North American coast to Monterey Bay, California (Figure 1).

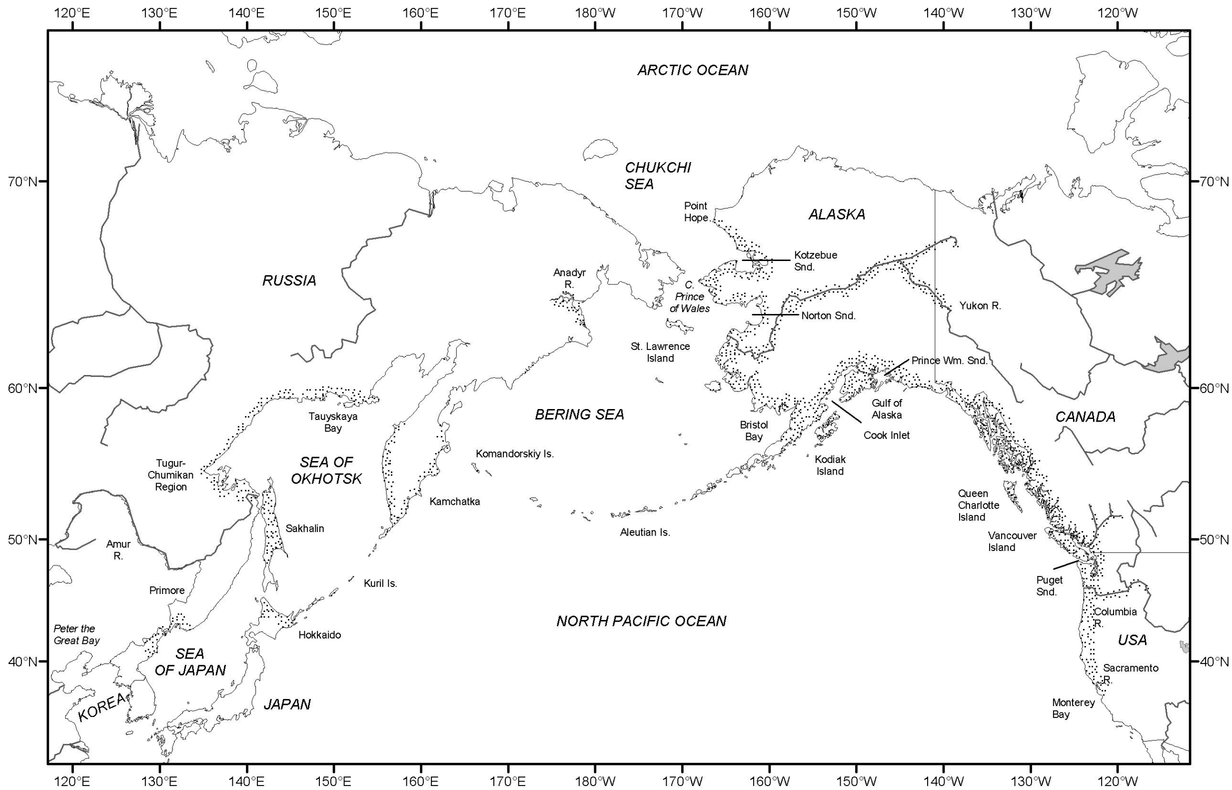


Figure 1. Native range of coho salmon (after Sandercock 1991).

Coho salmon historically ranged from the Oregon/California border (including the Winchuck and Illinois river drainages) south to the streams of the northern Monterey Bay (Snyder 1931; Fry 1973) including small tributaries to San Francisco Bay (Brown and Moyle 1991, Leidy and Becker 2001) (Figure 2). However, there is some evidence that they historically ranged as far south as the Pajaro River (Anderson 1995), the Big Sur River (Hassler et al. 1991), or even the Santa Ynez River (Lucoff 1980, as cited in National Council on Gene Resources 1982), although evidence of spawning populations south of the Pajaro River is anecdotal (Anderson 1995). Currently, the southernmost stream that contains coho salmon is Aptos Creek in Santa Cruz County (NMFS 2001a). Present distribution is shown in Figure 3.

Information on coho salmon in the San Joaquin and Sacramento rivers is sparse. Fry (1973) states that coho salmon did not occur in the Sacramento/San Joaquin river system prior to attempts to introduce them beginning in 1956. Hatchery fish returned in large numbers and spawned naturally, but were unable to maintain a natural run. Moyle (1976) notes that coho salmon in the Sacramento River are rare. It is likely that coho salmon historically observed in these streams were occasional strays (Hallock and Fry 1967; Hopkirk 1973). Intensive sampling efforts (trawling and beach seining) by the United States Fish and Wildlife Service (USFWS) in the Sacramento and San Joaquin rivers and estuary have recorded no coho salmon caught since the project began in 1976 (USFWS 2001 unpublished data). For these reasons, the Department does not consider the Sacramento/San Joaquin river system to be within the historical range of coho salmon.

III. BIOLOGY

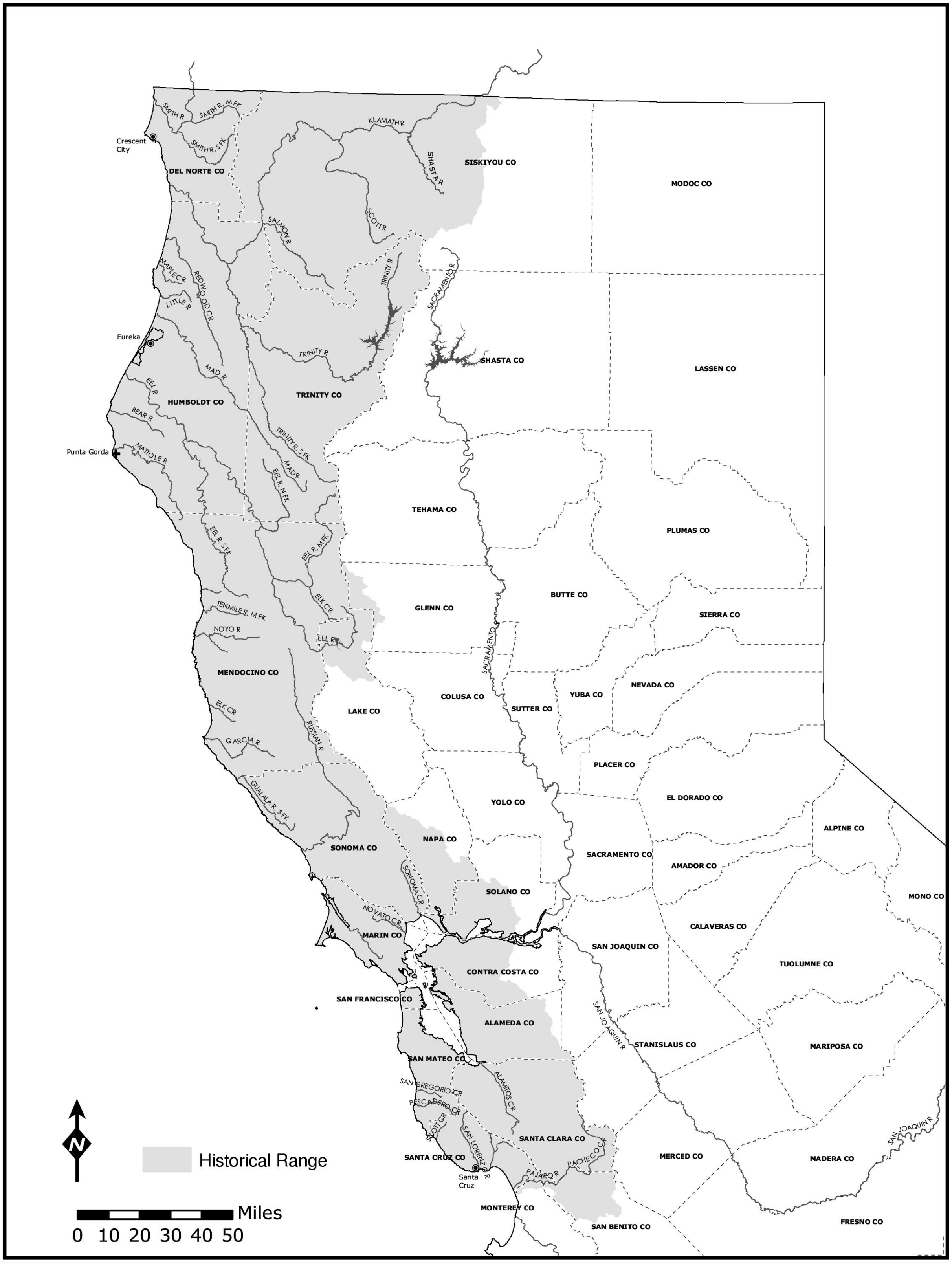


Figure 2. Historical distribution of coho salmon in California

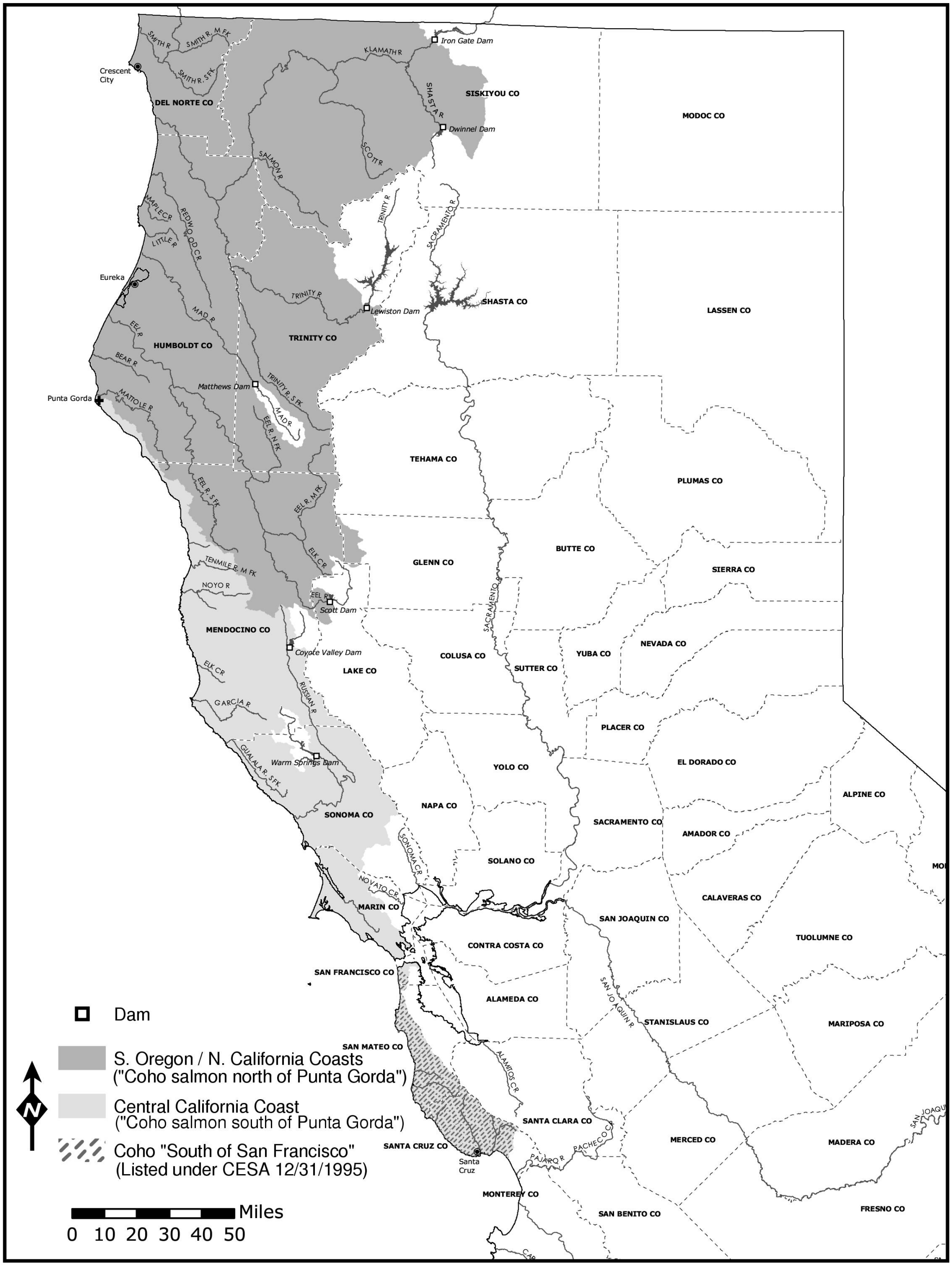


Figure 3. Present distribution of coho salmon in California. Shading depicts the general range of coho salmon. Coho salmon may not be present in all streams within the shaded area.

Taxonomy and Systematics

Coho salmon belong to the class Osteichthyes (bony fishes), of the order Salmoniformes (salmon-like fishes), and are a member of the family Salmonidae (salmon, trout, and char). Walbaum (1792) originally described coho salmon on the basis of type specimens from rivers and lakes in Kamchatka, Russia. Table 1 shows the nomenclature for the species. The currently valid scientific name derives from a combination of Greek roots, o*nkos* (hooked) and *rynchos* (nose), and *kisutch*, a colloquial name for the species in Kamchatka and Alaska (Hart 1973). The current English common name, coho, may have been used as early as 1878, when it appears as *co-hue*, a possible corruption of the similar Native American dialect names *kwahwult* (Chilliwack and Musqueam) and *kuchuks* (Sooke and Saanich)(Hart 1973, based on personal communication with Ricker).

Coho salmon are also known locally by the common names silver salmon, sea trout, saumon coho, and blueback (Scott and Crossman 1973). They are most commonly known in California as coho or silver salmon.

The systematic relationships of the five North American salmon in the genus *Oncorhynchus* have been described on the basis of morphology (Stearley 1992), allozyme variation (Utter et al. 1973), mitochondrial DNA (Thomas et al. 1986; Thomas and Beckenbach 1989; Shedlock et al. 1992; Domanico and Phillips 1995; Domanico et al. 1997), short interspersed repetitive elements (Murata et al. 1993, 1996), ribosomal DNA restriction fragment length polymorphisms (Phillips et al. 1992), nucleotide sequence of the D intron of growth hormone 2 (McKay et al. 1996), and nuclear DNA sequence data (Domanico et al. 1997). The general consensus of theses studies is that the Asian masu salmon (*O. masou*) is intermediate between rainbow trout (*O. mykiss*) and other Pacific salmon, and that the remaining *Oncorhynchus* species are arranged in two groups: one containing pink (*O. gorbuscha*) , sockeye (*O. nerka*), and chum (*O. keta*) salmon, and the other containing chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon. Although different studies support different relationships among the group containing pink, sockeye, and chum salmon, the group containing chinook and coho salmon is consistent. Based on these studies it is fair to state that coho salmon is most closely related to chinook salmon, and that the other three salmon species are more distantly related to them than they are to one another. Figure 4 shows a representative tree depicting the relationship among the North American *Oncorhynchus* species.

Table 1. Nomenclature for coho salmon (after Scott and Crossman 1973).

Scientific name	**Authority**
Salmo kisutch	Walbaum 1792: 70 (type locality rivers and lakes of Kamchatka, Russia)
Salmo tsuppitch	Richardson 1836: 224
Oncorhynchus kisutch (Walbaum)	Jordan and Evermann 1896-1900: 480

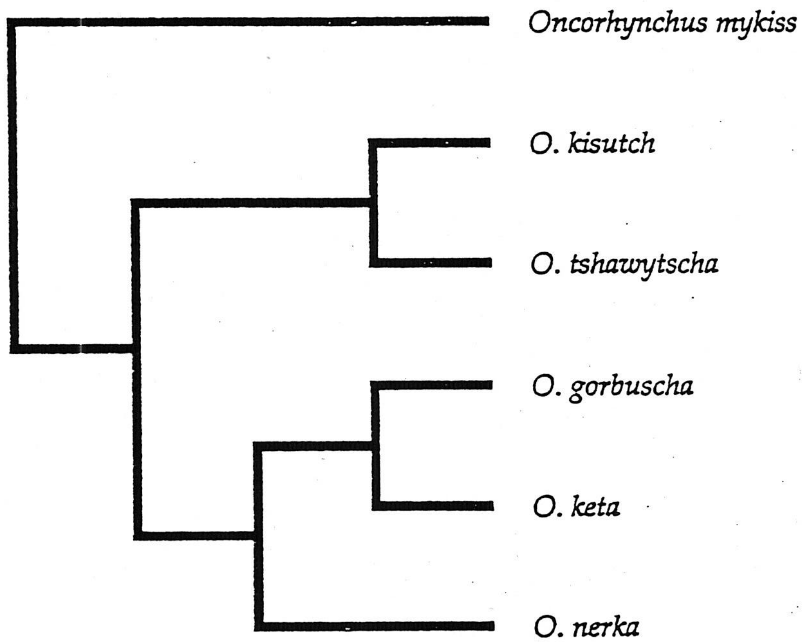


Figure 4. Bootstrapped parsimony tree showing the relationship of the six North American *Oncorhynchus* species that represent Pacific salmon using combined nuclear and mitochondrial DNA data. (After Domanico et al. 1997, with modification)

Genetics

Coho salmon population genetic structure has been studied using allozyme[3], transferrin[4], and DNA data since 1982 (Weitkamp et al. 1995). Most of these studies largely concern areas outside California. For example, Olin (1984) and Hjort and Schreck (1982) focus on more northerly populations and only include one or a few samples from California for comparison. Only a few published studies concentrate exclusively on relationships within and among California populations. In addition Weitkamp et al. (1995) caution that studies prior to 1988 may be limited by their inclusion of less than half of the ten most polymorphic allozyme loci[5] for coho salmon (Milner 1993). Also, studies including data from the transferrin locus are likely biased by selection acting on the transferrin gene (Weitkamp et al. 1995, Ford et al. 1999). A few of the other studies mentioned here (Banks et al. 1999, Hedgecock 2001) are not peer reviewed. Sample locations for genetic studies reviewed in this section are shown in Table 2.

[3] Alternate forms of an enzyme produced by different alleles and often detectable by electrophoresis.
[4] A polymorphic iron-binding protein found in body fluids that is important in iron metabolism and resistance to bacterial infection.
[5] Locus (pl. loci): the location of a gene on a chromosome. *Polymorphic loci* are those that have more than one allele.

Table 2. Sample locations for genetics studies reviewed in the text.

Literature Source	Sample Locations
Bartley et al. 1992	**California**: Scott Creek, Waddell Creek, Lagunitas Creek, Tanner Creek/Salmon Creek, Willow Creek/Russian River, Flynn Creek/Navarro River, John Smith Creek/Navarro River, Albion River, Little River, Twolog Creek/Big River, Russian Gulch, Caspar Creek, Hare Creek, Little North Fork Noyo River, Kass Creek/Noyo River, Pudding Creek, Little North Fork Ten Mile River, Cotteneva Creek, Huckleberry Creek/South Fork Eel River, Butler Creek/South Fork Eel River, Redwood Creek/South Fork Eel River, Elk River, Prairie Creek, Rush Creek/Trinity River, Trinity River Hatchery, Deadwood Creek/Trinity River, West Branch Mill Creek/Smith River
Hjort and Schreck 1982	**Washington**: Quilcene River, Quinault River **Oregon**: Cascade Hatchery/Columbia River, Beaver Creek, Cowlitz Hatchery stock (Cascade Hatchery), Sandy River Hatchery/Columbia River, North Nehalem River Hatchery, Trask River Hatchery, Salmon River Hatchery, Fall Creek Hatchery/Alsea River, Umpqua Hatchery stock/Smith River (Cole Rivers Hatchery), Rogue River **California:** Iron Gate Hatchery/Klamath River, Trinity River Hatchery, Mad River Hatchery
Olin 1984	Oregon Coast (23 samples) and Iron Gate Hatchery, California (1 sample)
Solazzi 1986	Data source was combination of the same data reported in Olin 1984 and Bartley et al. 1992.
Weitkamp et al. 1995	**Alaska:** Cabin, Kartam, Campbell, Goodnews **British Columbia:** Chilliwack, Coldwater, Cowichan, Big Qualicum, Roberson, Capilano, Squamish **Washington**: Lewis and Clark, Grays, Big Creek, Clatskanie, Cowlitz, Scappoose, Lewis, Clackamas, Eagle, Sandy, Hardy, Bonneville, Willard, Naselle, Nemah, Willapa, Chehalis, Humptulips, Queets, Quillayute, Soleduck, Hoko, Hood Canal, Big Beef, Green, Snohomish, Stillaguamish, Skagit, Nooksack **Oregon**: Rogue, Elk, Sixes, New, Coquille, Coos, Eel, Tenmile, Umpqua, Smith, Tahkenitch, Alsea, Beaver, Siletz, Salmon, Trask, Nehalem **California**: Scott Creek, Lagunitas Creek, Tanner Creek/Salmon Creek, Russian River/Willow Creek, Navarro River/Flynn Creek/John Smith Creek, Albion River, Little River, Russian Gulch, Caspar Creek, Hare Creek, Pudding Creek, Cottoneva Creek, Huckleberry Creek/South Fork Eel River, Butler Creek/South Fork Eel River, Redwood Creek/South Fork Eel River, Elk River, Deadwood Creek/Trinity River, Trinity River Hatchery, Iron Gate Hatchery/Klamath River, West Branch Mill Creek/Smith River
Banks et al. 1999	**California**: Warm Springs Hatchery/Russian River, Green Valley Creek/Russian River, Olema Creek, Noyo Egg Taking Station/Noyo River, Hare Creek
Hedgecock 2001	**California**: Eel River, Noyo River, Russian River, Lagunitas Creek, Olema Creek, Scott Creek

In the most comprehensive study of California coho salmon population genetics, Bartley et al. (1992) studied variation in 22 allozyme loci in 27 populations. The authors stated that the study could be improved by increasing sample sizes; average sample size in this study was 34 fish. The study reported low levels of variability and little evidence of geographic pattern in the observed variation. There were significant allele frequency[6] differences among samples and within six regional groupings. Average gene flow between populations in this study was estimated from genetics data to be 1.3 fish per generation.

Hjort and Schreck (1982) looked at population structure using a method based on frequencies for one allozyme locus and the transferrin locus. They also included life history and morphological characteristics in their study. Of the 35 sample locations examined in this study, only three were from California. Most samples were from Oregon (23) with some from Washington. Cluster analysis led to identification of three major groupings: 1) North Coast Oregon hatcheries, 2) Columbia, Rogue and Klamath rivers, and 3) Coastal Oregon samples. Several populations were outliers, including one sample from the Mad River Hatchery in California. These outlier populations were distinct from one another and other groups.

Olin (1984) studied population structure in Oregon coho salmon populations. This study also included one sample from the Iron Gate Hatchery (Klamath River) in California. Variation was observed at 31 of the 53 loci examined. The study found a low level of genetic variability. In this study, the Klamath River sample clustered with those from the Rogue River in a southerly cluster that was most genetically distinct from more northerly groupings, two of which overlapped geographically and were similar genetically. The similarity of the Iron Gate Hatchery sample and Rogue River groups was attributed by the author to geographic proximity, straying, and unrecorded egg transfers.

Solazzi (1986) inspected a dendrogram[7] based on allozyme and transferrin data contained in Olin (1984) and Bartley et al. (1992). The dendrogram included eight samples from the Columbia River, 28 from the Oregon coast, and 16 from the California coast. Three major clusters were discernable: 1) Oregon coast north of the Rogue River, 2) Columbia, Rogue and Klamath rivers plus two samples from two rivers north of Cape Mendocino, and 3) California samples from south of Cape Mendocino. Eight other samples from the Oregon coast and California were outliers to the major clusters.

NMFS (Weitkamp et al. 1995) developed new data and reanalyzed combined data in a review of the status of coho salmon pursuant to ESA listing. Allozyme data were collected from coho salmon populations across their North American range. However, the new data study focused on populations from Oregon, Washington, British Columbia, and Alaska. Only one new sample from California (Trinity River Hatchery, 1982, N = 98) was included in the new data analysis. Eighty-seven allozyme loci were examined. In a dendrogram of genetic distance[8] measures (Cavalli-Sforza and Edwards 1967), the California sample clustered with samples from the Rogue, Elk, and Umpqua rivers in Oregon.

Because the new data set only contained a single California sample, NMFS (Weitkamp et al. 1995) also conducted a reanalysis of combined data for Oregon and California. Data from

[6] Allele: a variant form of a gene. *Allele frequency* is the proportion of all of the alleles in a population that is of one type.
[7] A branching diagram that provides a way of visualizing similarities among different groups or samples.
[8] A quantitative measure of genetic differences between a pair of samples.

Olin (1984) and Bartley et al. (1992) were combined with the new data for reanalysis. Because the data are not directly comparable, genetic distance calculations (Cavalli-Sforza and Edwards 1967) were made using the maximum number of alleles in common between each pair of populations being compared. Two major geographic clusters, separated by a relatively large genetic distance, were identified: 1) a northern, mostly large rivers cluster containing samples from the Elk River, Oregon, to just north of Cape Mendocino, including the Eel River; and 2) a more southerly, mostly small rivers group, containing nine samples from Fort Bragg to Lagunitas Creek, and three samples from north of Cape Mendocino. Samples from Scott, Cotteneva, and Pudding creeks (Santa Cruz, Mendocino, and Mendocino counties respectively) were outliers to both major clusters. NMFS found considerable genetic diversity within each of the major groupings.

Data summarized in the NMFS status review of coho salmon (Weitkamp et al. 1995) were used to document areas of "genetic discontinuity/transition" for delineation of ESU boundaries. These discontinuities represent areas of restricted gene flow that likely results in some level of reproductive isolation. In California, this area of discontinuity occurs around Punta Gorda, i.e., populations north and south of Punta Gorda likely experience some level of gene flow restriction that is greater than that experienced within each geographic region. NMFS identified two ESUs that encompass California coho salmon populations: 1) the CCC Coho ESU from Punta Gorda south to the San Lorenzo River (the southernmost natural population of coho salmon in California); and 2) the SONCC Coho ESU extending from Punta Gorda north to Cape Blanco, Oregon. Populations in the transition region around Punta Gorda are not easily placed in either north-south geographic region. NMFS identified four other more northerly ESUs that extend from Oregon to Alaska.

Recent data in unpublished, non peer-reviewed reports include Banks et al. 1999, which reports on limited microsatellite data from the California coast. The authors stress that these results are preliminary, based on small samples containing a large proportion of juveniles from a small number of sampling events, with only a few loci included in the analysis. Samples included hatchery origin adults from Warm Springs Hatchery (Russian River, 1992 and 1993), juveniles from Green Valley Creek (Russian River, 1997 and 1998), juveniles from Olema Creek (1997), adults from Noyo Egg Taking Station (1994), and juveniles from Hare Creek (1997). Tests for homogeneity (i.e., uniformity) among populations based on data from five microsatellite loci indicated substantial genetic heterogeneity such that only a few of the samples could be pooled for analysis. The authors stated that this heterogeneity suggests that genetic drift might strongly influence these populations. A neighbor-joining phenogram of Nei's genetic distance (Nei 1972) constructed using data from two microsatellite loci yielded the following tentative relationships:

- Warm Springs Hatchery 1996 and 1997 (Brood year 1993) and Olema Creek samples clustered together;
- samples from Noyo Egg Taking Station and Hare Creek appear to be closely related;
- samples from Green Valley Creek collected in 1997 were combined with the 1995-1996 (Brood year 1992) Warm Springs Hatchery sample, suggesting that this year class is strongly influenced by the hatchery stock; and
- separate clustering of the 1998 Green Valley Creek sample suggests that they may represent remnants of a "more wild stock".

Hedgecock (2001) reported on analysis of a limited number of samples from seven populations of California coho salmon (Eel, and Russian rivers, Noyo Egg Taking Station, Lagunitas, Olema, and Scott creeks). Several of these populations, including some consisting of adults, failed to meet random mating expectations. Although data are limited and conclusions from them should be viewed with caution, one possible explanation is that some of the coho salmon populations in this analysis are already experiencing the effects of inbreeding (Hedgecock 2001). Genetic distances among sites are in general agreement with currently defined ESU structure (Weitkamp et al. 1995). Samples from sites within the CCC Coho ESU North of San Francisco form a reasonable cluster, joined next by Scott Creek, and finally by the Eel River.

No recent comprehensive study of coho salmon population genetics covering the range of coho salmon in California is available. Some studies (Bartley et al. 1992, Olin 1984) found a generally low level of diversity in California coho salmon. The reason for this low diversity is not clear. It may be a result of current or historical reduction in population size of all or a large portion of the existing natural spawning populations, historical naturally low population sizes in all coho salmon populations, or some level of homogenization of stocks. Also, some of the existing studies may not have adequately captured the true range of genetic variation in coho salmon because of limited geographic context, availability of variable loci, small sample size coupled with low levels of variation in a large number of loci examined, and complications due to the effects of selection in transferrin studies (Weitkamp et al. 1995, Ford et al. 1999). Weitkamp et al. (1995) and preliminary data in Banks et al. (1999) found substantial genetic diversity in the samples that they analyzed. All of the studies that attempted it were able to discriminate groups of coho salmon. These relatively consistent patterns are summarized in the NMFS ESU delineations.

Historical stock transfers and outplanting may have obscured geographic patterns of genetic variation in California coho salmon (see Chapter VI, *Hatcheries* and Chapter VII, *Hatchery Operations*). Although the relationship of genetic structure to geography is weak, there is a fairly strong separation between clusters of coho salmon populations north and south of Punta Gorda that also correspond to different ecological features in the two areas. Populations south of San Francisco may be separable from other California stocks. However, extremely small stock sizes in this area and hatchery influence greatly complicate the analysis. More data are needed to properly evaluate this relationship.

Preliminary data suggest that inbreeding may already be occurring in the Russian River coho salmon populations. This is troubling because of the known deleterious effects of inbreeding on production and growth and their implications for recovery potential (see Chapter VI, *Hatcheries* and *Genetic Diversity*).

The Evolutionarily Significant Unit Concept As Applied to Endangered Species Act Pacific Salmon Listings

Under the federal ESA, the definition of species includes “any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature”. In order to improve consistency, NMFS developed the ESU concept. In the document describing this concept, Waples (1991a) states, “A population (or group of populations) will be considered distinct (and hence a ‘species’) for purposes of the ESA if it represents an ESU of the biological species.” A population must meet two criteria in order to be considered an ESU: 1) it must be reproductively isolated from other conspecific population units, and 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991a).

Genetic analyses can be especially useful for evaluating ESU criteria. Since the relationship between genetics and phenotypic and/or life history characters is generally unknown (Myers et al. 1998), NMFS often relies heavily on direct genetics data for evidence of reproductive isolation. However, other data, within their limitations, can and should be used to evaluate the reproductive isolation criterion when they are available.

Two ESUs of coho salmon are found in California; one is entirely within California's borders (Figure 5). They are the SONCC Coho ESU, from Punta Gorda, California, north across the state border to Cape Blanco, Oregon, and the CCC Coho ESU, from Punta Gorda, California, south to the San Lorenzo River, California. Both are listed as threatened under the ESA. Only naturally spawning populations within these ESUs were included in the federal listings. The Mad River Hatchery population was deemed not a part of the ESU. The relationship of the Iron Gate Hatchery stock with the rest of the SONCC Coho ESU was judged "uncertain", and was therefore not included as part of the ESU. Four other populations deemed "hatchery populations" (Mattole River, Eel River, Trinity River, and Rowdy Creek) were specifically included as part of the ESU, but none were deemed essential to recovery, and were therefore not included in the listing. Any hatchery population that is included as part of an ESU may have a role in its recovery under certain conditions. (Current hatchery production is described in Chapter VII "Hatchery Operations")

ESUs reflect the best current understanding of the likely boundaries of reproductively isolated salmon populations over a broad geographic area. Understanding these boundaries is especially important for NMFS, which is charged with evaluating and protecting salmon species with broad ranges extending across state borders. Similar populations can be grouped for efficient protection of bio- and genetic diversity. The Department, in contrast, has responsibility for evaluation and protection of California stocks only. Therefore, the Department typically evaluates and manages salmon on a watershed basis, regardless of the biological affinities of California stocks to stocks across our borders. The Department recognizes the importance of genetic structure and biodiversity among California stocks in evaluating and protecting coho salmon. For example, the genetic affinities among nearby coho salmon populations will be used as part of the information in choosing appropriate broodstock to assist in the recovery of Russian River coho salmon. The Department's status review also responds directly to the geographic range and stocks specified in the petition to list. In the present case, coho salmon north of San Francisco are specified in the listing petition. Therefore, the status review focuses on information for all populations, including hatchery populations in that area.

The coho salmon ESU delineations described in Weitkamp, et al. (1995) represent important information about likely relationships among, and reproductive isolation of, coho salmon populations in California waters and the extension of affinities across the Oregon border. This information has important implications for interstate coordination of management, ocean harvest management, recovery planning, and recovery-action implementation. This approach is consistent with previous listings, the federal approach to species' evaluation, and the generally accepted biological criterion that a species is "a group of interbreeding organisms that is reproductively isolated from other such groups" (Mayr 1966). The Department agrees with NMFS that the coho salmon ESU designations are valid and justifiable constructs, both from a biological and management perspective, and that they represent distinct population segments of coho salmon.

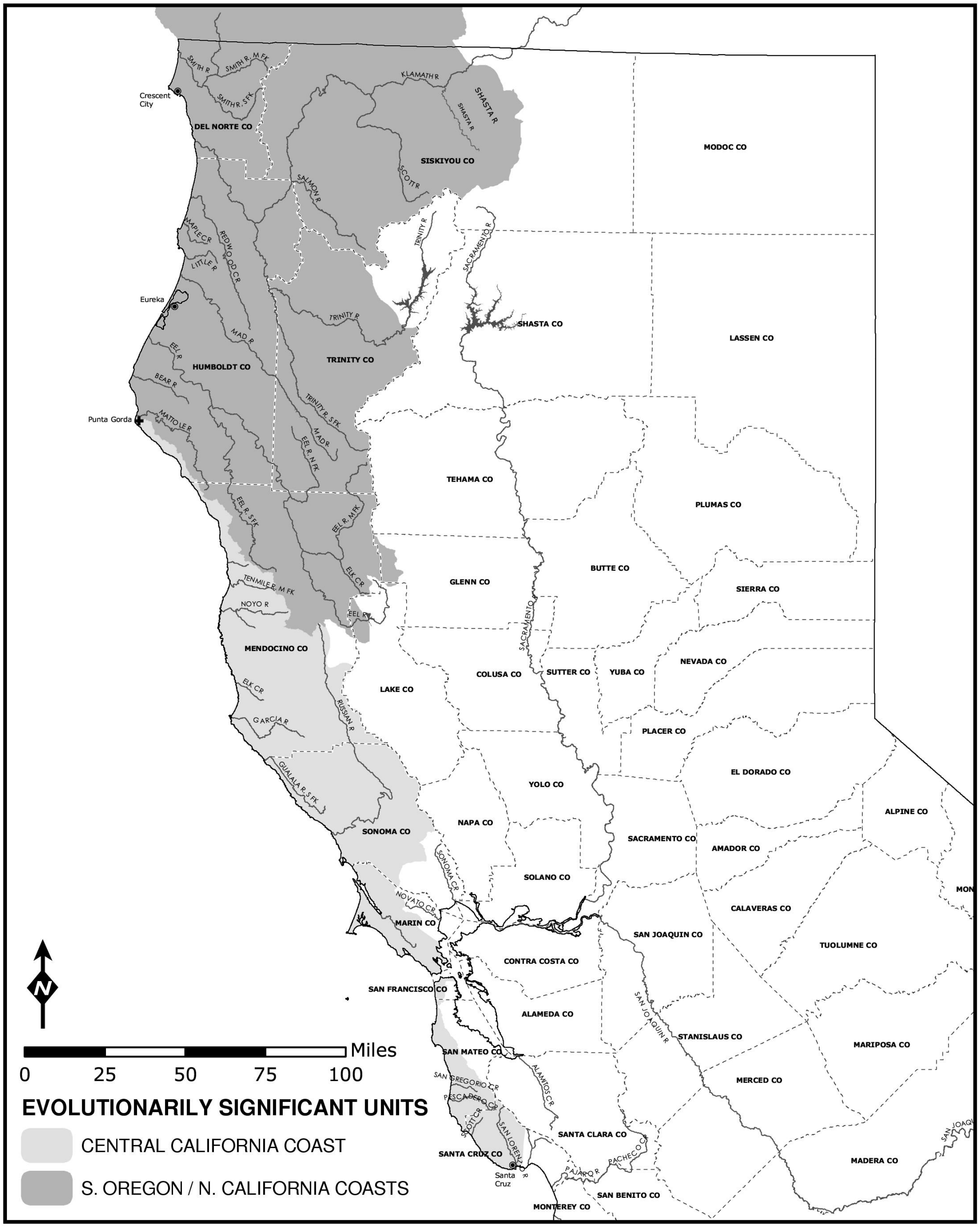


Figure 5. Coho salmon Evolutionarily Significant Units (ESU) in California.

Life History and Unique Characteristics

Adult coho salmon in general enter fresh water to spawn from September through January (Figure 6). In the short coastal streams of California, migration usually begins mid-November through mid-January (Baker and Reynolds 1986). Coho salmon move upstream usually after heavy fall or winter rains have opened the sand bars that form at the mouths of many California coastal streams, but the fish can enter the larger rivers earlier. On the Klamath River, coho salmon begin entering in early- to mid-September and reach a peak in late September to early October. On the Eel River, coho salmon return four to six weeks later than on the Klamath River (Baker and Reynolds 1986). Arrival in the upper reaches of these streams generally peaks in November and December. Neave (1943), Brett and MacKinnon (1954) and Ellis (1962) indicate that coho salmon tend to move upstream primarily during daylight hours. They also state that diurnal timing varied by stream and/or flow, but the majority moved between sunrise and sunset.

Generally, coho salmon spawn in smaller streams than do chinook salmon. In California, spawning mainly occurs from November to January although it can extend into February or March if drought conditions are present (Shapovalov and Taft 1954) (Figure 6). In the Klamath and Eel rivers, spawning occurs November to December (USFWS 1979). Shapovalov and Taft (1954) noted that the females choose the spawning sites usually near the head of a riffle, just below a pool, where the water changes from a laminar to a turbulent flow and there is a medium to small gravel substrate. The female digs a nest (redd) by turning partly on her side and using powerful rapid movements of the tail to dislodge the gravels, which are transported a short distance downstream by the current. Repeating this action creates an oval to round depression at least as deep and long as the fish. Eggs and sperm (milt) are released into the redd, where, due to the hydrodynamics of the redd, they tend to remain until they are buried. Approximately 100 or more eggs are deposited in each redd. The fertilized eggs are buried by the female digging another redd just upstream. The flow characteristics of the redd location usually ensures good aeration of eggs and embryos, and flushing of waste products.

There is a positive correlation between fecundity of female coho salmon and body size, and there is a definite tendency for fecundity to increase from California to Alaska (Sandercock 1991). Average coho salmon fecundities, as determined by various researchers working on British Columbia, Washington, and Oregon streams, range from 1,983 to 2,699 and average 2,394 eggs per female Sandercock (1991). Scott and Crossman (1973) found that fecundity of coho salmon in Washington streams ranged from 1,440 to 5,700 eggs for females that were 44 to 72 cm in length.

In California, eggs incubate in the gravels from November through April (Figure 6). The incubation period is inversely related to water temperature, but the embryos usually hatch after eight to twelve weeks. California coho salmon eggs hatch in about 48 days at 48 ^{o}F, and 38 days at 51.3 ^{o}F (Shapovalov and Taft 1954). After hatching, the alevins (hatchlings) are translucent in color (Shapovalov and Taft 1954, Laufle et al. 1986, Sandercock 1991). This is the coho salmon’s most vulnerable life stage when they are susceptible to siltation, freezing, gravel scouring and shifting, desiccation, and predators (Sandercock 1991, Knutson and Naef 1997, PFMC 1999). They remain in the interstices of the gravel for two to ten weeks until their yolk sac has absorbed (becoming pre-emergent fry), at which time their color changes to that more characteristic of fry (Shapovalov and Taft 1954, Laufle et al. 1986, Sandercock 1991). These color characteristics are silver to golden with large vertically oval parr marks along the lateral line that are narrower than the spaces between them.

The fry emerge from the gravel between March and July, with peak emergence occurring from March to May, depending on when the eggs were fertilized and the water temperature during development (Shapovalov and Taft 1954) (Figure 6). The fry seek out shallow water, usually moving to the stream margins, where they form schools. As the fish feed heavily and grow, the schools generally break up and the juveniles (parr) set up territories. As the parr continue to grow and expand their territories, they move progressively into deeper water, until July and August when they are in the deepest pools (CDFG 1994a). This is the period of maximum water temperatures, when growth slows (Shapovalov and Taft 1954). Food consumption and growth rate decrease during the months of highest flows and coldest temperatures (usually December to February). By March, following the resumption of peak flows, they again begin to feed heavily and grow rapidly.

Rearing areas generally used by juvenile coho salmon are low gradient coastal streams, wetlands, lakes, sloughs, side channels, estuaries, low gradient tributaries to large rivers, beaver ponds and large slackwaters (PFMC 1999). The more productive juvenile habitats are found in smaller streams with low-gradient alluvial channels containing abundant pools formed by large woody debris (LWD). Adequate winter rearing habitat is important to successful completion of coho salmon life history.

After one year in fresh water, the smolts begin migrating downstream to the ocean in late-March or early April. In some years emigration can begin prior to March (CDFG unpubl. data) and can persist into July in some years (Shapovalov and Taft 1954, Sandercock 1991). Weitkamp et al. (1995) indicates that peak downstream migration in California generally occurs from April to late May/early June (Figure 6). Factors that affect the onset of emigration include the size of the fish, flow conditions, water temperature, dissolved oxygen (DO) levels, day length, the availability of food. In Prairie Creek, Bell (2001) indicated there is a small percentage of coho salmon that remains more than one year before going to the ocean. Low stream productivity, due to low nutrient levels and or cold water temperatures, can contribute to slow growth, potentially causing coho salmon to reside for more than one year in fresh water (PFMC 1999). Though there may be other factors that contribute to a freshwater residency of longer than one year, Bell (2001) suggests that these fish are spawned late and are too small at time of smolting.

The amount of time coho salmon spend in estuarine environments is variable, though PFMC (1999) indicated the time spent is less in the southern portion of their range. Upon ocean entry the immature salmon remain in inshore waters, collecting in schools as they move north along the continental shelf (Shapovalov and Taft 1954; Anderson 1995). Most remain in the ocean for two years, however, some return to spawn after the first year, and these are referred to as grilse or jacks (Laufle et al. 1986). Data on where the California coho salmon move to in the ocean are sparse, but it is believed they scatter and join schools of coho salmon from Oregon and possibly Washington (Anderson 1995).

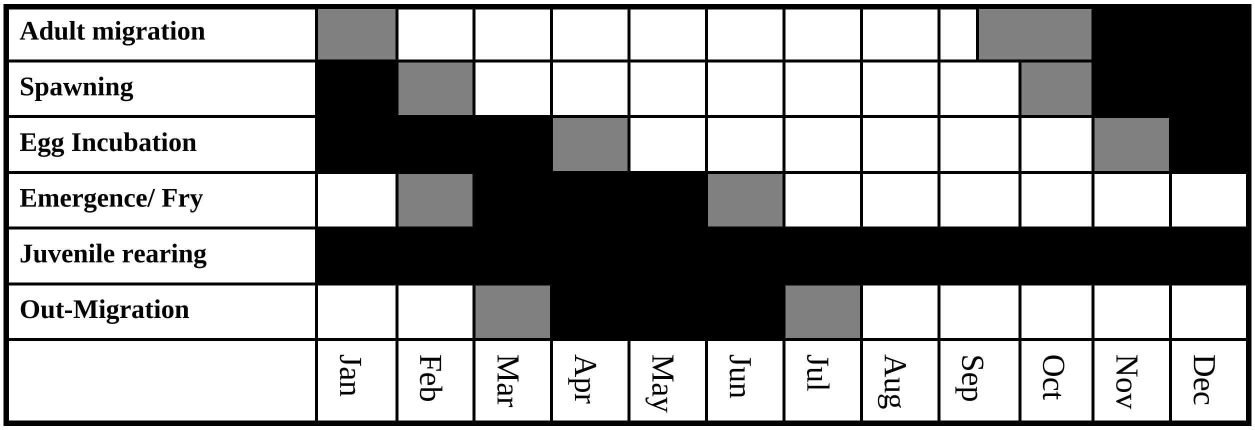


Figure 6. Generalized life stage periodicity of coho salmon in California Coastal watersheds. Gray shading represents months when the life stage is present, black shading indicates months of peak occurrence.

IV. HABITAT NECESSARY FOR SURVIVAL

Adults

Migration

Coho salmon usually immigrate during late summer and fall and their behavior may have evolved in response to particular flow conditions. For example, obstructions that may be passable under higher discharges may be insurmountable during low flows. Conversely, early-running stocks are thought to have developed because those coho salmon could surmount obstacles during low or moderate flows but not during high flows. If flow conditions in a stream are unsuitable, the fish will often mill about the vicinity of the stream mouth, sometimes waiting weeks or even, in the case of early-run fish, months for conditions to change (Sandercock 1991). Although substantially greater depth may be needed to negotiate barriers, preferred average depth to allow passage of coho salmon is approximately 7.1 in. (Bjorn and Reiser 1991).

Reiser and Bjornn (1979) indicate that migration normally occurs when water temperature is in the 45^0 to 61^0 F range. Excessively high temperature may result in delays in migration (Monan et al, 1975). Additionally, excessively high temperature during migration may cause outbreaks of disease (Spence et al. 1996) and may reduce the viability of ova (Leitritz and Lewis 1980).

The high energy expenditures of sustained upstream swimming by salmonids require adequate concentrations of DO (Davis et al. 1963). Supersaturation of dissolved gases (especially nitrogen) has been found to cause gas bubble disease in migrating salmonids (Ebel and Raymond 1976).

Reid (1998) found that high turbidity affects all life stages of coho salmon. In the case of adults, high concentrations of suspended sediment may delay or divert spawning runs (Mortensen et al. 1976). As an example of a response to a catastrophic event, coho salmon strayed from the highly impacted Toutle River to nearby streams for the first two years following the eruption of Mount St. Helens, Washington (Quinn and Fresh 1984). Salmonids were found to hold rather than migrate in a stream where the suspended sediment load reached 4,000 mg/L (Bell 1986).

Migrating coho salmon require deep and frequent pools for resting and to escape from shallow riffles where they are susceptible to predation. Deep pools are also necessary for fish to attain swimming speed necessary to leap over obstacles. Pool depth needs to be one-and-one-quarter times the height of the jump for adult fish to attain the necessary velocity for leaping (Flosi et al. 1998)

LWD and other natural structures such as large boulders provide hydraulic complexity and pool habitat. LWD also facilitates temperature stratification and the development of thermal refugia by isolating pockets of cold water (Bilby 1984; Nielsen et al. 1994). Riparian vegetation and undercut banks provide cover from terrestrial predators in shallow reaches.

Spawning

Coho salmon spawn mostly in small streams where the flow is 2.9 - 3.4 cfs and the stream depth ranges between 3.94 and 13.78 inches, depending on the velocity (Gribanov 1948;

Briggs 1953; Thompson 1972; Bovee 1978; Li et al. 1979). On the spawning grounds, they seek out sites of groundwater seepage and favor areas where the stream velocity is 0.98 - 1.8 ft/s. They also prefer areas of upwelling. Upwelling increases circulation of water through redds, which helps eliminate wastes and prevents sediments from filling in the interstices of the spawning gravel. The female generally selects a redd site at the tail-out of a pool or head of a riffle area where there is good circulation of oxygenated water through the gravel.

About 85% of redds occur in areas where the substrate is comprised of gravel of 15cm diameter or smaller. In situations where there is mud or fine sand in the nest site, it is removed during the digging process. However, there must be sufficient appropriate-sized gravel and minimal fine sediments to ensure adequate intersticial space for egg survival. The depth at which coho salmon deposit their eggs within the substrate is critical to incubation success. Eggs deposited within a zone of scour and fill can wash downstream. Bedload and bank stability, aided by LWD and upslope integrity, can minimize that risk. A pair of spawning coho salmon requires about 125.9 ft^2 for redd and inter-redd space. LWD and other structures such as large boulders provide streambank support, which over time helps to meter out sediment resulting from bank failure, thus decreasing large sediment input to redds. LWD also diversifies flows, reducing stream energy directed towards redds (Naiman et al. 1992). Pockets of relatively stable gravels help protect redds from the scouring effects of high flows.

Juveniles

Eggs and Larvae Incubation

Low winter flows can result in dessication of redds or may expose eggs to freezing temperatures. High water flows can disrupt and mobilize redd gravel, resulting in eggs being dislodged, swept downstream, and lost. Winter storms often cause excessive siltation that can smother eggs and inhibit intergravel movement of alevins. The associated silt load of these storms can reduce water circulation in the gravel to the point where low oxygen levels become critical or lethal.

According to Bjornn and Reiser (1991), the optimum temperature for coho salmon egg incubation has been found to be between 40 to 55 ^{o}F. Coho salmon embryos sustained 50% mortality at temperatures above 56.3 ^{o}F (Beacham and Murray 1990). Because of the tight coupling of temperature and developmental processes, changes in thermal regime, even when well-within the physiological tolerable range for the species, can have significant effects on development time (and hence emergence timing), as well as on the size of emerging fry.

A high proportion of fines in the gravel effectively reduces the DO levels and results in smaller emergent fry. Embryos and alevins need high levels of oxygen to survive (Shirazi and Seim 1981), and Phillips and Campbell (1961) suggest that DO levels must average greater than 8.0 mg/L for embryos and alevins to survive well. Eggs require gravels that have low concentrations of fine sediments and organic material for successful incubation. Bedload or suspended materials deposited on spawning redds may clog intersticial space and diminish intragravel flows, thus suffocating the eggs. Excessive sediment deposition may also act as a barrier to fry emergence (Cooper 1959). McHenry et al. (1994) found that when sediment particles smaller than 0.85mm made up more than 13% of the total sediment, it resulted in intragravel mortality for coho salmon embryos because of oxygen stress. Cederholm et al. (1981) found that in the Clearwater River in Washington, the survival of salmonid eggs to emergence was inversely correlated with percent fines, when the proportion of fines exceeded the natural level of 10 percent. Tagart (1984) found that if sediment composition included a high concentration (up to 50%) of fine sediment and sand (<0.85mm), survival was lower.

Shade provided by tall and/or mature vegetation is an important temperature regulator. LWD and other structures such as large boulders provide streambank support which, over time, help to meter out sediment resulting from bank failure, thus decreasing large sediment input to gravels.

Fry Emergence

Recently emerged coho salmon fry prefer shallow water, which leaves them vulnerable to floods that can displace them downstream into unsuitable habitat. This problem is greatly exacerbated in streams having little complexity due to lack of in-channel LWD. Displacement downstream may lead to early migration toward the estuary, and fry are poorly equipped to survive early emigration into salt water.

After emergence, fry continue to hide in gravel and under large stones during daylight hours, and within a few days they will progress to swimming close to the banks, taking advantage of available cover. They congregate in quiet backwaters, side channels, and small creeks, especially in shady areas with overhanging branches. Fry are found in both pool and riffles, but they are best adapted to holding in pools. Cold, deep, complex pools are optimum for coho salmon rearing provided there is enough dark habitat conditions and streamside vegetation for shading. Large wood and associated pool habitats provide cover from predators and refugia during high flow events (Everest et al. 1985).

Rearing

The amount of physical space available to juveniles for rearing is directly related to stream discharges (Everest et al. 1985). Lloyd et al. (1987) found that juveniles avoided chronically turbid streams, although they appear to be little affected by short transitory episodes (Sorenson et al. 1977). Published data suggest that feeding efficiency of juvenile coho salmon drops by 45% at a turbidity of 100 NTU (Reid 1998). Coho salmon rarely feed on non-moving food or from the bottom, preferring to select food in suspension or on the surface. At the yearling stage, they may become piscivorous, supplementing their insect diet with the fry of their own or other species.

By late summer and early fall, juvenile coho salmon feeding activity decreases and the fish move into deeper pools, especially those with overhanging logs and dense overhanging sidestream vegetation. Coho prefer side pools with cover instead of pools without cover. Juveniles spend more time hiding under the cover of logs, exposed tree roots, and undercut banks. Lack of adequate pools and side channels make them more susceptible to predation. By seeking cover and entering side channels, the fish avoid being swept out of the stream during winter high flows and they also avoid some predators at a time when their swimming ability is reduced because of lowered metabolic rate.

Salmonid strategies for coping with high turbidity include use of off-channel and clean-water refugia and temporarily holding at clean-water tributary mouths. These coping strategies are partially defeated by sediment inputs from roads, such as when road runoff discharges into low-order channels that once would have provided clean inflows, and riparian roads that restrict access to flood-plain and off-channel refugia (Reid 1998). Coho salmon streams with the best over-wintering habitat are those with LWD accumulations, spring-fed ponds adjacent to the main channel, or protected and slow-flowing side channels that may only be wetted in winter. Backwaters and side channels that develop along unconstrained reaches in alluvial floodplains were historically important rearing habitats for juveniles (Sedell and Luchessa 1982).

In unstable coastal systems, coho salmon production may be limited by the lack of side channels and small tributaries to provide protection against winter floods. Beaver ponds can create additional habitat used by coho salmon, both in winter to avoid high flows, and in summer to avoid stranding as a result of low flows. Habitat complexity contributes to the creation of microhabitats within reaches, thus providing more opportunities for inter and intra-species stratification (Bjornn and Reiser 1991). Terrestrial insects and leaf drop falling into streams from riparian vegetation much of the food base for stream macroinvertebrates, which in turn are a major food source for juvenile coho salmon.

Emigration

Stream flow is important in facilitating the downstream migration of coho salmon smolts. Dorn (1989) found that increases in stream flow triggered downstream movement of coho salmon. Similarly, Spence (1995) also found short-term increases in stream flow to be an important stimulus for smolt emigration. Thus, the normal range of stream flow may be required to maintain normal temporal patterns of migration. In years with low flows, emigration is earlier. Artificial obstructions such as dams and diversions may impede emigration where they create unnatural hydraulic configurations or impediments.

Temperature affects emigration timing of coho salmon smolts by influencing their rate of growth and physiological development, and their responsiveness to other environmental stimuli (Groot 1982). Alteration of thermal regimes through land-use practices and dam operations can influence the timing of emigration. The probability that coho smolts will migrate downstream increases with rapid increases in temperature (Spence 1995). Holtby (1988) found that coho salmon smolts in British Columbia emigrated approximately eight days earlier in response to logging-induced increases in stream temperatures. In addition, the age-class distribution was shifted from populations evenly split between one- and two-year old smolts to populations dominated by one-year old fish. If the majority of smolts emigrate at the same age, poor ocean conditions could have a greater effect on that particular year class than if the risk was spread over two years. Coho salmon have been observed throughout their range to emigrate at temperatures ranging from 36.6ºF up to as high as 55.9ºF (Sandercock 1991). Coho salmon have been observed emigrating through the Klamath River estuary in mid-to late-May when water temperature ranged from 53.6 to 68ºF (CDFG unpubl. data).

Supersaturation of dissolved gases (especially nitrogen) has been found to cause gas bubble disease in downstream migrating salmonids (Ebel and Raymond 1976). Emigrating fish are particularly vulnerable to predation (Larsson 1985). Physical structures in the form of undercut banks and LWD provide refugia during resting periods and cover from predators.

Essential Estuarine Habitat

Estuaries are essential habitat of Pacific salmon, including coho salmon (Sedell et al. 1991). Both adult and juvenile coho salmon utilize estuaries throughout their range in California. Adults use estuaries for staging as they prepare for their migration upstream. Juveniles use estuaries for rearing, and completion of smoltification. Juveniles may occupy estuaries for several weeks before migrating out to sea. In fact, the phenomenon of smolts migrating out is not a single, unidirectional event; smolts may move in and out of the estuary a few times before finally remaining in the marine environment.

Returning adults enter the freshwater environment through estuaries. Access to the estuaries, sufficient cover, and adequate flow and water quality, including temperature, are all important factors for these fish. Once in the estuaries, upstream migration generally is associated with high out flow combined with high tides (Sandercock 1991).

Young fish are very susceptible to predation once they reach the lower river system and estuary, where water quality and habitat complexity is a crucial factor in their ability to survive. Substrate habitat complexity and adequate woody debris are necessary for shelter and hiding, while a sufficient, invertebrate food source is necessary for continued growth and physiological development prior to leaving the estuary. These physical and biological conditions are related to the (1) type, diversity, distribution, and quality of substrate, (2) amount, timing and quality of freshwater discharge, and (3) tidal pattern and quality of marine waters. Estuaries provide important rearing habitat, especially in smaller coastal streams where freshwater rearing habitat is limited.

Summary of Essential Habitat

Coho salmon inhabit three aquatic environments during the course of their life cycle: freshwater streams, coastal estuaries, and the ocean. In each of these environments, particular ecological conditions are necessary for each coho salmon life-stage, as described in the preceding sections. Each condition has a broader range that allows for survival and a narrower range that represents the optimum for coho salmon health, as measured by activity, growth, resistance to disease, and other factors.

It should be noted that most studies define optimal conditions on the basis of physiological responses or efficiencies under laboratory conditions. If coho salmon populations are locally adapted to the particular suite of environmental conditions in their natal stream, then ecologically optimal conditions may fall outside of the narrow range deemed physiologically optimal. Most important of these potential influences is the alteration in timing of life-history events.

Table 3 identifies the major freshwater habitats used by each life-stage of coho salmon. Table 4 summarizes essential habitat elements and shows the range of suitability necessary for the viability and survival of coho salmon for each element. The following is a summary of these essential habitat elements that were discussed by life-stage in the preceding sections.

Table 3. Freshwater habitats of the different life-stages of northern California coho salmon.

Freshwater Habitat	Coho Salmon Life-Stage
Flat water-riffle	fry, juveniles, spawning adults
Flat water	juveniles, spawning adults
Gravel streambed	eggs, alevins, young fry, spawning adults
Pool	fry, juveniles, migrating adults
Side-channel	fry, juveniles
Stream bank	fry, juveniles
Submerged vegetation and LWD	juveniles

Stream Vegetation and Canopy Cover

Vegetation in the riparian corridor provides many benefits to stream conditions and habitat. The vegetation serves as a buffer from sediment and pollutant deposition in the watercourse. The riparian community as a whole also influences the geomorphology and stream flow of the channel. Vegetation adjacent to the water stabilizes the stream bank. Shade, provided by canopy, and the riparian buffer is vital to moderating water temperatures that influence spawning and rearing. The riparian canopy also serves as cover from predators, and supplies both insect prey and organic nutrients to streams.

Large Woody Debris

LWD is an essential component for several ecological functions. Within the estuarine environment, it stabilizes substrate, provides cover from predators, and provides shelter. In the freshwater environment, it serves these same functions as well as providing for pool establishment and maintenance, spawning bed integrity, habitat for aquatic invertebrate prey, and in-stream productivity.

Sediment and Substrate

The channel substrate type and size, and the quantity and distribution of sediment have important direct and indirect functions for several life-stages of coho salmon. Adults require gravel of appropriate size and shape for spawning, building redds, and laying eggs. Eggs develop and hatch within the substrate, and alevins remain there for some time for protection and shelter. The substrate also functions as habitat for rearing juveniles providing shelter from faster flowing water and protection from predators. Also, some invertebrate prey inhabit the benthic and epibenthic environment of the stream substrate habitat. An excess of fine sediment is a significant threat to eggs and fry because it can (1) reduce interstitial flow, which is necessary to regulate water temperature and DO, remove excreted waste, and provide food for fry, (2) reduce available habitat, and (3) encase, and then suffocate, eggs and fry. The flushing and cycling of fine sediments is paramount to coho salmon survival.

Hydrological Regime

The nature of the water properties (i.e. quality and quantity) and the characteristics of the stream channel are fundamental to all coho salmon life-stages that inhabit coastal watersheds. Some important characteristics include water temperature, water velocity, flow volume, and the seasonal changes and dynamics of each of these (e.g. summer maximum and mean temperature, summer flow, peak flow, winter storm surges).

Water Temperature

Water temperature is one of the most significant ecological elements for all life-stages of coho salmon. Water temperature is important to: the rate and success of egg development; fry maturation; juvenile growth, distribution, and survival; smoltification; initiation of adult migration; and survival and success of spawning adults. Water temperature is influenced by many factors including stream flow, riparian vegetation, channel morphology, hydrology, soil-geomorphology interaction, climate, and anthropogenic impacts. The heat contained within the water (stream thermal budget) and the ecological paths through which heat enters and leaves the water (heat transfer mechanisms) are dynamic and complex. There is also small- and large-scale heterogeneity based on stream depth, cross-section width, and flow (Essig 1998).

Water temperature requirements can be partitioned into important categories, each representing a temperature regime related to unique physiological phenomena. Three important complicating factors are important to note. First, environmental conditions in specific watersheds may effect the range and extreme end-points for any of these temperature categories for coho salmon within these watersheds. Second, water temperature requirements are dependent on fish metabolism and health, and available food. Third, individual coho salmon populations are adapted to habitat conditions within specific watersheds, therefore some populations may differ slightly in their temperature requirements and tolerances. These factors need to be considered together when trying to understand the habitat needs of coho salmon in a particular watershed or on a particular river system. Important water temperature regimes include:

- Optimum temperature: temperature that allows for optimum conditions for one or more activities (e.g. migration, spawning, foraging) or physiological process (e.g. growth, embryo or alevin development, fertilization) of any given life-stage of fish.

- Threshold temperature: temperature that inhibits a physiological process or behavior of a particular life-stage of fish (e.g. inhibits upstream migration or inhibits proper embryo development).

- Disease threshold: threshold where increased temperature results in an increased probability of mortality from warmwater- related diseases.

- Ultimate upper incipient lethal temperature: temperature that kills 50% of fish within a 24-hour period in a constant-temperature laboratory test after those test fish were acclimated to the highest temperature that allowed the maximum degree of thermal tolerance.

- Maximum weekly maximum temperature (MWMT): the highest daily temperature averaged over a seven day period. For fisheries biology, this a measurement used to understand presence/absence, stream and fish population productivity, physiological health or stress, mortality, and susceptibility to disease.

- Maximum weekly average temperature (MWAT): the highest mean temperature averaged over a seven day period. Like MWMT, this a measurement used to understand presence/absence, stream and fish population productivity, physiological health or stress, mortality, and susceptibility to disease.

<u>Dissolved Oxygen</u>

An adequate quantity of DO is necessary for each life-stage of coho salmon. DO is affected by water temperature, in-stream primary productivity, and stream flow. Also, fine sediment concentrations in gravel beds can affect the DO levels, impacting egg and fry.

Table 4. Fundamental habitat elements and suitable ranges for coho salmon life-stages.

Element	Life Stage	Suitable Range	Reference or Citation
Large woody debris	rearing juvenile	> 400f^3/100f reach [a]	Murphy 1995
Riparian cover	rearing juvenile	$ 80%	Flosi et al. 1998
Sediment and substrate	spawning adult	20% fine sediment; .51-4.02 inches (size) [b]	Reiser and Bjornn 1979; Bjornn and Reiser 1991
	eggs and fry	depth: 7.01-15.41 inches; 0=9.85; diameter: 1.54-5.40, 0=3.70; < 20% fine; < 12% fine, < 5% fine (optimum)	Briggs 1953; Cederholm and Reid 1987; PFMC 1999
Stream flow (peak flow, storm surges, minimum summer flow)	migrating adult	*- discharge is specific to stream -*	
	spawning adult	*- discharge is specific to stream -*	
	rearing juvenile	*- discharge is specific to stream*	
Territory (square feet)	spawning pair	126f^2	Bjornn and Reiser 1991
	rearing juvenile	26-59/fish;0= .001-1.0 fish per 3.281 [.5-1 year old]	Reiser and Bjornn 1979; Bjornn and Reiser 1991

Table 4, continued

Element	Life Stage	Suitable Range	Reference or Citation
Turbidity (NTU [c])	migrating adult	< 30 ounces/gal[a]	Bjornn and Reiser 1991
	spawning adult	clear to heavily silted	Sandercock 1991
	juvenile	> 60 (disrupted behavior); > 70 (avoidance)	Bjornn and Reiser 1991
Water depth (inches)	migrating and spawning adult	4.02-7.88; 0=6.19; 7 (minimum)	Briggs 1953; Bjornn and Reiser 1991
	rearing juvenile [d]	9.46-48.07	Bjornn and Reiser 1991
Dissolved oxygen (ounces/gallon)	migrating adult	$80% saturation and > .037[1]	Bjornn and Reiser 1991
	rearing juvenile	100% saturation (preferred); .037-.044 stressed, > .059 (optimum)	Reiser and Bjornn 1979; Bjornn and Reiser 1991, PFMC 1999
	egg and fry	near saturation (preferred); > .059 (optimum)	Reiser and Bjornn 1979; Bjornn and Reiser 1991, PFMC 1999
Water temperature (EF)	migrating adult	44.6-59	Reiser and Bjornn 1979
	spawning adult	39.2-48.2	Bjornn and Reiser 1991
	rearing juvenile	35 (lower lethal), 78.8-83.8 (upper lethal), 53.6-57.2 (optimum); 48-59.9 (optimum); 63.7-64.9 (MWAT); 62.1 (MWAT) and 64.4 (MWMT)	Bjornn and Reiser 1991; Flosi et al. 1998; Ambrose et al. 1996, Ambrose and Hines 1997, 1998, Hines and Ambrose ND; Welsh et al. 2001
	eggs and fry	39.2-51.8; 39.2-55.4 (optimum); 32-62.6	Davidson and Hutchinson 1938; Bjornn and Reiser 1991, PFMC 1999; PFMC 1999
Water velocity (ft/s)	migrating adult	< 8	Reiser and Bjornn 1979
	spawning adult	.98-2.46; 1.02; 0=1.9, .98-2.99	Briggs 1953; Reiser and Bjornn 1979; Bjornn and Reiser 1991
	rearing juvenile	.30-.98 (preferred for age 0), 1.02-1.51 (riffle), .30-.79 (pool); .16-1.28[3]; .16-.98	Reiser and Bjornn 1979; Bjornn and Reiser 1991; PFMC 1999
	eggs and fry	.82-2.95	PFMC 1999

a Coho salmon research conducted in southeast Alaska.
b Estimated from other species or general for anadromous salmonids.
c NTU is nephelometric turbidity units
d Various sizes and ages. Fish either aged (0 and 1) or measured 15.8-24.4cm).

V. STATUS OF CALIFORNIA COHO SALMON POPULATIONS NORTH OF SAN FRANCISCO

Structure and Function of Viable Salmonid Populations

Structure of Pacific Salmon Populations

The McElhany et al.'s (2000) definition of population is used for the purposes of this review. This definition is much the same as Ricker's (1972, as cited in McElhany et al. 2000) definition of "stock": "An independent population is a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season." The term "coho salmon population" in this document typically refers to spawning adults. However, the term "population" also may be used at times to refer to juveniles, or adults in the ocean.

The Department defines and manages runs of anadromous salmonids based on genetic distinctiveness, run-timing differences, juvenile outmigration timing, and watershed (CDFG 1998). In many cases, California coho salmon populations roughly correspond to distinct spawning runs within watersheds. However, there is not enough information to assess connectivity between groups of spawners in different reaches of large streams. The relationship of tributary spawners to one another and to mainstem spawners is similarly unknown. Therefore, coho salmon spawning runs may actually be composed of more than one population.

Salmon have strong fidelity to breeding in the stream of their origin. This provides the potential for substantial reproductive isolation of local breeding populations, and may result in significant local adaptation. Isolated populations are subject to different levels of genetic drift and unique natural selection pressures that tend over time to result in differences between them. In addition, populations arising through colonization or artificial production, and populations that have experienced recent drastic reductions in size, are often genetically different from the population from which they were derived. Salmon also naturally exhibit a small and variable amount of exchange among populations that tends to connect them genetically, and make them more similar to one another. Even small amounts of gene flow between stocks (e.g. due to straying) can prevent their complete separation unless there is strong differential selection to maintain separation (Nei 1987). The amount of exchange may be influenced by factors like stream blockages (e.g. sandbars at the mouths of rivers or road crossings) and straying. Because of these factors, salmon populations are largely, but often not completely, isolated.

Levins (1969) proposed the idea of the metapopulation to describe a "population of populations". Metapopulations are comprised of subpopulations which are local breeding populations, with limited exchange among the subpopulations so that they are reasonably isolated and connected. Similarly, larger assemblages (e.g. all of the breeding populations in a watershed) can themselves form a metapopulation due to the connection between them afforded by natural straying. Fragmentation of this structure can affect the ability of populations to respond to natural environmental variation and catastrophic events.

Differential productivity among habitat patches can lead to a "source-sink" relationship in which some highly productive habitats support self-sustaining subpopulations (source subpopulations) that continually supply individuals to other non-self-sustaining subpopulations (sink subpopulations) in less productive habitats (Pulliam 1988). Data for at least one coho salmon population in Washington (McElhaney et al. 2000) is consistent with this model. Because of the fact that sink subpopulations are not self-sustaining and rely on source subpopulations for their existence, Schlosser and Angermeier (1995), and Cooper and Mangel (1999) have stressed the importance of protecting natural source subpopulations. However, over longer periods, the relationship between source and sink subpopulations may change (i.e., sources may become sinks and vice versa). Thus, protecting only current source subpopulations may be inadequate to ensure long-term persistence. In some salmonid systems, hatchery and wild populations may represent sources and sinks, respectively (McElhaney et al. 2000).

Structure within a salmon species can be seen as hierarchical. Further, more than one logical hierarchical system can be envisioned. For example, NRC (1996) described the structure of genetic variation in salmon populations as beginning with substantially reproductively isolated local breeding populations that form metapopulations typically connected by some small amount of gene flow, followed by larger biological races, then subspecies/ecotypes, and culminating with the species as a whole. McElhaney et al. (2000) suggested a hierarchy containing individual, subpopulation, population, ESU, and species levels. An ESU can also function as a "metapopulation" (McElhaney et al. 2000). For purposes of this review, coho salmon populations are assumed to be organized in a hierarchical structure that includes connections among subpopulations as well as connections over a larger geographic scale.

Coho salmon have an almost fixed three-year life cycle throughout most of their range, including California (Sandercock 1991; Waples et al. 2001). Therefore, a complete generation of coho salmon in a stream consists of three consecutive, almost completely non-overlapping, brood-years[9]. Because of this, the number of locally-produced adults returning to a stream in a given spawning season is almost entirely dependent upon the number of juveniles produced there three years earlier. Loss of one of the three coho salmon brood-years in a stream (called brood-year extinction or cohort failure) therefore represents loss of a significant component of the total coho salmon resource in that stream. Brood-year extinction in a stream may be the result of the inability of adults to return to their place of origin, productivity failure, or high mortality. Recovery of an extinct coho salmon brood-year in a stream is made more difficult by its almost complete dependence on strays from other, usually nearby, sources (including hatcheries). Stray rates among natural populations are variable, unpredictable, and are probably low in healthy natural populations (McElhaney et al. 2000). This dependence on sources that may also be depressed and fragmented adds considerable uncertainty to the potential for natural recovery of missing coho salmon brood-years.

For purposes of this status review, each of the two California coho salmon ESUs is considered separately.

Population Viability Analysis

McElhany et al. (2000) defined a viable salmonid population for purposes of the ESA as "an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible

[9] "Brood-year" or "cohort": Synonyms meaning a group of fish that hatched during a given spawning season. When the spawning season spans portions of more than one year, as it does for coho, the brood year is identified by the year in which spawning began. For example, offspring of coho that spawned in 1996-1997 are identified as "brood-year 1996" or "the 1996 cohort".

risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100 year time frame." One hundred years was chosen to represent a long time-frame over which to evaluate risk of extinction. This long time scale is important because typical recovery actions can affect populations over many years. Many genetic processes (e.g. loss of diversity) can occur over long time-frames (decades or centuries), and at least some environmental cycles occur over decadal or longer time scales. By considering extinction risk far into the future, large-scale environmental oscillations and long-term trends can be accounted for. Short term viability (i.e. 10 or fewer years) is also considered. Evaluations of both long-term viability (i.e., 100 years) and short-term viability (i.e. 10 or fewer years) use the same parameters over different time scales.

The number of individuals that would ensure population viability to a negligible probability of extinction over 100 years is difficult to calculate (McElhaney et al. 2000). Evaluation of viability is based on assessments of abundance, population growth rate, population structure, and diversity. Reliable estimates of these parameters are not available for California coho salmon. Therefore, it is not possible to determine viability targets, in terms of numbers of fish, for coho salmon at this time.

For a description of habitat necessary to sustain viable coho populations, see Chapter IV *Summary of Essential Habitat.*

Sources of Information

Literature Review

Population abundance and trends have been estimated recently by Brown and Moyle (1991), Brown et al. (1994), and NMFS (2001a). Weitkamp et al. (1995) reviewed available population data in their status review of coho salmon. The Department reviewed the status of coho salmon north of San Francisco in a petition to the California Board of Forestry and Fire Protection (BOF) (CDFG 1994a). Status of coho salmon south of San Francisco was reviewed by the Department in response to a petition to list them under CESA (Anderson 1995). Distribution of coho salmon in California was also reviewed by Hassler et al. (1991). Nehlsen et al. (1991) reviewed Pacific salmon stocks at risk. Hatchery data and ocean catch data are also informative, and are reported here and in other sections of this document. In addition, the available coho salmon abundance and distribution data were subjected to a new analysis by the Department. The Department believes that these sources are the best available information on coho salmon abundance and distribution in California.

Presence-by-Brood-Year Investigation

Brown and Moyle (1991) reviewed the available information on coho salmon distribution and found records indicating historical occurrence of coho salmon in 582 California streams. Of these 582 streams, they found recent records of coho salmon presence or absence for 248 streams (42%). Their report summarizes published and unpublished information concerning the distribution and status of coho salmon in California.

To assess more recent trends in distribution and to augment Brown and Moyle's analysis, staff of the Department's Northern California - North Coast Region began an effort in 2001 to compile all historical presence information and data collected for 396 streams identified by Brown and Moyle (1991) north of Punta Gorda (includes streams from the Oregon border south to the Mattole River). Staff attempted to gather all published and unpublished data from as many streams as possible, including original field notes, planting records, and fish surveys found in north coast offices of the Department, United States Forest Service (USFS), USFWS, Barnum Timber Company, Pacific Lumber Company (PALCO), Forest Science Project, Simpson Timber Company, Yurok Tribal Fisheries Department, Humboldt State University Fisheries Cooperative Research Unit, Redwood National Park, and Sea Grant. In addition, data from scientific collectors and recently published status reviews such as Ellis (1997), Brownell et al. (1999), and NMFS (2001a) was reviewed. A standard protocol for document review was followed and all documents were reviewed at least twice. If a document indicated that more than one life stage of coho salmon was present, then the appropriate brood years were judge to be present for that stream.

Staff made no attempt to assess effort or effectiveness of sampling described in the documents, therefore the likelihood of finding coho salmon could not be determined. In addition, the number of coho salmon observed was not considered, i.e., presence could be determined based on an observation of only one fish. Some streams with no documentation were considered to have coho salmon present if fish were documented in an upstream tributary. In other words a stream could be classified as a coho salmon stream even if it only served as a migration corridor.

2001 Presence Surveys

As a result of the above investigation, streams without a consecutive brood year lineage were surveyed in summer and fall of 2001 to determine if coho salmon presence could be detected. Department survey efforts were augmented by coordinating research efforts with other agencies and scientific collectors. The Department contracted with the Forest Science Project and Humboldt State University to survey streams from Redwood Creek through Humboldt Bay. In addition, historical coho salmon streams south of the Mattole River were surveyed by the Department's Central Coast Region staff, Campbell Timber Management, Mendocino Redwood Company, Marin Municipal Water District, Center for Ecosystem Management and Restoration, Tomales Bay Association, and the National Park Service. A modified version of the NMFS's ten-pool protocol (Adams et al. 1996) was used (Appendix C-I). The primary sampling technique used was direct observation by snorkeling. Other sampling methods used were backpack electrofishing, seining, and baited minnow trapping. For the Central Coast Region, streams for which surveys indicated presence for three consecutive years between 1994 and 2000 were assumed to have an extant population of coho salmon and were not surveyed.

Historical and Current Distribution by Watershed

This section describes the historical and current distribution of coho salmon in California north of San Francisco. Much of the historical information was derived primarily from literature and file searches performed by Brown and Moyle (1991), Hassler et al. (1991), CDFG (1994a), Brownell et al.(1999), and Adams et al. (1999). Information on current range and distribution was taken primarily from Ellis (1997), Brownell et al. (1999), and Department field surveys and document reviews conducted in 2001 (noted in the text as "CDFG unpubl. data"). Together, these sources comprise the only comprehensive information on coho salmon range and distribution within California north of San Francisco. The waters discussed below are streams and rivers for which coho salmon information currently exists and are arranged from north to south. Counties listed after the stream name represent those portions of the basin in which coho salmon were found historically.

"Historical information," for purposes of this report, is defined as information developed prior to 1995, while information developed in 1995 or later is considered current information. This corresponds to two brood year life cycles of coho salmon.

Winchuck River (Del Norte County)

Historical Distribution: The South Fork Winchuck River historically supported a small population of spawning coho salmon. Adult coho salmon were first reported in 1940, then again in 1979, 1992 and 1993 (Brownell et al. 1999; CDFG 1994a).

Current Distribution: Juvenile coho salmon were observed during surveys of the South Fork Winchuck River in 1996. Coho salmon juveniles of the 1997 and 2000 cohorts have also been reported in the South Fork Winchuck River (Ellis 1997). It appears coho salmon presence and distribution has changed little in the South Fork Winchuck River.

Illinois River (Del Norte County)

Historical Distribution: Within the California portions of the Illinois River system, Broken Kettle and Elk creeks, tributaries to the West Fork Illinois River, are known to have historically contained coho salmon. Dunn Creek, tributary to the East Fork Illinois River also historically contained coho salmon (Hassler et. al 1991).

Current Distribution: Coho salmon were recently confirmed in Broken Kettle Creek, the South Fork Broken Kettle Creek and Elk Creek. Coho salmon were also recently sighted in the East Fork Illinois and its tributaries, Dunn Creek and North Fork Dunn Creek (CDFG unpubl. data). Coho salmon distribution appears to have changed little within the California portion of this system.

Miscellaneous Del Norte County Coastal Streams

Historical Distribution: Coho salmon have been reported in Jordan and Yonkers creeks, tributaries to Lake Earl north of Crescent City (Hassler et al. 1991). Access to these two tributaries is at least partly dependant on when the sand bar that separates Lake Earl from the Pacific Ocean is breached. Coho salmon have also been reported in Elk and Wilson creeks, which connect directly to the Pacific Ocean (Hassler et al. 1991).

Current Distribution: Coho salmon have been confirmed in Elk and Wilson creeks since 1995. Coho salmon were not confirmed during recent surveys of Jordan and Yonkers creeks (CDFG unpubl. data).

Smith River (Del Norte County)

Historical Distribution: The Smith River basin is California's fourth largest coastal river system. Coho salmon are found throughout, although their numbers are typically small. The more notable Smith River tributary systems in which coho salmon were reported historically are: Rowdy Creek, including its tributaries Dominie, South Fork Rowdy, Savoy and Copper creeks; Morrison, Jaqua (a.k.a. Little Mill), and Mill creeks, including both the West and East branches; Kelly and Bummer Lake creeks; and Middle and South Forks Smith River (Brownell et al. 1999). Coho salmon have also been reported historically in smaller tributaries such as Sultan, Peacock, and Clarks creeks, (Brownell et al. 1999).

Within the South Fork sub-basin, coho salmon have been reported in Craigs, Coon, Rock, Hurdygurdy, Jones (and its tributary Muzzleloader Creek), Buck, Quartz, and Eightmile creeks, and the Prescott Fork Smith River. In the Middle Fork Smith River, coho salmon have been historically documented in Myrtle, Hardscrabble, Eighteenmile, Patrick, Monkey, Packsaddle, Griffin, and Knopti creeks, and the Siskiyou Fork Smith River. Twelvemile, Shelly, Elevenmile, Tenmile, and West Fork Patrick creeks (all tributaries to Patrick Creek) also supported coho salmon. Coho salmon historically utilized the North Fork Smith River, including its tributaries Stony, Peridotite, Still, and Diamond creeks (Brownell et al. 1999).

Current Distribution: In 1996, spawning coho salmon were reported in Mill Creek (Brownell et al. 1999). Juveniles have been observed in the West Branch Mill Creek as well as in the East Fork Mill Creek and its tributaries Bummer Lake, Kelly, and Low Divide creeks in recent years. Coho salmon have been confirmed in Rowdy Creek and its tributaries the South Fork Rowdy, Savoy, Dominie, and Copper creeks. Within the South Fork of the Smith River, coho salmon have only been confirmed in Eightmile Creek and in the mainstem South Fork. Recent surveys of Patrick Creek and Knopti Creek, tributaries to the Middle Fork Smith River, have resulted in confirmed coho salmon observations. Other Smith River tributaries where coho salmon have been documented since 1995 include Little Mill and Clarks creeks (CDFG unpubl. data).

Rowdy Creek Fish Hatchery, a small, privately operated hatchery on Rowdy Creek, has propagated coho salmon on an irregular basis since 1987. Adult coho salmon spawners returned to the hatchery in 1996, 1997 and 1998 (Brownell et al. 1999). They were also observed in 2001. Hatchery reared and released coho salmon have likely influenced adult returns to Rowdy Creek over the years.

Coho salmon presence was unconfirmed in most of the tributaries recently surveyed in the South and Middle forks Smith River in 2001 (CDFG unpubl. data). These two sub-basins constitute the majority of the Smith River tributaries that historically contained coho salmon. Coho salmon were observed in 2001 only in Mill and Rowdy creeks and their tributaries, Clarks and Little Mill creeks.

Klamath River (Del Norte, Siskiyou, Humboldt and Trinity Counties)

Historical Distribution: The Klamath River basin is California's second largest river system, draining a watershed of approximately 15,600 square miles.. The watershed is commonly divided into the Lower Klamath River, the Upper Klamath River, and the Trinity

River basins. Anadromous fish have been blocked from the Oregon reaches of the upper Klamath basin since 1918 when Copco No.1 Dam was constructed. Currently, anadromous fish have access to about 190 miles of the Klamath River (from Iron Gate Dam, near the Oregon border in Siskiyou County, to the Pacific Ocean at Requa in Del Norte County).

The Trinity River is the largest tributary to the Klamath River and drains approximately 1,369 square miles of watershed. The headwater streams originate in the pristine wilderness areas of the Trinity Alps and Trinity Mountains located in eastern Trinity County. The river flows 172 miles south and west through Trinity County, then north through Humboldt County and the Hoopa Valley and Yurok Indian reservations until it joins the Klamath River at Weitchpec, about 40 river miles (RM) from the Pacific Ocean. Anadromous fish passage is blocked by Lewiston Dam approximately 110 RM upstream from the mouth of the Trinity River.

Information on adult coho salmon returns to the Klamath basin is spotty prior to the construction of Iron Gate and Trinity River hatcheries. Counts of adult returns to the basin's hatcheries have been recorded since the facilities began operating in the 1960s.   Counts of coho salmon observed at the Klamathon Racks, a mainstem weir located below Iron Gate Dam, were recorded during the 1920s and 30s. Although adult counts were not made, coho salmon eggs were collected at the Klamathon Station during its first year of operation in 1910. Adult coho salmon returns to the Shasta River, a major tributary to the Klamath River, have been documented since 1934. Similar information is lacking for the Scott and Salmon rivers, two other major Klamath River tributaries, as few attempts have been made to document their returns in the past **(see Appendix D, a report on the historical occurrence of coho salmon in the upper Klamath, Shasta, and Scott rivers)**. Snyder (1931) reported that significant coho salmon runs once occurred in the Klamath River, especially in the lower tributaries (below the Trinity River confluence). He found that 11,162 adult coho salmon were landed in one month by commercial gill-netting at the mouth of the river in 1919.

In the Trinity River, coho salmon have historically been observed in Scotish, Mill, Hostler, Supply, Campbell, Tish Tang a Tang, Horse Linto, Willow, Manzanita, Canyon, Browns, Conner, Dutch, Reading, Weaver (including its tributaries East and West Weaver), Rush, and Deadwood creeks, the South and North Fork Trinity rivers, and New River. Within the South Fork Trinity River, coho salmon have been documented in Madden, Eltapom, Pelletreau, Hayfork, Butter and Rattlesnake creeks (Brownell et al. 1999). They have also been documented in Big Creek, East Fork New River, tributaries to New River and in East Fork of the North Fork Trinity River (Hassler et al. 1991).

Other major Klamath Basin tributary systems that historically supported naturally spawning coho salmon include the Salmon, Shasta, and Scott rivers. In the Salmon River, coho salmon have been seen in Wooley Creek, Nordheimer Creek, and North Fork and South Fork Salmon River. In the Scott River, coho salmon have been documented in Tompkins, Kelsey, Canyon, Shackleford, Kidder, Etna, French, and Sugar creeks as well as the East and South Forks. Coho salmon have been documented in Big Springs Creek, a spring-fed tributary to the Shasta River (Brownell et al. 1999).

Many smaller Klamath River tributaries between the mouth and the Trinity River confluence that historically supported coho include: Hunter, Richardson, Hoppaw, Saugep, Waukell, Turwer, McGarvey, Omagar, Tarup, Blue, Ah Pah, Bear, Tectah, Pecwan, Mettah, Roach, Miners, Tulley, and Pine creeks (Brownell et. al. 1999). Klamath River tributaries between the Trinity River confluence and Iron Gate Dam that also historically supported coho salmon are: Aikens, Bluff, Slate, Red Cap, Boise, Camp, Irving, Dillon, Swillup, Ukonom, Independence Clear, Oak Flat, Elk, Little Grider, Indian, China, Thompson, Fort Goff, Portugese, Seiad, Grider, Walker, Horse, Bark House, Beaver, Humbug, Lumgrey, Empire, Cottonwood, Willow, and Bogus creeks (Brownell et al. 1999). Coho salmon were historically documented in Fall Creek, which is now upstream of Iron Gate Dam (Coots 1957).

The Klamath River basin has two hatcheries that produce coho salmon. Iron Gate Hatchery, located at the base of Iron Gate Dam, was completed in 1966. Trinity River Hatchery is located at the base of Lewiston Dam and began operating in 1963. Both of these facilities are mitigation hatcheries designed to offset losses in salmon habitat above the dams.

Current Distribution: In the Klamath River downstream of the Trinity River confluence, coho salmon have occupied Hunter Creek every year since 1995. Coho salmon have also been confirmed in tributaries to Hunter Creek such as the East Fork Hunter and Mynot creeks. Other recent surveys have resulted in coho salmon observations in Hoppaw, Waukell, Saugep, Turwar, McGarvey, Tarup, and Omagar creeks. Since 1995, coho salmon have been seen in Blue Creek and its tributaries such as Pularvasar, One-mile, West Fork Blue and Nickowitz creeks and in the Crescent City Fork. In other tributaries of the Klamath River below Weitchpec, coho salmon juveniles have been confirmed in the Ah Pah, Bear, Tectah, Little Surpur, Johnson, Pecwan, Mettah, Roach, and Pine creeks (CDFG unpubl. data).

In the Klamath River above the Trinity River confluence, Brownell et al. (1999) reported finding coho salmon in Camp, Swillup, and Elk creeks and its tributary East Fork Elk Creek. They also reported finding coho salmon in China, Fort Goff, Portuguese, Seiad, Horse, Salt, Little Humbug, Beaver, and Humbug creeks. Other Klamath River tributaries in which coho salmon have recently been reported include Dillon, Swillup, One-Mile (tributary to Ukonom Creek), Independence, Clear, Indian (and its South Fork tributary), Grider, Cottonwood, Little Bogus, and Bogus creeks. Juvenile coho salmon were rescued from Dry Creek, an intermittent stream near Iron Gate Hatchery, in 1995 and 1996. In 1998, they were also observed in Blue Gulch, a seasonal intermittent stream a few miles downstream of Dry Creek (Dennis Maria pers. comm.). Iron Gate Hatchery has reported coho salmon returns every year since it began tracking returns in 1963.

During surveys that began in 1996, coho salmon were not observed in eleven minor Klamath River tributaries that are historical coho salmon streams. These were: Salt and High Prairie creeks (tributaries to Hunter Creek), Bluff, Slate, Red Cap, Boise, Irving, Thompson, Middle (tributary to Horse Creek), Barkhouse, and Lumgrey creeks (Ellis 1997; CDFG unpubl. data).

In the Trinity River, coho salmon have recently been seen in the mainstem and its tributaries, such as Horse Linto Creek, Willow Creek, the South Fork Trinity River and its tributaries Madden and Eltapom creeks, Sharber Creek, New River, Weaver Creek (including its East and West Forks), Grass Valley Creek, Rush Creek and Deadwood Creek. Kier Associates (1999) reported observing coho salmon juveniles in the East Fork of the North Fork Trinity River and in Big French and Canyon creeks. Adult coho salmon have returned annually to Trinity River Hatchery since the facility began operations in 1963.

Coho salmon were not observed in recent surveys of six streams that historically supported coho salmon within the Trinity River basin. These are: Pelletreau, Hayfork, Butter and Rattlesnake creeks (tributaries to the South Fork Trinity River), Manzanita Creek, and the East Fork of the North Fork Trinity River (CDFG unpubl. data).

Within the Salmon River drainage, coho salmon were recently observed in the mainstem and in the South Fork Salmon River (CDFG unpubl. data). Coho salmon were observed in Knownothing Creek in 1998 (Brownell et al. 1999). Coho salmon were not observed in recent surveys of eight historical coho salmon streams within the Salmon River basin: Wooley Creek, Nordheimer Creek, North Fork Salmon River and its tributary North Russian Creek, Methodist Creek, and the East Fork of the South Fork and its tributary Taylor Creek (CDFG unpubl. data).

Coho salmon have been observed in the mainstem Scott River as well as several of its tributaries. These tributaries include Canyon, Shackleford, Mill, Kidder, French, Miners, and Sugar creeks and South Fork Scott River and its tributary Boulder Creek (CDFG unpubl. data). In Mill Creek near the town of Scott Bar, one suspected coho salmon redd was observed in December 2001 and 5 juveniles were seen in October 2001. In 1996, 61 juvenile coho salmon were captured from Kelsey Creek during fish rescue operations. Ninety-six juveniles were rescued from the upper Scott Valley near the mouth of Sugar Creek that same year. Adult spawners were observed in 2001 in the South Fork Scott River (64 adults), Sugar Creek (40 adults), French Creek (25 adults), Miners Creek (5 adults), Shackleford Creek and its tributary Mill Creek (2 adults), and Patterson Creek (1 confirmed, several others suspected) (Dennis Maria pers. comm.). In surveys conducted since 1996, coho salmon were not observed in five historical coho salmon streams: Tompkins, Kelsey, Patterson, Big Mill (tributary to the East Fork Scott River) and Etna creeks.

Adult coho salmon returned to the Shasta River in 1996, 1997, 1999 and 2001, and annually to Iron Gate Hatchery since 1996. Adult coho salmon have also been reported in the Salmon (1996, 1997, and 1998) and Scott rivers (1996) and in Bogus Creek (1996, 1997, 1998, 1999, 2000, 2001) (Mark Pisano pers. comm.). Juvenile coho salmon were observed in the Shasta River during the springs of 2000 and 2001 (Bill Chesney pers. comm.).

The lack of observed coho salmon during recent surveys within the Klamath Basin does not necessarily imply they have been fully extirpated from those areas. It does, however, provide insight for potential problem areas.

Redwood Creek (Humboldt County)

Historical Distribution: Redwood Creek flows for 65 miles from the headwaters to the Pacific Ocean, draining an area of 282 square miles. Coho salmon were first reported in Redwood Creek in 1895 (U.S. Commission on Fish and Fisheries 1895). Prairie Creek and its main tributaries, Little Lost Man and Godwood creeks, produced relatively large numbers of coho salmon historically. Other tributaries such as Tom McDonald, Bridge, Coyote, Panther, and Lacks creeks have also historically supported coho salmon. Prairie Creek Hatchery, a small, State owned hatchery located on Lost Man Creek near the town of Orick, began producing coho salmon in 1928. Coho salmon fry were primarily released in waters of Humboldt and Del Norte counties (Leitritz 1970). Operation of Prairie Creek Hatchery was turned over to Humboldt County in 1957 and was closed in 1992 due to water quality concerns and funding issues.

Current Distribution: Coho salmon have been recently documented in Redwood Creek and its tributaries Elam, Tom McDonald, Bridge, Cole, Hayes, and Davidson creeks. Coho salmon are also found in Prairie Creek and in its tributaries Little Lost Man, Lost Man, May, Godwood, Boyes, Browns, and Streelow creeks. Coho salmon were not observed in Coyote, Panther, and Lacks creeks during recent surveys (CDFG unpubl. data).

Miscellaneous Humboldt County Coastal Streams

Historical Distribution: Coho salmon have been found in small coastal waters such as Big Lagoon and its tributary Maple Creek, and in Strawberry Creek. They have also been documented in Stone Lagoon and its tributaries McDonald and Fresh creeks (Brownell et al. 1999). In the southern portion of Humboldt County, Guthrie, and McNutt creeks are also known to have supported coho salmon (Brown and Moyle 1991; Hassler et al. 1991).

Current Distribution: Coho salmon have recently been documented in Strawberry Creek and in tributaries to Big Lagoon such as Pitcher, and Maple creeks. Coho salmon were not observed during recent surveys of McDonald and Fresh creeks, nor were they seen in Big Lagoon. No coho salmon were observed in a recent survey of McNutt Creek (CDFG unpubl. data).

Little River (Humboldt County)

Historical Distribution: Coho salmon were documented historically in the Little River mainstem, the South Fork Little River, and Upper and Lower South Forks Little River (Hassler et al. 1991; Brownell et al. 1999).

Current Distribution: During recent surveys, coho salmon have been observed in the Little River and its tributaries Railroad Creek, Carson Creek, Lower South Fork Little River and Upper South Fork Little River (CDFG unpubl. data).

Mad River (Humboldt and Trinity Counties)

Historical Distribution: The Mad River flows 100 miles through Trinity and Humboldt counties to the Pacific Ocean, draining approximately 497 square miles. Adult coho salmon were counted at Sweasey Dam between 1938 and 1963 (CDFG 1994a). Lindsay Creek and its tributary Squaw Creek have been known to produce relatively large numbers of coho salmon (CDFG 1994a; Brown and Moyle 1991). Coho salmon have also been reported in other tributaries such as Grassy, Noisy, Canon, Warren, Hall, Powers, Leggit, Palmer, Maple, Black, Boulder, Quarry and Dry creeks as well as the North Fork Mad River (Brown and Moyle 1991). Ruth Dam was built in 1961 about 80 miles upstream of the mouth of the Mad River in Trinity County to provide water for industrial use (e.g., pulp mills), domestic use, and hydroelectric power. The dam is a barrier to the migration of adult salmonids.

Current Distribution: Coho salmon have been recently observed in the Mad River and its main tributaries Warren, Lindsay, Hall, Canon, Maple, and Boulder creeks and the North Fork Mad River. Within the Lindsay Creek sub-basin, coho salmon have also been observed recently in the South and North Fork Anker creeks and Squaw and Mather creeks. However, they were not observed in Grassy Creek. Coho salmon have also been recently documented in Noisy

Creek, a tributary to Hall Creek, and in Canyon and Sullivan creeks, tributaries to the North Fork Mad River. Streams in which recent surveys failed to detect coho salmon presence are Mill (tributary to Hall Creek), Powers, Leggit, Kelly, Palmer, Dry, Quarry, and Black creeks (CDFG unpubl. data).

Coho salmon adults have recently been observed returning to Mad River Fish Hatchery (Patrick Overton, pers. comm.).

Humboldt Bay Tributaries (Humboldt County)

Historical Distribution: Historically, tributaries to Humboldt Bay, such as the Elk River and Jacoby Creek, have supported substantial populations of coho salmon. Freshwater Creek, as well as other tributaries to Eureka Slough, have also historically supported substantial populations of coho salmon (CDFG 1994a). Coho salmon have also been reported in Janes (trib of McDaniel Slough), Jolly Giant, Rocky Gulch, and Salmon creeks, and Fay Slough (Cochran Creek) (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

Current Distribution: Coho salmon were recently observed in Jolly Giant Creek, Jacoby Creek and its tributary Morrison Gulch, Ryan Creek (tributary to Eureka Slough), Freshwater Creek and the Elk River. Within the Freshwater Creek system, coho salmon were observed in McCready Gulch, Little Freshwater Creek, Cloney Gulch, Falls Gulch, Graham Gulch, and the South Fork Freshwater Creek. In the Elk River system, coho salmon were observed in Martin Slough, North Fork Elk River, South Branch North Fork Elk River, South Fork Elk River, and Little South Fork Elk River (CDFG unpubl. data). Coho salmon were not observed during recent surveys of Janes, Rocky Gulch, Cochran, salmon, and College of the Redwoods creeks (CDFG unpubl. data).

Eel River (Humboldt, Mendocino, Trinity, and Lake Counties)

Historical Distribution: The Eel River is the third largest river system in California, encompassing approximately 3,681 square miles. Major sub-basins of the Eel River system include the mainstem Eel River (1,477 sq. mi.), North Fork (283 sq.mi), Middle Fork (753 sq. mi.), South Fork (690 sq. mi.), Van Duzen River (428 sq. mi.), and the estuary and delta (50 sq. mi.)

Mainstem Eel River flows have been regulated and managed for hydroelectric power and exported for agriculture since 1922. There are two dams associated with the Potter Valley Hydroelectric Project located on the upper mainstem Eel River: Scott Dam impounds Lake Pillsbury, a 94,000 acre-foot storage reservoir and, twelve miles downstream, Cape Horn Dam forms the 700 acre-foot Van Arsdale diversion reservoir.

In the mainstem Eel River, coho salmon historically occurred as far upstream as Indian and Tomki creeks (Brown and Moyle 1991). The Van Arsdale Fish Station, an egg taking station operated by the Department, is located at Cape Horn Dam. Coho salmon have been reported twice at this facility: 47 fish in 1946/47 and one fish in 1984/85. Other smaller tributaries to the mainstem where coho salmon have been reported historically include: Palmer, Rohner, Strongs, Price, Howe, Nanning, Monument, Killer, Twin, Stitz, Greenlow, Dinner, Jordan, Shively, Bear, Chadd, Larabee, Allen, Newman, Thompson, Jewett, Kekawaka, and Outlet creeks, the North

Fork and Middle Fork Eel Rivers, and the Salt River (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

In the Van Duzen River, coho salmon have been historically documented in many tributaries of Yager Creek, and Wolverton (tributary to Barber Creek), Cuddeback, Fiedler, Cummings, Hely, Root, Grizzly, and Hoagland creeks (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

Counts of coho salmon at Benbow Dam on the South Fork Eel River were made between 1938 and 1975. The largest number of fish reported was over 25,000 in 1947. Only 500 who were counted in 1973 (CDFG 1994a). There are a total of approximately 52 tributaries to the South Fork Eel River that have historically supported coho salmon (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999). Of these, Bull, Redwood, Sproul, Indian, Bear Pen, Wildcat, Hollow Tree, Rattlesnake and Ten Mile creeks and the East Branch of the South Fork have tributaries that also supported coho salmon historically (Brown and Moyle 1991; Hassler et al. 1991).

Current Distribution: Recent field surveys have confirmed the presence of coho salmon in the Eel River and in tributaries such as the Van Duzen River (and its tributary Shaw Creek), Howe Creek, the South Fork Eel River, and in tributaries to Outlet Creek. Within the Van Duzen River sub-basin, another 14 tributaries were recently surveyed in which no coho salmon were observed: Wolverton Gulch (tributary to Barber Creek), Yager Creek and its tributaries Cooper Mill and Lawrence creeks, Cuddeback Creek, Fiedler Creek, Cummings Creek, Hely Creek, Root Creek, Wilson Creek, Grizzly Creek and its tributary Stevens Creek, Hoagland Creek, and Little Larabee Creek (CDFG unpubl. data).

Recently in the South Fork Eel River sub-basin, coho salmon were seen in Bull (and its tributary Squaw Creek), Canoe, Salmon, Sproul (and its tributaries Little Sproul and West Fork Sproul creeks), Redwood (and its tributaries Seely, China, and Dinner creeks), and Leggett creeks. Coho salmon were not observed in Warden Creek (tributary to Sproul Creek) or in Miller Creek (tributary to Redwood Creek). Other coho salmon streams in the South Fork Eel River system in which coho salmon have been recently observed include Indian, Piercy, Standley, McCoy, Bear Pen, Wildcat, Jack of Hearts, Dutch Charlie, Kenny, and Taylor creeks (CDFG unpubl. data). Coho salmon were not observed during recent surveys of Albee, Mill, Bridge, Elk, Fish, Anderson, Dean, Durphy, Milk Ranch, Low Gap, Red Mountain, Cedar, Rattlesnake (and its tributary Cummings Creek), Fox, Elder, Little Charlie, Rock, Haun and Bear creeks and the East Branch of the South Fork Eel River (CDFG unpubl. data).

Coho salmon have also been recently observed in the Hollow Tree Creek system, another tributary to the South Fork Eel River. Hollow Tree Creek tributaries such as Redwood (and its South Fork tributary), Bond, Michaels, Butler, and Huckleberry creeks were also found to contain coho salmon during recent surveys. Two small tributaries to Michaels Creek (Doctors Creek and an unnamed tributary) also contained coho salmon, as did Bear Wallow Creek and Little Bear Wallow Creek (tributaries to Huckleberry Creek). Coho salmon were not observed in Mule, Walters, and Waldron creeks (tributaries to Hollow Tree Creek). Likewise, coho salmon were not observed during recent surveys of Grub, Streeter, Big Rock, Mill and Cahto creeks, which are tributaries to Ten Mile Creek. Coho salmon were observed recently in Ten Mile Creek, however (CDFG unpubl. data).

Coho salmon have not been observed recently in the Middle Fork Eel River, nor in its tributaries Rattlesnake, Rock, Mill, and Grist creeks. In the Outlet Creek sub-basin, coho salmon were recently confirmed in Mill, Willits, Broaddus and Baechtel creeks (CDFG unpubl. data). Ellis (1997) reports coho salmon juveniles were also observed in Ryan Creek. Coho salmon were not observed during recent surveys of Bloody Run, Long Valley, Rowes, Reeves, and Haehl creeks (all tributaries to Outlet Creek) (CDFG unpubl. data).

No coho salmon were observed during recent surveys of smaller Eel River tributaries such as Price, Atwell, Dinner, Jordan, Shively, Bear, Chadd, Larabee (and its tributary Carson Creek), Newman, Bluff (tributary to the North Fork Eel River), and Kekawaka creeks, and Tomki Creek tributaries Rocktree, String and Tartar creeks (CDFG unpubl. data).

At the Van Arsdale Fish Station, one adult coho salmon was seen in 2000 and three have been observed through December 7, 2001 (Alan Grass, pers. comm.).

Records indicate coho salmon were more widespread in the Eel River basin in the past. Coho salmon were once present in the North Fork Eel River and its tributary Bluff Creek. They were also present in the Middle Fork Eel and its tributaries Rattlesnake, Mill, Grist, and Rock creeks (CDFG 1994a). Coho salmon in the North Fork and Middle Fork Eel are now believed to be extirpated (Brown and Moyle 1991; CDFG 1994a). Coho salmon were noticeably absent during recent surveys of many of the tributaries to the Van Duzen River, in contrast to older surveys conducted on those same streams. Similarly, recent surveys failed to find coho salmon in many of the smaller tributaries to the Eel River where coho salmon had been reported historically. Although coho salmon were recently confirmed in many of the South Fork Eel River tributaries, there were nearly as many streams in which coho salmon were not observed.

Miscellaneous Mendocino County Coastal Streams

Historical Distribution: Brown and Moyle (1991) list historical runs of coho salmon in 43 small streams along the Mendocino County coast. Other coho salmon status reviews have listed from 22 to 74 streams as historically containing populations (Brown et al. 1994; Adams et al. 1999; NMFS 2001a).

Current Distribution: The most persistent coho salmon populations in these smaller watersheds have been located within the Cottoneva, Pudding, Hare, Caspar, Little River, Albion, and Big Salmon watersheds. Recently, coho salmon have been either completely absent or have been represented very sporadically within the Whale Gulch, Jackass (Wolf), Usal, Hardy, Juan, Russian Gulch, Buckhorn, Greenwood, Mallo Pass, Elk, Brush, Garcia, Schooner Gulch, or Fish Rock Gulch watersheds.

Ten Mile River (Mendocino County)

Historical Distribution: Recent status reviews on coho salmon distribution place the number of streams historically containing coho salmon in the Ten Mile River watershed at between eight and 18 (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). The discrepancy in the number of streams reflects of the availability of records at the time of reporting, the ephemeral nature of this watershed with respect to availability of habitat, and how distribution has been reported in the past. In 1963, there was an estimated 103 miles of coho salmon habitat within the Ten Mile River watershed (CDFG 2001b).

Coho salmon migration has periodically been impeded by natural events and anthropogenic factors within this watershed. In 1976, and from 1978 to 1982, drought was a notable impediment to fish migration and thus distribution within the watershed (CDFG 2001a). Coho salmon distribution over time has most likely been influenced by logging activities, especially by the formation of log jam barriers. In 1961, no less than 13 stream survey reports recommended removal of log jams that were acting as fish passage barriers (CDFG 1961).

Current Distribution: Since the mid 1990s, fisheries surveys have revealed a spotty distribution of coho salmon within the historical Ten Mile River coho salmon streams (CTM 2001; GP 1997; Maahs 1996, 1997; NMFS 2001a). Coho salmon have been recently documented in nine of the 11 tributaries listed by Brown and Moyle (1991). Mill Creek and Redwood Creek are the only historical tributaries where coho salmon were not observed in 2001.

<u>Noyo River (Mendocino County)</u>

Historical Distribution: Reported distribution of coho salmon has ranged from 12 to 25 streams within the Noyo River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). The differences in the number of streams reported as once supporting coho salmon is most likely a combination of several factors, including past reporting methods, drought, and barriers hindering passage throughout the watershed. The Noyo River harbor has eliminated the initial problem of access to the river experienced during drought conditions.

The Department conducted many stream surveys in the 1950s and 1960s, similar to the surveys conducted in other coastal watersheds in Mendocino County. Many of the survey reports cataloged log jams and barriers, which may have contributed to fish passage problems (CDFG 1957, 1959, 1966). The Department has maintained a coho salmon egg collecting station on the South Fork Noyo River since 1962 and coho salmon have been reported at that facility every year since 1962 (CDFG 2001a). The egg collecting station, flashboard dams at the Parlin Fork Conservation Camp on the South Fork Noyo, and the Boy Scout camp on the mainstem Noyo River may have caused passage problems during drought conditions. These persistent structures may also be problematic for juvenile migration (NMFS 2001b). A dam that impounds McGuire's Pond on the South Fork Noyo River was built in the early 1900s and has eliminated approximately 1.5 miles of salmonid habitat.

Current Distribution: Coho salmon persist throughout much of the Noyo River watershed. Since the ESA listing of coho salmon in the mid 1990s, surveys and monitoring efforts have increased within this watershed (CTM 2001; Harris 2000a, 2000b; MRC 1999; Valentine and Jameson 1994). Eight of the 12 streams identified by Brown and Moyle (1991) as historical coho salmon streams were surveyed in 2001 and coho presence was detected in all but the Middle Fork of the North Fork Noyo River.

<u>Big River (Mendocino County)</u>

Historical Distribution: Previous reports list the number of streams historically containing populations of coho salmon in the Big River watershed as ranging from 14 to 23 streams (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). All main branches of Big River have supported populations of coho salmon. There were approximately 101 stream miles considered to be coho salmon habitat in 1963 (CDFG 2001b). Stream surveys conducted by the Department in 1959 suggest the most common reason for poor distribution of coho salmon was the numerous log jam barriers (CDFG 1959). Many of these barriers persisted into the 1960s and some were still present into the 1980s.

Current Distribution: Surveys conducted since the mid-1990s reveal a spotty distribution with coho salmon documented more consistently in the North Fork tributaries than the remainder of the watershed. Most of the 16 streams listed by Brown and Moyle (1991) as historically containing coho salmon are either within Jackson State Forest (North Fork Big River) or within property owned and managed by Mendocino Redwood Company. Recently, 15 of the 16 historical streams were surveyed and coho salmon were documented in nine streams (60%): mainstem Big River, Little North Fork Big River, Berry Gulch, Two Log Creek, North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Arvola Gulch, and James Creek (CDFG unpubl. data).

Navarro River (Mendocino County)

Historical Distribution: Reported distribution of coho salmon has ranged from 15 to 28 streams within the Navarro River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). CDFG (2001b) estimated approximately 130 miles of coho salmon stream habitat were present in 1963. Logging, cattle grazing, drought, and more recently viticulture, have impacted coho salmon distribution within this watershed. Drought and low flow conditions have also affected both salmonid distribution and production. Most of these surveys conducted by the Department in the late 1950s and 1960s reported numerous log barriers caused by accumulated debris from historical logging activities (CDFG 1957, 1959, 1966). These barriers likely limited distribution and overall production of coho salmon.

Current Distribution: The present distribution of coho salmon within the Navarro River watershed is substantially less than that recorded historically. Fourteen of the 19 streams listed by Brown and Moyle (1991) as historical coho salmon streams were surveyed in 2001. Coho salmon were observed in only six of these streams: mainstem Navarro River, Flynn Creek, South Branch of the North Fork, North Branch of the North Fork, Little North Fork, and John Smith Creek (CDFG unpubl. data). Presence of coho salmon was higher in North Fork tributaries than in the remainder of the watershed. Coho salmon populations are now restricted to the western portion of the watershed.

Albion River (Mendocino County)

Historical Distribution: Brown and Moyle (1991) and Adams et al. (1999) list five and eight streams, respectively, as historically containing coho salmon populations. The increase in the number of streams is directly related to information supplied by Louisiana Pacific in the early and mid-1990s. Since the building of the harbor, sand bar closure no longer inhibits passage during drought years.

Current Distribution: Although coho salmon runs were stronger in the past, runs persist to this day. Brown and Moyle (1991) list the mainstem and four tributaries within the watershed as historical coho salmon streams. In 2001, three of the four streams were surveyed and coho salmon were found in all three streams. Several other tributaries including Deadman Gulch, Railroad Gulch, Pleasant Valley Gulch, Duckpond Gulch, East Railroad Gulch, Tom Bell Creek, and unnamed tributaries to Marsh Creek, have been identified as supporting coho salmon since 1995 (LP 1996; MRC 2000).

Garcia River (Mendocino County)

Historical Distribution: Brown and Moyle (1991) and Adams et al. (1999) list one and three streams, respectively, as containing historical runs of coho salmon populations. Coho salmon presence has been established sporadically in the past few decades (CDFG 1967, 1968, 1989). In the late 1960s, stream surveys were conducted by the Department throughout much of the Garcia River watershed. Similar surveys conducted within other Mendocino County watersheds at approximately the same time identified logging and its effects as the main issues limiting distribution and production of coho salmon (CDFG 1967, 1968). An estimated 38 miles of coho salmon habitat exist within the Garcia River watershed (CDFG 2001b).

Current Distribution: Only the mainstem of the Garcia River was identified by Brown and Moyle (1991) as an historical coho salmon stream, but NMFS (2001a) also identified the South Fork and Fleming Creek (tributary to the South Fork) as historical coho salmon streams. Surveys conducted on these three streams since 1989 have detected coho salmon presence only in the South Fork Garcia River 1994 and 1996 (MRC 1999).

Gualala River (Mendocino and Sonoma Counties)

Historical Distribution: Reported historical distribution of coho salmon has ranged from 10 to 15 streams within the Gualala River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). There is an estimated 75 miles of coho salmon habitat within the watershed (CDFG 2001b).

In the mid-1970s, the Department’s Coastal Steelhead Project was conducted, in part, on the Gualala River. During the life of this project, several types of fish surveys were conducted. Between 1973 and 1976, at least 33 adult coho salmon were counted during creel census surveys on the mainstem of the Gualala River (CDFG 1973, 1974, 1975, 1976). In 1963, coho salmon escapement was estimated at 4,000 fish.

Stream surveys have reflected poor distribution of coho salmon throughout the Gualala River watershed. Logging activities have been identified as impacting distribution, mainly through barrier formation (CDFG 1952, 1964). Coho salmon were reported in Marshall and Fuller Creeks in 1964 and coho salmon were again found in Marshall Creek in 1970 (CDFG 1964, 1970). Coho salmon were also reported in the North Fork and Little North Fork Gualala River (CDFG 1964).

Current Distribution: The present distribution of coho salmon is drastically different from historical accounts in this watershed. Ten of the eleven historical coho salmon streams listed by Brown and Moyle (1991) were surveyed in 2001 and coho salmon were not observed in any of the streams. Since 1995, presence of naturally produced coho salmon has only been documented in Robinson and Dry creeks (both are tributary to the North Fork) (GRI 2001). Neither Robinson or Dry creeks were listed by Brown and Moyle (1991) as historically containing coho salmon. Both of these streams were surveyed in 1999, 2000, and 2001 and no coho salmon were found (CDFG unpubl. data). There are now no known remaining viable coho salmon populations in the Gualala River system.

A total of 45,000 juvenile coho salmon, from 1995-1997 brood years, was planted in the Little North Fork Gualala River over three years. The juveniles were the products of the Noyo River Egg Collecting Station run by the Department. Subsequent surveys through the year 2000 have revealed no adult returns.

Miscellaneous Sonoma County Coastal Streams

Historical Distribution: Brown and Moyle (1991) listed 10 streams as historically containing coho salmon. These streams are located within four watersheds: Fort Ross Creek, Russian Gulch, Scotty Creek, and Salmon Creek.

Current Distribution: Coho salmon have not been observed in any of these watersheds in recent years (CDFG unpubl. data).

Russian River (Sonoma and Mendocino Counties)

Historical Distribution: Reported historical distribution of coho salmon has ranged from 29 to 46 streams within the Russian River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). SEC (1996) stated the distribution of coho salmon is much reduced from its historical range and that coho salmon once inhabited streams throughout portions of the watershed, from the lower mainstem tributaries upstream to the tributaries of the West Fork.

Coho salmon distribution within the Russian River watershed has been affected by dams, augmented flows, introduced fishes, gravel mining, sport and commercial harvest, land use practice (logging, road building, agriculture, urbanization), and an increase in hatchery production (SEC 1996). The overall conversion of this watershed from its natural state has led to a fishery dominated by introduced and warmwater species. Of the 48 fish species known to inhabit the Russian River, 29 have been introduced.

Current Distribution: Data collected recently indicates that there has been a catastrophic reduction in coho salmon distribution in the Russian River system. During field surveys conducted in 2001, 29 of the 32 streams listed by Brown and Moyle (1991) as historical coho salmon streams were surveyed. Coho salmon were found in only one of these streams (Mark West Creek). Additional surveys conducted in 2001 found coho salmon in Green Valley Creek and Redwood Creek, neither of which were listed by Brown and Moyle (1991). All of these streams are in the lower portion of the Russian River basin.

During 287 electrofishing and 58 spawning surveys in the Russian River over seven field seasons, only 79 coho salmon juveniles and one coho salmon carcass were observed (Coey 2000). Twenty three of the juveniles were found in a single year in one place (Mill Creek, tributary to Dry Creek, Sonoma County).

Several historical coho salmon streams are now located upstream of dams. Rocky, Mariposa, Fisher, and Corral creeks are located above Mumford Dam, which will soon be retrofitted to allow anadromous fish passage. The roughs near the mouth of Mill Creek, a tributary to Forsythe Creek, most likely preclude use of that tributary by coho salmon.

Miscellaneous Marin County Coastal Streams

Historical Distribution: The 10 streams listed by Brown and Moyle (1991) as historical coho salmon streams are located within four watersheds: Walker, Lagunitas, Pine Gulch, and Redwood creeks.

At one time, Walker Creek supported a good return of coho salmon (Worsely 1972) but there are very few recent records of coho salmon in that creek. Emig (1984) recorded at least eight species of fish, including coho salmon, during a survey in 1981. Water diversion activities may have affected conditions in Redwood Creek, most likely impacting distribution of coho salmon (Snider 1984; Arnold 1971). Coho salmon were observed there sporadically from 1956 to 1996 (CDFG 1956, 1976, 1977, 1984; Smith 1998).

Major tributaries to Lagunitas Creek are Olema, Nicasio, Devil's Gulch, and San Geronimo creeks. Surveys indicate that all of these tributaries have contained coho salmon populations (CDFG 1986; Trihey & Assoc., Inc. 1995). Marin Municipal Water District, the largest water user in the watershed, operates Lagunitas, Bon Tempe, Kent, and Alpine reservoirs on the mainstem and Nicasio Reservoir on a tributary. The five reservoirs have eliminated almost half of the once available anadromous habitat

Current Distribution: Recently, coho salmon were observed in Pine Gulch Creek in 1997 and 2001, but not in 1998 and 1999 (Brown et al. 1998, 1999; NPS 2001). Very few surveys have been conducted in the past decade within the Walker Creek watershed, and those that have been conducted have not found coho salmon. Coho salmon are still extant in Redwood Creek (Smith 2000; Bill Cox, pers. comm.).

Coho salmon have been observed consistently for the past decade within the Lagunitas Creek watershed, despite the numerous dams and subsequent loss of habitat. Lagunitas Creek and all of its tributaries, except probably Nicasio Creek, still contain coho salmon. The current estimated number number of spawners is about 800 adults annually (Bill Cox, pers. comm.).

San Francisco Bay Tributaries (Marin, Sonoma, Solano, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco Counties)

Historical Distribution: Brown and Moyle (1991) list six Bay Area streams as historically containing coho salmon: Alameda, San Pablo, Walnut, San Anselmo, Corte Madera, and Mill Valley creeks. Other streams believed to have had historical runs of coho salmon include Strawberry, San Leandro, Sonoma, Arroyo Corte Madera del Presidio, and Coyote creeks (Leidy and Becker 2001). In 1969, and during the winter season of 1985/86, coho salmon were observed in Corte Madera Creek (CDFG 1969; Emig 1986; Leidy 1981). Undoubtedly, the effects of urbanization throughout the Bay Area have been the leading factor in the loss of salmonid populations and habitat.

Current Distribution: Prior to 1992, very few surveys were conducted on the fisheries of Bay Area tributaries. Coho salmon were not observed in periodic surveys conducted by East Bay Municipal Utility District fishery biologists in Pinole and San Leandro creeks from 1995 through

2001 (Jose Setka, pers. comm.). Leidy (1999) conducted fisheries surveys on 79 Bay Area streams between 1992 and 1998, and coho salmon were not observed in any of the surveys. The last known observation of coho salmon was in 1981, consequently, it is believed that coho salmon populations are now extinct in San Francisco Bay tributaries (Leidy and Becker 2001).

Presence-by-Brood-Year Investigation

Brown and Moyle (1991) identified 582 historical California coho salmon streams, 569 of which were north of, or tributary to, San Francisco Bay. Of the 235 streams for which there was recent information, coho salmon presence could be documented in only 130 streams (55%) (Table 5). Their analysis indicated that the proportion of streams that appeared to have lost their coho salmon populations increased from north to south. In Del Norte County, 45% of the streams for which there are reliable records had lost their coho salmon populations, mainly in the Klamath-Trinity river system. In Humboldt, Mendocino, and Sonoma counties, the proportion of historical streams that no longer appeared to contain coho salmon populations was 31% , 41%, and 86%, respectively (Table 5). When Del Norte and Humboldt County streams were combined, coho salmon were present in 73 (63%) of the historical streams where recent information existed regarding coho salmon distribution (Brown and Moyle 1991).

The Department's presence-by-broodyear investigation found four discrepancies in the historical coho salmon streams identified by Brown and Moyle (1991): some streams were listed twice, one stream was located above a barrier, and one stream that was listed because coho salmon were planted but did not result in adult returns, which violated one of their criteria for inclusion as a historical stream (see Brown and Moyle [1991] for a description of their criteria). Therefore, for purposes of this review, the 396 historical coho salmon streams north of Punta Gorda identified by Brown and Moyle (1991) was reduced to 392.

In addition, Department staff found considerable additional documentation on the 392 historical coho salmon streams of Del Norte, Humboldt, Trinity, Siskiyou, and northern Mendocino counties (which coincides with the California portion of the SONCC Coho ESU), increasing the number of streams with information from 115 as reported in Brown and Moyle (1991) to 235 for brood years 1986 through 1991. Of these 235 streams, coho salmon presence could be detected in 143 streams (61%) (Table 5). This does not appear to be appreciably different from the 63% presence as reported by Brown and Moyle (1991) for these streams despite the additional documentation.

More recent information on brood years 1995 through 2000[10] was found for 355 of the Brown and Moyle (1991) historical coho salmon streams in Del Norte, Humboldt, Trinity, Siskiyou, and northern Mendocino counties. Of the 355 streams for which there are recent data, presence of coho salmon could not be detected in 176 (50%) of the streams (Table 5). This proportion is not directly comparable with that of the 1986 through 1991 time frame (61%) used by Brown and Moyle (1991) because not necessarily the same streams were included in the analysis. When only those streams with information that are common to both time frames are considered (223 streams), then the number of streams where presence can be detected is 62% for the 1986 -1991 period vs. 57% for the 1995-2000 period. Both Pearson chi square and Yates corrected chi square tests indicated that the difference is not statistically significant ($p= 0.228$ and 0.334, respectively).

[10] The length of this time period was chosen to include two brood-year cycles and to facilitate comparison with the time period used by Brown and Moyle (1991) that is of similar length.

Table 5. Historical presence of coho salmon north of San Francisco, as determined by Brown and Moyle (1991) and the Department's presence-by-brood-year investigation (as of February 2002). County classifications are based on the location of the mouth of the river system. Dash line indicates analysis was not done.

	Brown & Moyle Calendar years 1987 through 1990					Coho Presence as Determined by CDFG Investigation Brood years 1986 through 1991					Coho Presence as Determined by CDFG Investigation Brood years 1995 through 2000				
	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent
DEL NORTE COUNTY Coastal	9	1	1		0	8	5	3		2	8	8	6		2
Smith River	41	2	2		0	41	21	7		14	41	39	14		25
Klamath River	113	41	21		20	112	82	48		34	112	89	55		34
Subtotal	163	44	24	(54%)	20	161	108	58	(53%)	50	161	136	75	(55%)	61
HUMBOLDT COUNTY Coastal	34	7	7		0	33	16	14		2	33	32	18		14
Redwood Creek	14	3	3		0	14	12	12		0	14	14	11		3
Mad River	23	2	2		0	23	10	8		2	23	22	14		8
Eel River	124	56	34		22	123	80	48		32	123	116	45		71
Mattole River	38	3	3		0	38	9	3		6	38	35	16		19
Subtotal	233	71	49	(69%)	22	231	127	85	(67%)	42	231	219	104	(47%)	115
Subtotal: Del Norte & Humboldt Counties	396	115	73	(63%)	42	392	235	143	(61%)	92	392	355	179	(50%)	176
MENDOCINO COUNTY Coastal	44	35	13		22	-	-	-		-	-	-	-		-
Ten Mile River	11	10	7		3	-	-	-		-	-	-	-		-
Noyo River	13	12	11		1	-	-	-		-	-	-	-		-
Big River	16	13	11		2	-	-	-		-	-	-	-		-
Navarro River	19	8	4		4	-	-	-		-	-	-	-		-
Subtotal	103	78	46	(59%)	32	-	-	-		-	-	-	-		-
SONOMA COUNTY Coastal	10	2	1		1	-	-	-		-	-	-	-		-
Gualala River	11	2	1		1	-	-	-		-	-	-	-		-
Russian River	32	24	2		22	-	-	-		-	-	-	-		-
Subtotal	53	28	4	(14%)	24	-	-	-		-	-	-	-		-
MARIN COUNTY Coastal	10	7	7		0	-	-	-		-	-	-	-		-
Subtotal	10	7	7	(100%)	0	-	-	-		-	-	-	-		-
TRIBUTARIES TO S.F. BAY Coastal	7	7	0		7	-	-	-		-	-	-	-		-
Subtotal	7	7	0	(0%)	7	-	-	-		-	-	-	-		-
Total	569	235	130	(55%)	105	392	235	143	(61%)	235	392	355	179	(50%)	176

In contrast, analyses by NMFS (2001a; and peer review comments in Appendix B2) on ungrouped annual presence data show declines in the probability of detecting coho between 1989-2000 in the California portion of the SONCC Coho ESU. Also, in the CCC Coho ESU, NMFS found that increasing trends in coho detectability are confounded by variation in sampling effort between 1989 and 2000. Based on their most recent analysis, NMFS (2001a) concludes that the ability to detect coho is declining in the north, is lower in the south than in the north, and apparent trends in the south are confounded by changes in sampling effort between 1989-2000.

2001 Presence Survey Information

Southern Oregon/Northern California Coast Coho ESU

Of the 396 streams that were identified by Brown and Moyle (1991) as historically supporting coho salmon within the SONCC Coho ESU, 287 were surveyed in 2001 to determine if coho salmon presence could be detected. Of the 287 streams surveyed, presence of coho salmon was confirmed in 121 (42%) streams; conversely, presence of coho salmon was not confirmed in 166 (58%) streams (Table 6). Presence of coho salmon ranged from 100% in the Little River drainage (n=4) to 0% in the Bear River drainage (n=4). In the Eel River drainage, presence of coho salmon could be detected in 32 (27%) of the 117 streams surveyed (Table 6). Results of the presence surveys are shown in Figures 7, 8, 9, 10 and 11.

It should be noted that "presence not detected" for a particular stream does not necessarily mean that coho salmon have been extirpated. In some instances, only one reach of a sampled stream was surveyed, and coho salmon may have been present in those reaches not surveyed. Also, because coho salmon have a three-year life cycle, the inability to document one cohort (in this case, the 1999 or 2000 BYs) does not mean that other cohorts are missing, but would not be detected until surveys are done in subsequent years. Also, a single year's data from surveys may reflect adverse climatic or ocean conditions and not be completely representative of the population as a whole. For example, 2001 was classified as a drought year on the north coast, and this undoubtedly affected distribution to a greater degree than if it were a normal, above normal, or wet year.

On 110 (66%) of the 166 streams where presence could not be detected, sampling was considered to be intensive enough to detect coho salmon populations if they had been present in the stream. For these streams, surveys were done in at least two of three reaches (lower, middle, upper) following the "Modified Ten-Pool Protocol" methodology (Appendix C1), or were surveyed in only one reach because the other two reaches were inaccessible to coho salmon (because of either a barrier to migration or the other reaches were dry), or were not surveyed at all because the entire stream was dry. Although this does not show conclusively that coho salmon are absent from these streams, this high level of sampling effort indicates that coho salmon were likely not present in the stream, or that population size is so low that coho salmon were not detectable by standard survey methods.

Central California Coast ESU

Of the 173 streams listed by Brown and Moyle (1991) as historically supporting coho salmon populations within the CCC Coho ESU, 135 were surveyed during 2001 by the Department and other organizations (Table 7). Of the streams surveyed, presence was confirmed in 43 streams, and not confirmed in 92 streams. The percentage of streams within a basin with confirmed presence ranged from 88% (n=8) in the Noyo River basin to 0% for the Gualala River basin (n=10).

In addition to the 2001 surveys, 23 streams surveyed between 1995 and 2000 were assumed to have extant populations of coho salmon because they were found in three consecutive years during this period. Combining the 2001 survey results with the assumed presence of coho salmon, Mendocino County streams had a greater coho salmon presence in historical streams than the watersheds to the south. In Mendocino County, coho salmon were present in 58 (62%) of 93 streams that were surveyed or were assumed to have coho salmon present. To the south of Mendocino County, only eight (12%) of the 65 historical streams surveyed, or assumed to have coho salmon, contained them (Table 7). Results of the Department's 2001 presence surveys are shown in Figures 12 and 13).

Table 6. Results of the Department's 2001 coho salmon presence surveys of SONCC Coho ESU streams listed by Brown and Moyle (1991) as historically containing coho salmon. Appendix C2 lists streams surveyed in 2001 by the Department.

Basin	No. of streams surveyed	No. of streams with coho present (%)	No. of streams with coho presence not detected
Smith River	37	14 (38%)	23
Klamath River	25	17 (68%)	8
Redwood Creek	14	11 (79%)	3
Little River	4	4 (100%)	0
Mad River	21	12 (57%)	9
Humboldt Bay	18	12 (67%)	6
Eel River	117	32 (27%)	85
Bear River	4	0 (0%)	4
Mattole River	31	9 (29%)	22
Other Coastal	13	6 (46%)	7
Total Streams Surveyed:	**284**	**117 (41%)**	**167 (59%)**

Table 7. Results of the coho presence surveys in streams listed by Brown and Moyle (1991) as historically containing coho salmon for CCC Coho ESU streams. Appendix C2 lists streams surveyed in 2001 by the Department.

	No. of streams surveyed in 2001 (A)	No. of streams with coho present in 2001 (B)	No. of streams with coho assumed present [e] (C)	No. of streams w/ coho not detected in 2001	Percent present (1995 - 2001) [f]
MENDOCINO COUNTY					
Coastal	30	11	10	19	52%
Ten Mile River	11	9	-	2	82%
Noyo river	8	7	5	1	92%
Big River	8	3	6	5	64%
Navarro River	14	6	1	8	47%
Subtotal	71	36	22	35	62%
SONOMA COUNTY					
Coastal	4	0	-	4	0%
Gualala River	10	0	-	10	0%
Russian River	29	1	1	28	7%
Subtotal	43	1	1	42	4%
MARIN COUNTY					
Coastal	5	2	-	3	40%
Salmon Creek	5	0	-	5	0%
Lagunitas Creek	5	4	-	1	80%
Subtotal	15	6	-	9	40%
TRIBUTARIES TO S.F. BAY					
Coastal	6	0	-	6	0%
Subtotal	6	0	-	6	0%
TOTAL	135	43	23	92	42%

[e] Coho salmon were assumed to be present if presence in three consecutive brood years was detected between 1995 to 2000. These streams were not surveyed in 2001.

[f] (B+C) / (A+C)

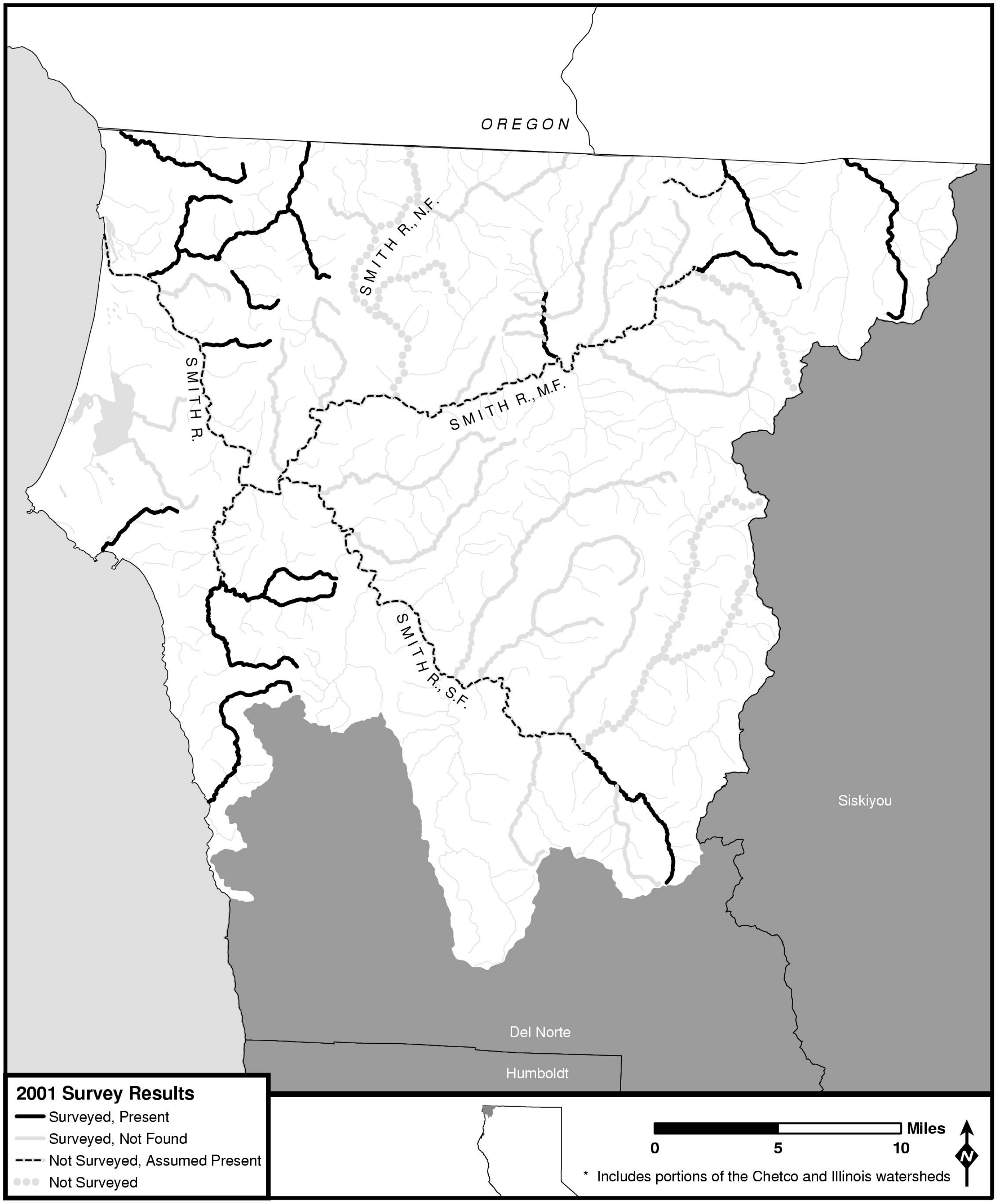


Figure 7. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Smith River watershed. Includes portions of the Chetco River and Illinois River watersheds.

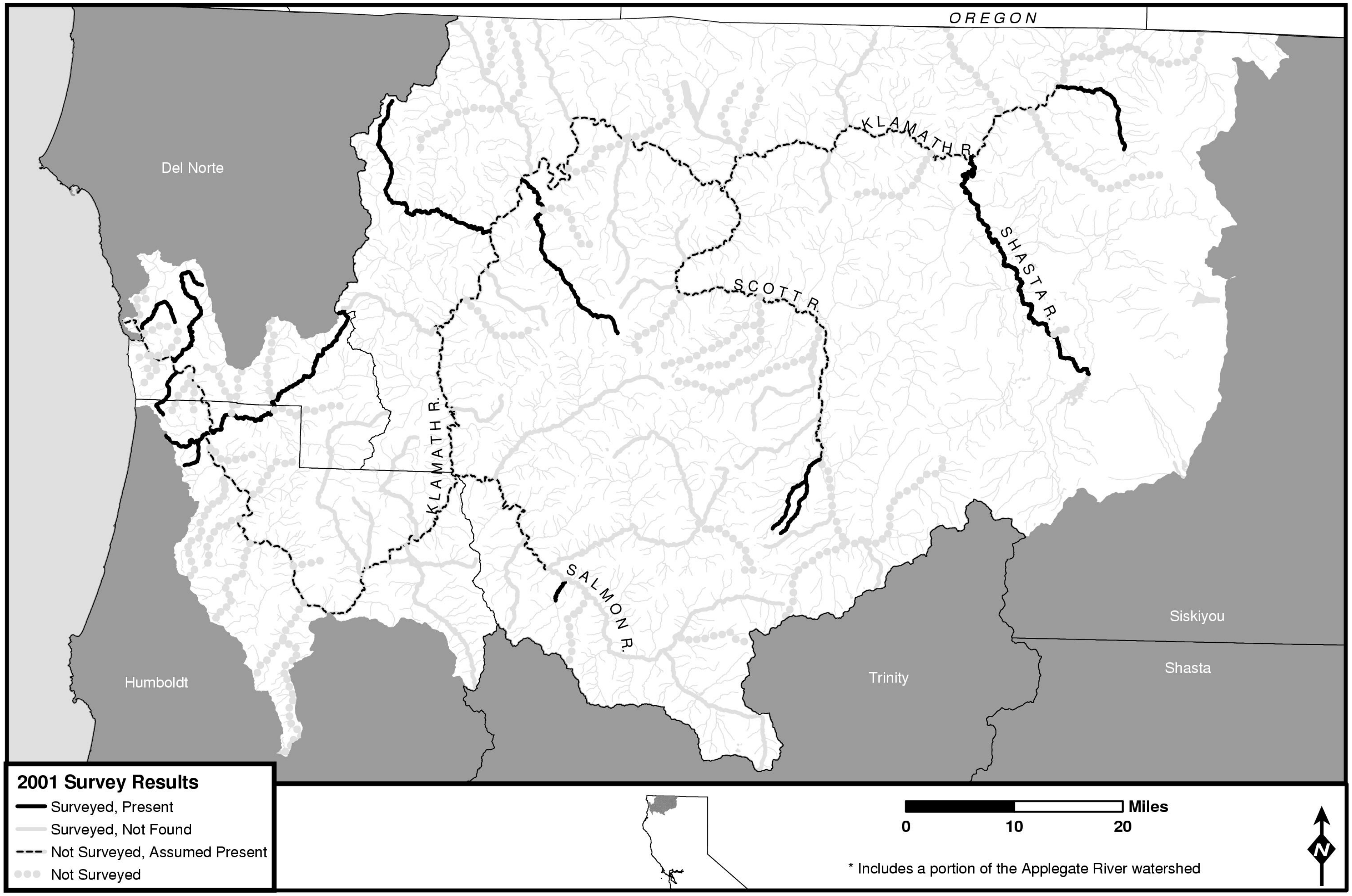


Figure 8. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Klamath River watershed.

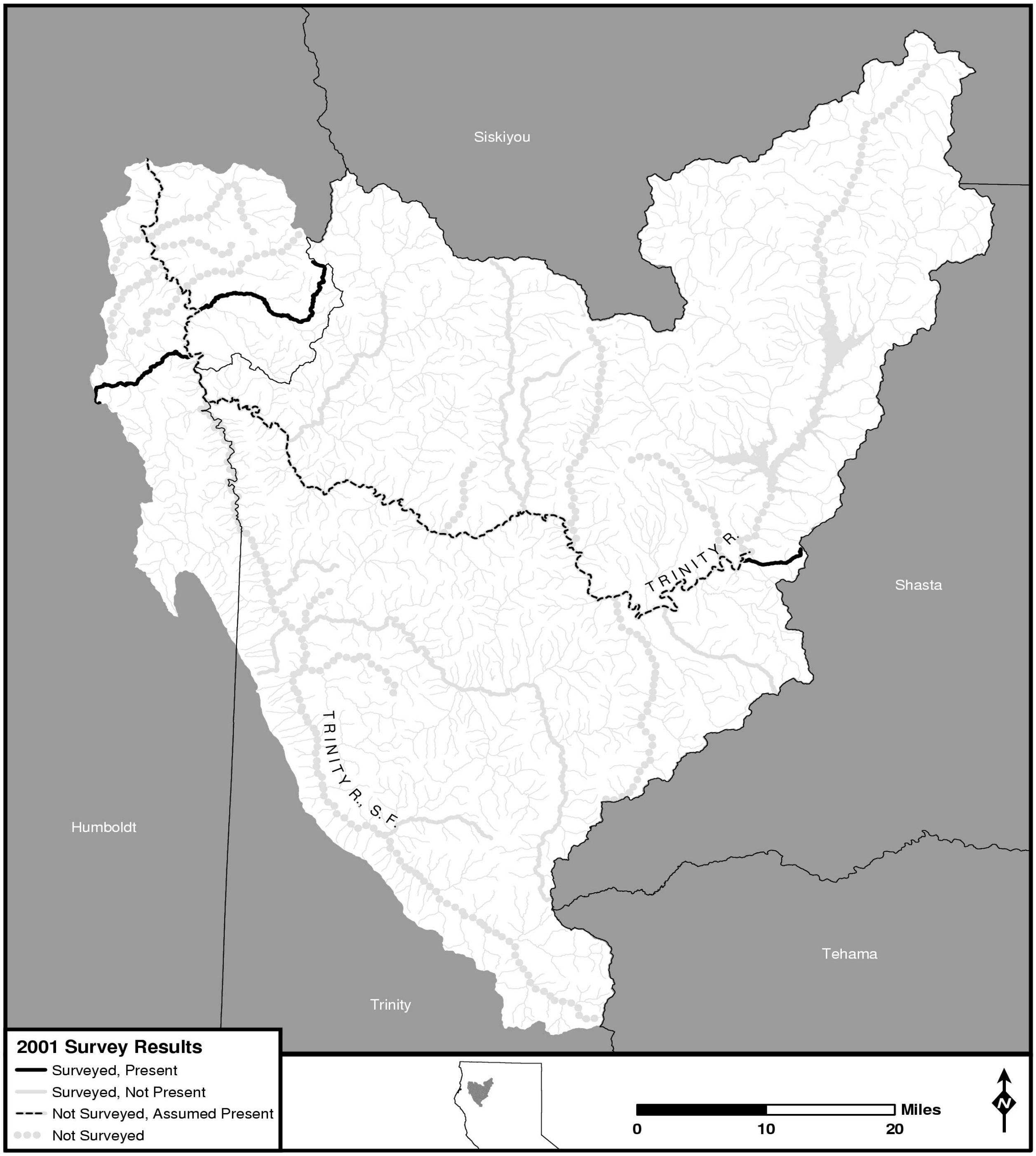


Figure 9. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Trinity River watershed.

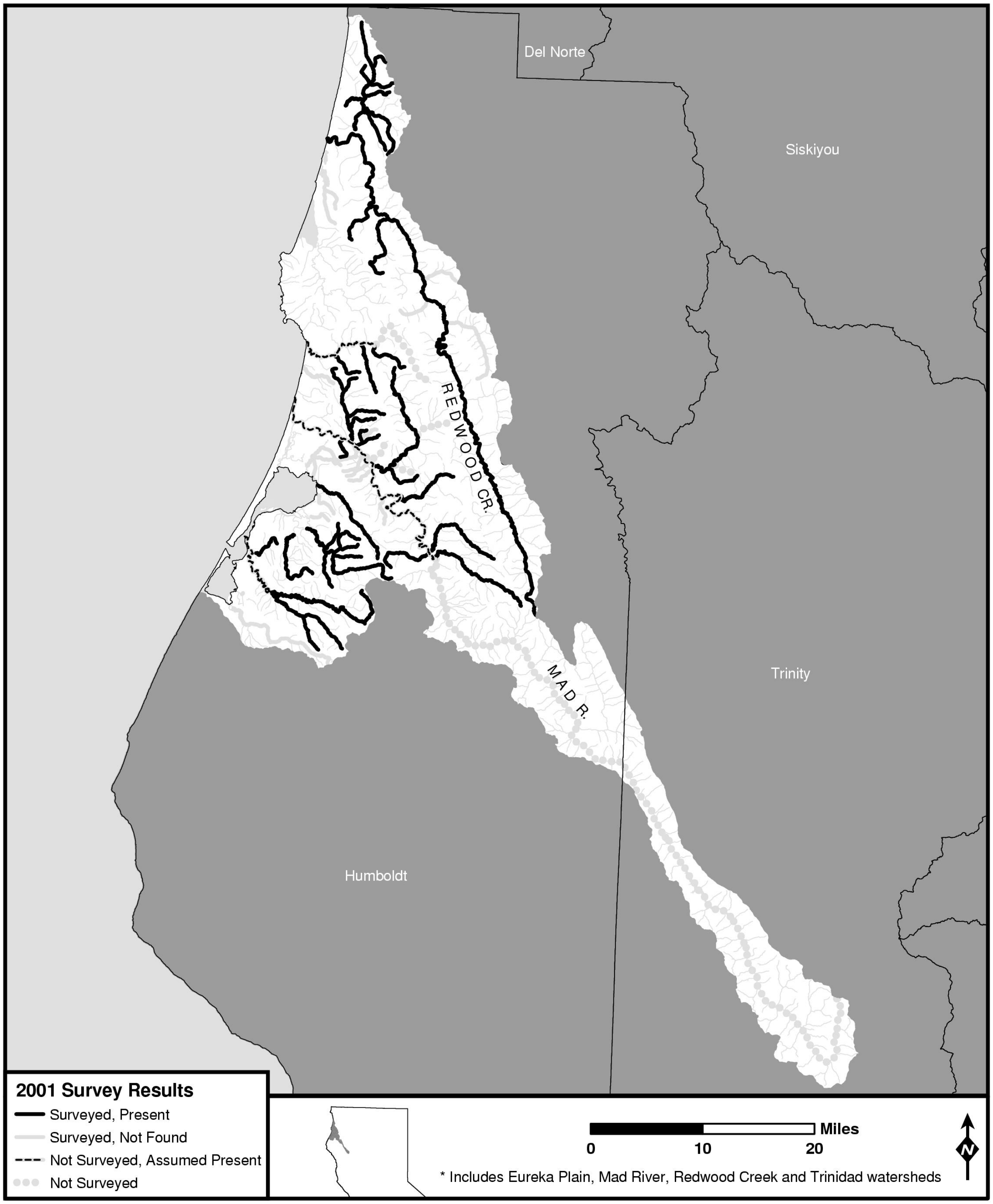


Figure 10. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Redwood Creek, Mad River, Eureka Plain, and Trinidad watersheds.

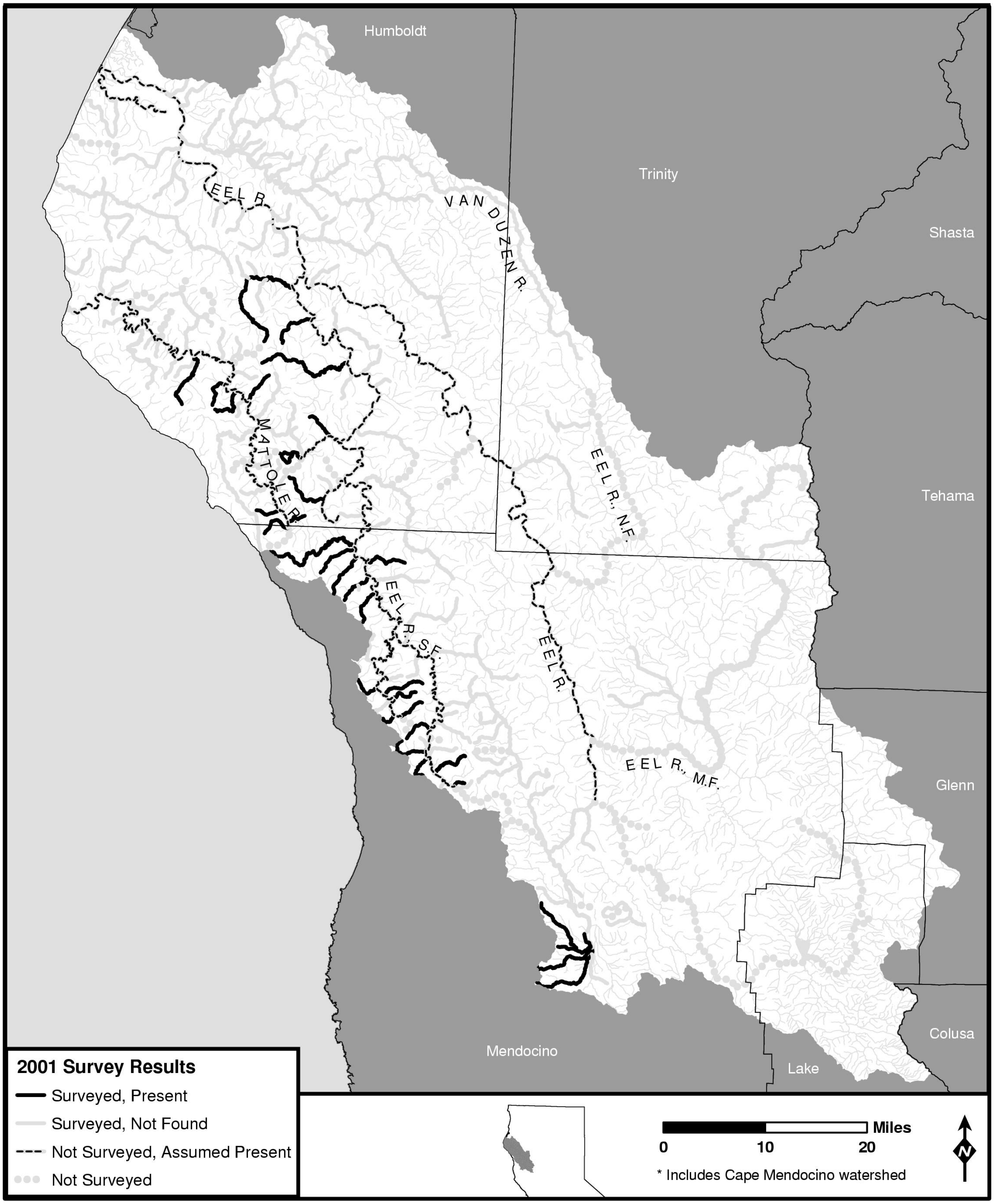


Figure 11. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Eel River watershed.

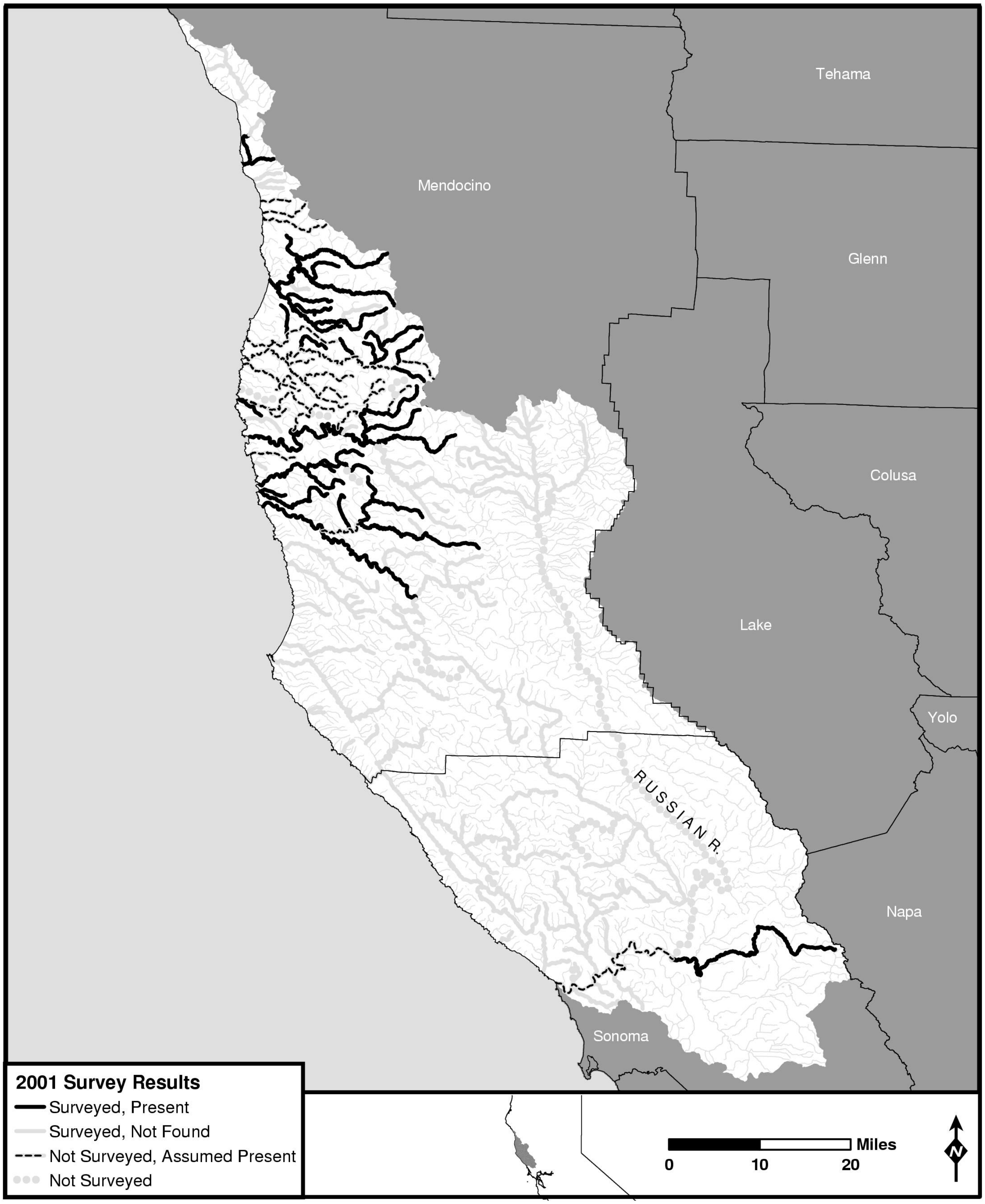


Figure 12. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of Mendocino County coastal and Russian River watersheds.

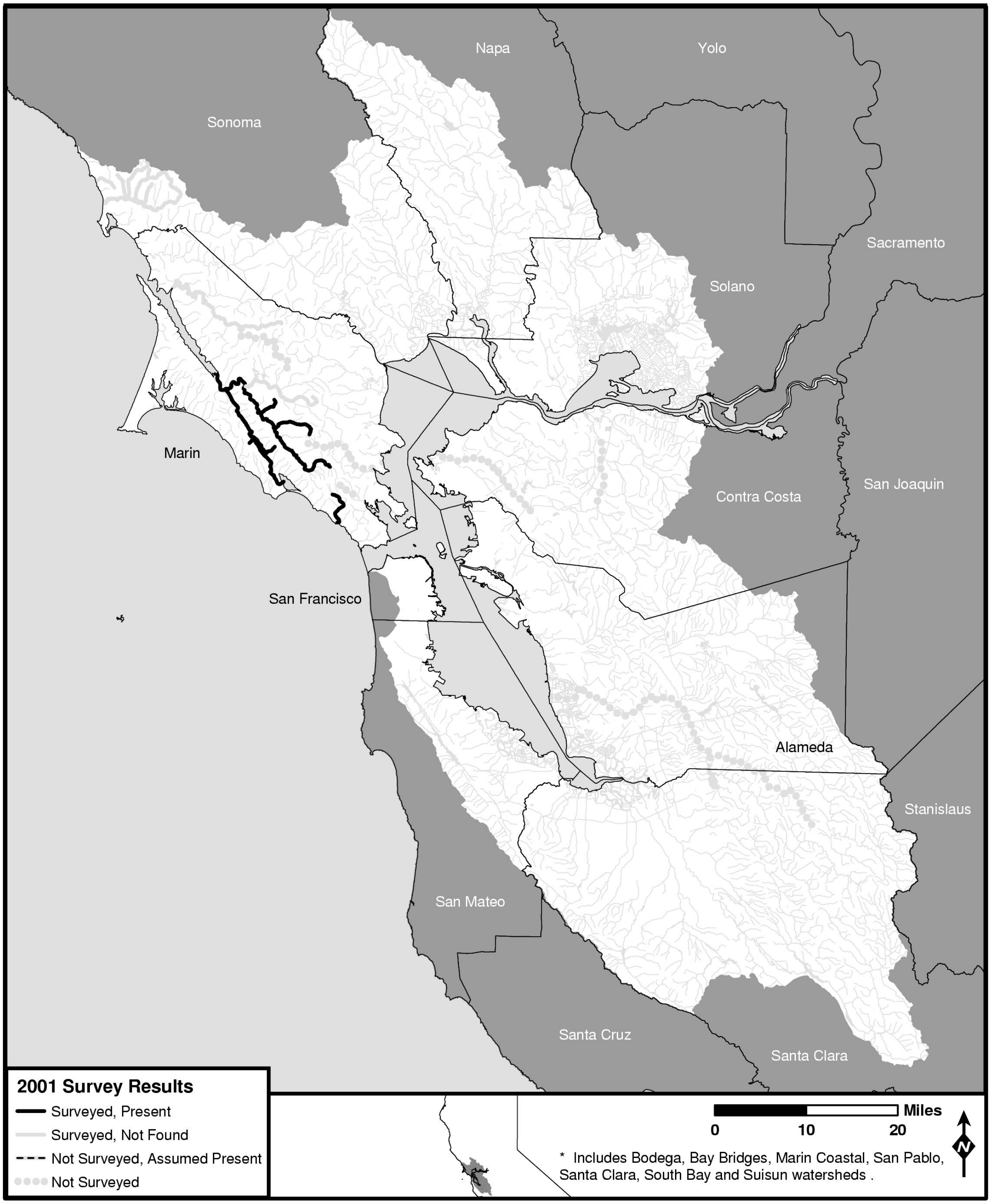


Figure 13. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of Marin County and San Francisco Bay coastal watersheds.

Abundance and Trends

Historical assessments of coho salmon abundance are based on estimates made by fisheries managers from limited catch data, hatchery records, and personal observations (Brown et al. 1994). Historical population estimates and subsequent declines are not easy to document because the species is divided into many small populations of which very few are monitored closely (Brown et al. 1994). In the 1940s, there were estimated to be between 200,000 and 500,000 coho salmon spawning in California. The number of spawners decreased to about 100,000 in the 1960s, with 40,000 in the Eel River alone (CDFG 1965; Brown et al. 1994). In 1984-85 the statewide total of natural spawners was estimated at 30,480 (Wahle and Pearson 1987), 6% to 15% of the level in the 1940s.

Coho salmon were historically an important part of the ocean salmon catch. Commercial coho salmon landings totaled over 1.6 million pounds annually between 1976 and 1979 (data from NMFS 1977-1993, as cited in Brown et al. 1994). Increased hatchery production is correlated with the large catches of the 1960s and 1970s, and is probably responsible for them (Brown et al. 1994). However, the commercial catch dropped precipitously in the late 1970s despite continued large hatchery releases (Brown et al. 1994). Correlation analysis indicates that there is an inverse relationship between California hatchery production and commercial landings $r = 0.65$; $p = 0.02$) from 1979 through 1990 (Figure 14)[11]. As hatchery production increased, commercial landings decreased, indicating that the decline in catch during this period is not due to reduction in hatchery production. Commercial catch dropped to less than 20% of 1976-79 levels (301,000 pounds annually) during the 1980s. Annual commercial and sport catch combined still totaled 83,000 coho salmon in the 1980s (Brown et al. 1994). The harvest of 11,000 pounds in 1992, the last year of coho salmon retention in the commercial fishery, was substantially lower than previous years (Brown et al. 1994). Catch per unit effort for the commercial fishery similarly plummeted in 1992 compared to previous years (Figure 15). Retention of coho salmon in the ocean recreational fishery has been prohibited for areas north of Horse Mountain, California since 1994, and coastwide since 1995.

Brown et al. (1994) compiled data on historical and current presence/absence, population size, and trends in abundance from a variety of sources and for numerous coho salmon streams. Their recent estimates covered the years 1987-91. They concluded at that time that California native stocks were at low levels and that the streams containing coho salmon were fewer compared to historical estimates. The authors stated that the methods employed likely overestimated population sizes, so documented declines are probably more severe than estimated. Among their specific findings are:

- The total number of coho salmon adults in California streams between 1987-91 is estimated to be an average of 31,000 per year, 57% of which are hatchery-origin fish.

- The total estimated number of non-hatchery adult coho salmon, including both naturalized and native wild stocks, returning to spawn between 1987-91 was about 13,000 per year.

[11] Figure 14 depicts California coho salmon production only and does not reflect Oregon coho salmon production. Oregon hatchery coho salmon are known to comprise a large portion of the ocean catch.

- Naturalized spawners with recent hatchery ancestry were estimated to number about 9,000 per year between 1987-91. This was 69% of the total natural-spawning stock.

- Native wild coho salmon are estimated to consist of less than 5,000 fish per year. Many of these were thought to exist in populations of less than 100 individuals per year.

- Coho salmon abundance is likely less than 6% of 1940s levels. There has been an estimated decline of at least 70% since the 1960s.

- California coho salmon populations will likely continue to decline.

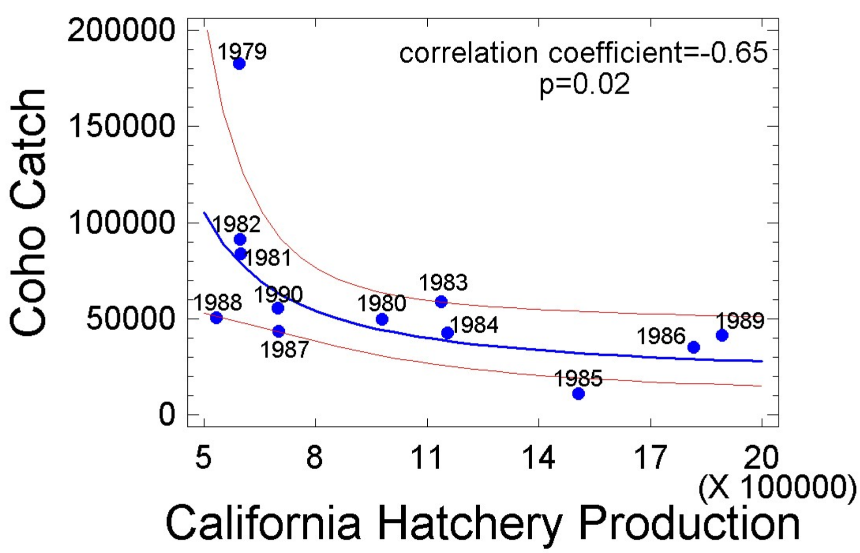
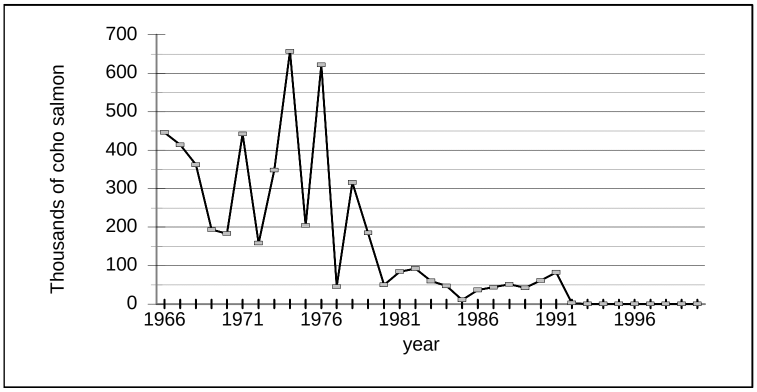
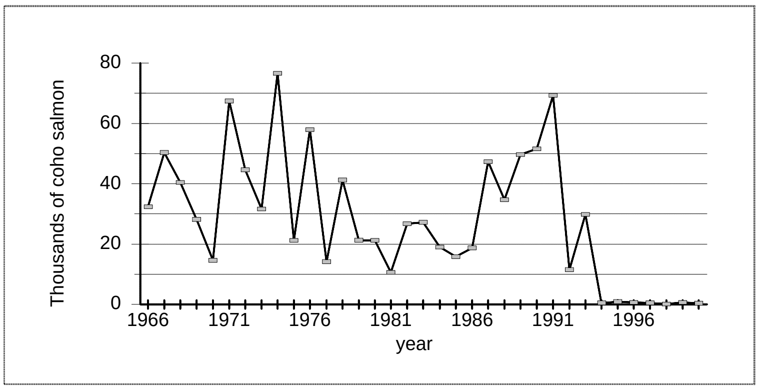


Figure 14. California coho salmon hatchery production of juveniles vs. commercial catch of adults two years later, 1979 to 1990. Both catch and production are numbers of fish. Catch is determined from landings at Crescent City, Eureka, Fort Bragg, and San Francisco. An S-curve model was used to fit the line.





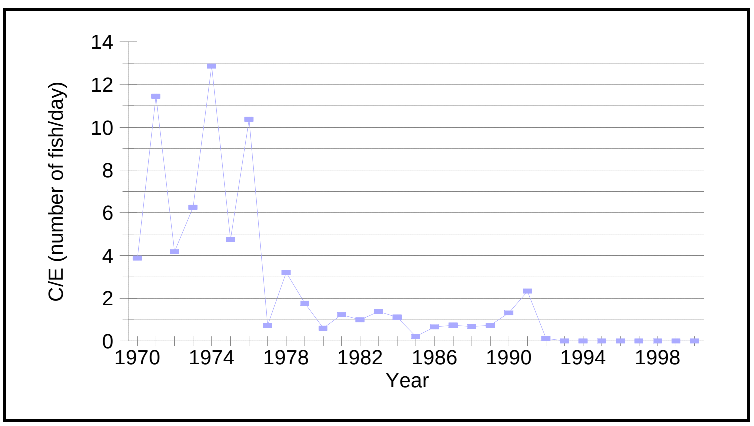


Figure 15. California commercial and ocean recreational coho salmon catch. Top graph is commercial ocean catch, 1966 to 2000; middle graph is recreational ocean catch, 1966 to 2000; and bottom graph shows number of coho salmon caught per day in California's commercial ocean salmon fishery, 1970-2000. The last year of commercial and ocean recreational coho salmon retention in California was 1992 and 1993, respectively.

Between 1987 and 1991, the estimated average coho salmon spawning escapement in the CCC Coho ESU was 6,160 natural-and 332 hatchery-spawned coho salmon. Of the naturally spawning fish, 3,880 were from tributaries with hatchery supplementation. Most of the fish in the remaining rivers were also judged as being influenced by hatchery stock and only 160 fish in this ESU were identified as native stock (Brown et al. 1994). The Eel River was estimated to have less than 1,000 coho salmon by 1991 (Brown et al. 1994). Naturally-spawned coho salmon returning to California streams were estimated to be less than one percent of their abundance at mid-century (Brown and Moyle 1991).

Weitkamp et al. (1995) reviewed the status of coho salmon in Washington, Oregon, and California. They relied upon estimates in Brown et al. (1994) for assessment of California ESUs of coho salmon. A summary of the population size data (originally from Brown et al. 1994) used in that review are in Table 8. NMFS (2001a) is an update of the Weitkamp et al. (1995) coho salmon status review that focuses on California and contains more recent information. NMFS (2001a) reviewed available data from juvenile surveys, outmigrant trapping, adult migrant trapping, spawning surveys, and redd counts. Data for the CCC Coho ESU consist largely of short time-series summer density estimates from short stream reaches. A few data sets extend into the mid- to late-1980s. The conclusions reached in these NMFS reviews are summarized below.

- Consistent patterns found in most basins within the CCC Coho ESU suggest that, while these data may not be particularly robust in detecting trends within a specific stream reach, they do appear to track large scale trends in abundance over watersheds and larger geographic areas reasonably well (Figure 16).

- For those data that extend to the mid-1980s (Caspar Creek, Little River, and Pudding Creek), the abundance in the 1990s was clearly lower than in the mid-to late 1980s.

- Overall, 126 (55%) of the 229 cohort replacement rates (CRRs)[12] calculated from the available census data were less than one, indicating a significantly ($p = 0.0045$) higher likelihood that abundance decreased rather than increased at a particular site. If a population increase is as likely as a population decrease, an equal number of observations would be expected to fall above and below 1.

- Although there is some variability among sites, the general overall trend in the 1990s is one of continued decline. The authors concluded that coho salmon in this ESU were depressed relative to historical levels and are presently in danger of extinction.

Juvenile coho salmon densities for index sites in Caspar, Pudding, Hollow Tree creeks, and Little River in the CCC Coho ESU are shown in Figure 17. The decline from the late 1980s to the late 1990s is evident. However, Caspar and Pudding creeks (Mendocino County coast) and one index site on Hollow Tree Creek (tributary to the South Fork Eel River) show a fairly substantial upward swing in 2001 (and in 2000 for Caspar Creek). Despite the recent upswing at Caspar Creek, the 1987 brood year lineage has shown a precipitous decline at both index sites since the late 1980s (Figure 18). However, counts on Caspar Creek show relatively substantial

[12] CRR = N_{t+3}/N_t; a measure of the growth rate of a population over a single generation. CRR = 1 represents replacement and no change. CRR > 1 represents a population increase. CRR < 1 represents a population decline. In a run with stable population size over all generations, CRR would oscillate around 1.

numbers of smolts of the 1987 cohort emigrating in 2001, indicating that this brood year lineage may be recovering (Figure 19). These counts also show a decline in the 1988 cohort and relatively stability for the 1989 cohort. Smolt counts on Little River show a substantial decline for the 1987 and 1988 cohorts (Figure 19).

Despite the recent increases, time series analysis for Caspar Creek and Little River coho salmon smolts and juveniles show a declining trend and predict that this trend will continue (Figures 20 and 21) . Variability in abundance in the 1990s is potentially variation around population means that are substantially lower than they were historically. Both of the time series analyses presented here exhibit a negatively inclined forecast for future expected values. The confidences that the modelled time series are a good fit to the data do show varying uncertainty. Caution must be applied in interpreting these trend lines given the limited data analysed and the limited time period of the available data. However, despite the level of uncertainty, the data sets show the same negatively inclined forecast as evidenced by both the linear trend line and the time series model. This suggests that not only are coho salmon populations in decline, they are likely to continue this decline in the future.

Current data for the SONCC Coho ESU was less available than for the CCC Coho ESU. Only one data set extended to the 1980s. NMFS (2001a) determined that arriving at conclusions about declines in this ESU were more difficult than for the CCC Coho ESU. However, analysis of available CRRs showed that in 40 (60%) of 67 paired observations, CRR was less than one. This number was significantly ($p = 0.0278$) higher than expected based on an expectation of equal numbers of CRRs above and below 1. The authors concluded that the analysis documented a general decline of the populations analyzed. With the caveat that more data may reveal further declines not seen in the available data, coho salmon in this ESU were judged not to be presently at risk of extinction, although they are likely to become endangered in the foreseeable future.

The available data on coho salmon abundance was reviewed by the Department (CDFG 1994a) in a petition to the BOF to list coho salmon as a sensitive species. Coho salmon counts at the South Fork of the Eel River at Benbow Dam were presented as evidence of decline in the region (Figure 22). Coho salmon abundance in the Eel River at Benbow Dam averaged 15,000 fish annually in the 1940s. Averages declined to about 1,800 coho salmon adults annually between 1966 and 1975, the last 10 years of counts. This represents a decline in annual average of 88%, and is an indication that the magnitude of the coho salmon decline prior to the 1970s may have been more substantial than the observed declines of more recent years in this ESU. Coho salmon counts at Sweasey Dam on the Mad River show a slight decline from the 1930s to the late 1950s, and a relatively large increase in the early 1960s (Figure 22). However, returns of adult coho salmon at Mad River Hatchery indicate a declining trend in this river in more recent years (CDFG unpubl. data).

Nehlsen et al. (1991) reviewed Pacific salmon stocks at risk. Although the review does not contain information about specific coho salmon stocks in California, it identified small coastal stream stocks in the region north of San Francisco at moderate risk of extinction, and those in small coastal streams south of San Francisco at high risk of extinction. The Klamath River was identified as being of special concern, and coho salmon stocks in small streams were identified at moderate risk of extinction. Higgins et al. (1992) reviewed watersheds north of the Russian River and identified three coho salmon stocks in the CCC Coho ESU as being of special concern, and one (Gualala River) at high risk of extinction. In the California portion of the

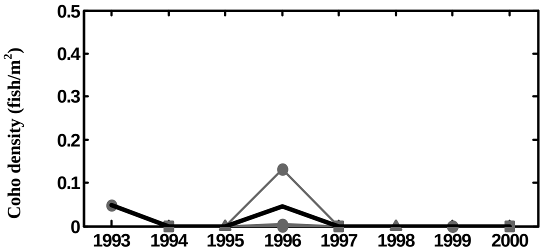
SONCC Coho ESU, ten stocks were identified as being of special concern and six at high risk of extinction.

Hatchery data are reviewed in Chapter VI, *Hatcheries*, and Chapter VII, *Hatchery Operations*. Hatchery production has declined dramatically in recent years largely due to decreases in returning spawners. Recent five-year average production for Warm Springs, Mad River, and Iron Gate hatcheries, and Noyo Egg Taking Station is only 11% to 44% of the average between 1987-91. While some of this reduction can be attributed to reduced production goals, lack of spawners has been the most important limiting natural factor. Only Trinity River Hatchery has maintained production at historical levels, and only Trinity River and Iron Gate Hatcheries currently produce relatively large numbers of coho salmon.

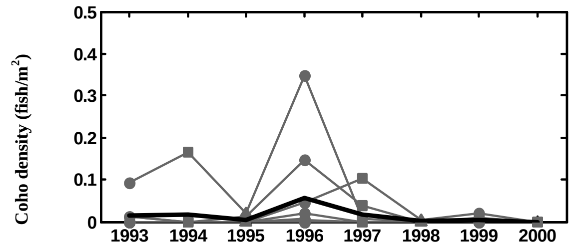
Table 8. Summary of estimated average coho salmon spawner abundance in California ESUs. Data are for the years 1987 through 1991. Reproduced from Weitkamp et al. (1995). Original estimates from Brown et al. (1994).

Region	Probably native	Native and naturalized	Hatchery	Total
Del Norte County	1,000	1,860	16,265	19,125
Humboldt County	3,480	740	891	5,111
Subtotal North of Punta Gorda [g]	4,480	2,600	17,156	24,236
Mendocino County	160	4,790	0	4,950
Sonoma County	0	635	332	967
San Francisco Bay	0	435	0	435
South of San Francisco Bay	0	140	0	140
Subtotal South of Punta Gorda	160	6,000	332	6,492
Total Spawners	4,640	8,600	17,488	30,728

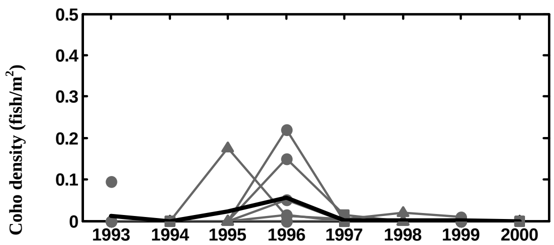
[g] A few minor streams in Humboldt County south of Punta Gorda are included in this subtotal.



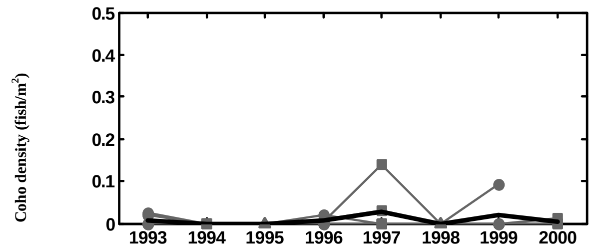
Densities for three index sites in the Usal Creek basin, Mendocino County.



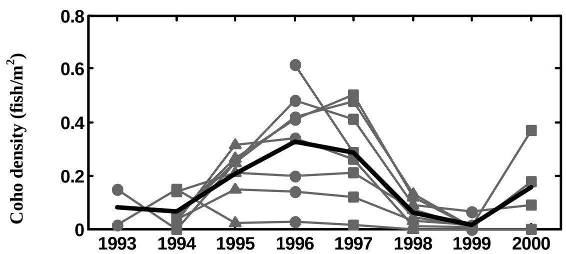
Densities for eight index sites in the South Fork Ten Mile River basin, Mendocino County.



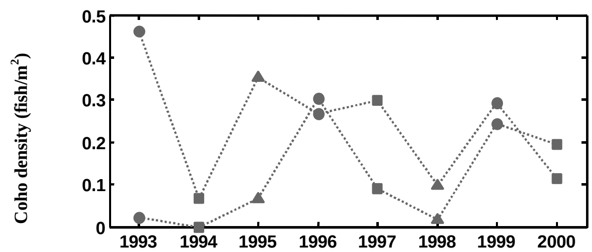
Densities for six index sites in the North Fork Ten Mile River basin, Mendocino County.



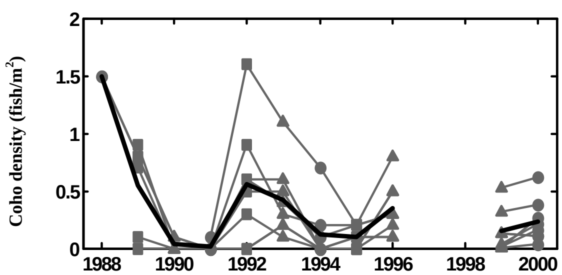
Densities for three index sites in the Middle Fork Ten Mile River basin, Mendocino County.



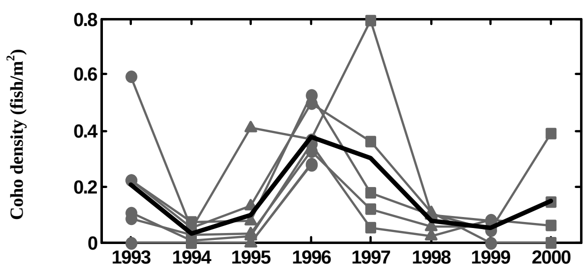
Densities for eight index sites in the Noyo River basin, Mendocino County.



Densities for two index sites in Big River, Mendocino County.



Densities for seven index sites in Albion River and its tributaries, Mendocino County.



Densities for six index sites in Big Salmon Creek and its tributaries, Mendocino County

Figure 16. Summer juvenile coho salmon densities in the Central California Coast Coho ESU (from NMFS 2001a).

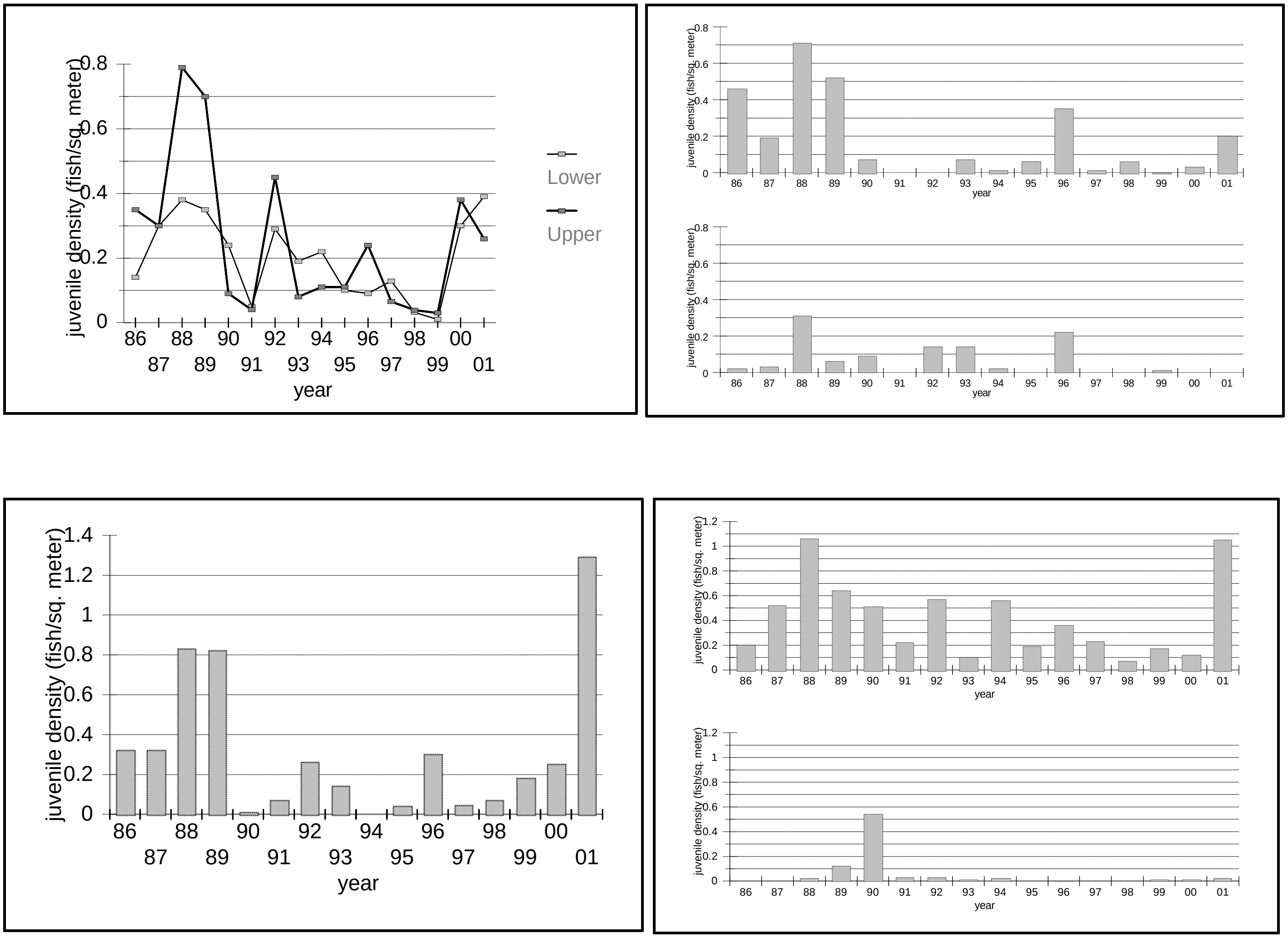


Figure 17. Juvenile coho salmon densities for: two index sites on Caspar Creek (top left); two index sites on Little River (top right); Pudding Creek (bottom left); two index sites on Hollow Tree Creek, South Fork Eel River (bottom right). No bar indicates that coho salmon were not observed during the survey in that year. (CDFG unpubl. data).

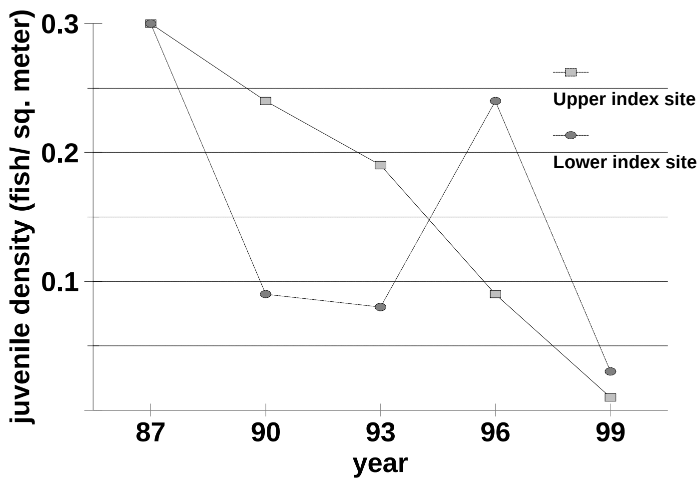


Figure 18. Juvenile coho salmon density at two index sites in Caspar Creek for the 1987 brood year lineage, 1987 to 1999.

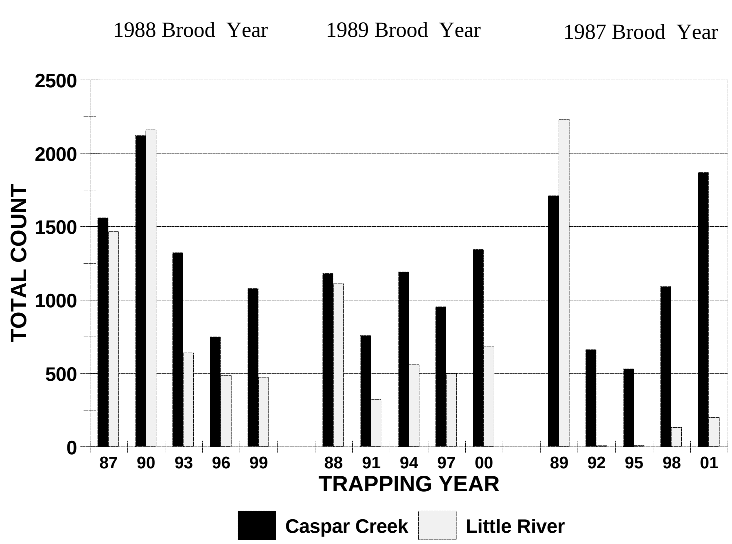


Figure 19. Coho salmon outmigration in Caspar Creek and Little River, 1987 through 2001.

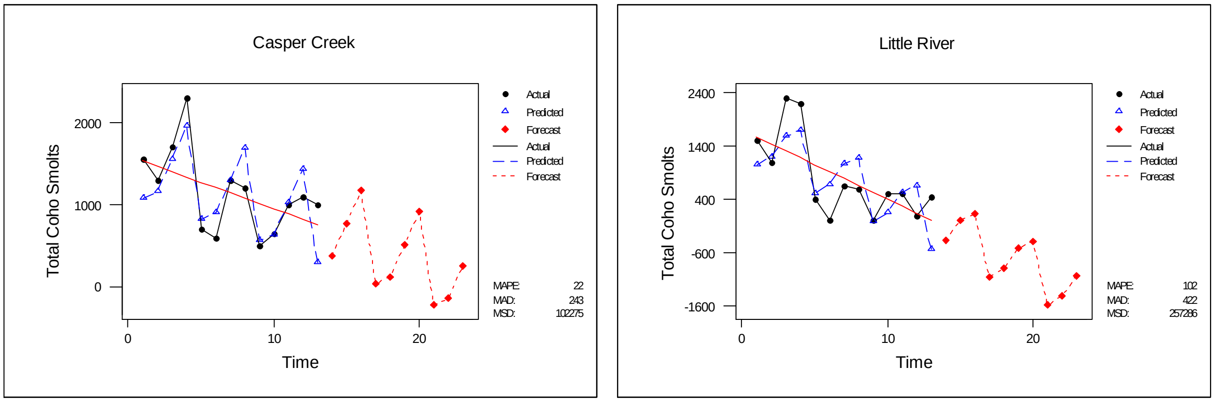


Figure 20. Time series plots and predictions for coho salmon smolt counts from Caspar Creek and Little River, Mendocino County. Decomposition time series with a seasonal trend of 4 years provided the best fit to the available data.

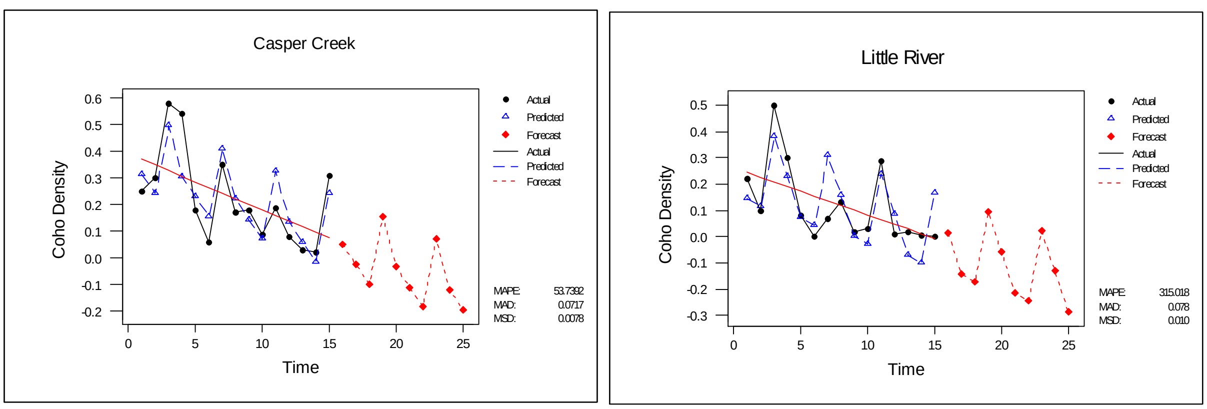
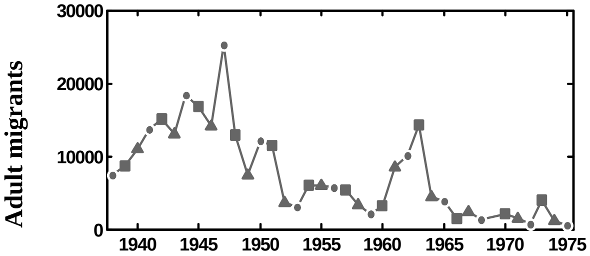
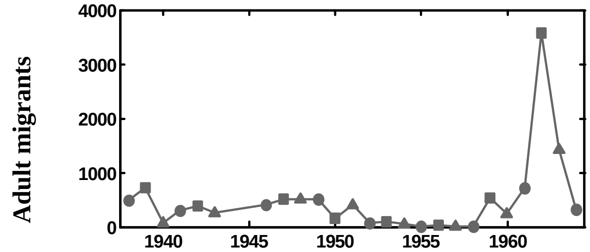


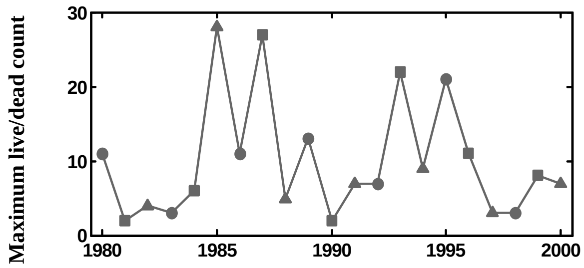
Figure 21. Time series plots with ≥ 10 years of data and predictions for coho salmon juvenile indices from Caspar Creek and Little River, Mendocino County. Decomposition time series with a seasonal trend of 4 years provided the best fit to the available data.



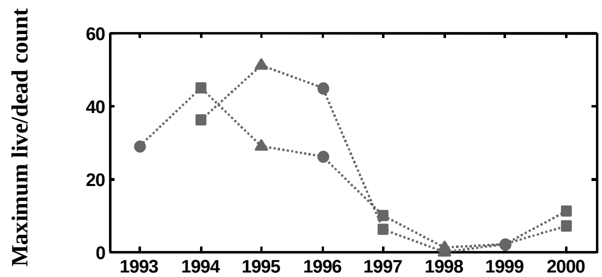
Coho counts at Benbow Dam, South Fork Eel River.



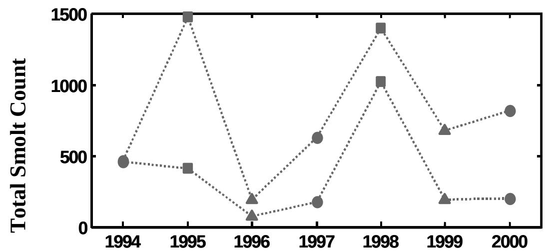
Coho counts at Sweasey Dam, Mad River.



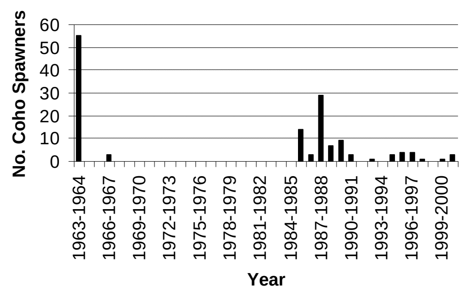
Spawner counts for West Branch of Mill Creek, Del Norte County. Symbols represent brood lineages.



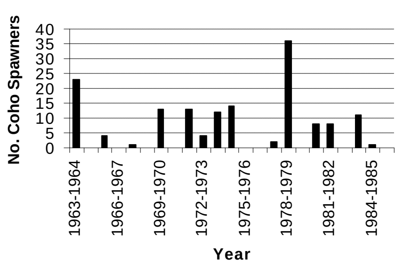
Spawner counts for West Branch of Mill Creek, Del Norte County. Symbols represent brood lineages.



Counts from downstream migrant traps in West Branch and East Branch of Mill Creek, Del Norte County.



Counts from spawner surveys on Cannon Creek, Mad River. Missing data indicates years when surveys where not done.



Counts from spawner surveys on Sprowl Creek, Eel River. Missing data indicates years when surveys where not done.

Figure 22. Abundance trend indicators in the Southern Oregon/Northern California Coast Coho ESU (from NMFS 2001a). Note the differences in the scale of the x and y axes.

Conclusions

Prior to 1994, commercial and recreational harvest provided a good measure of the decline of coho salmon statewide (Figure 15) and Pacific salmon ocean catch has been used in the literature as an estimate of abundance (Beamish and Bouillon 1993, Hare and Francis 1995, Mantua et al. 1997). Once an important part of the total salmon industry until the 1970s, coho salmon harvest dropped-off considerably in the late 1970s, and by 1992, stocks were perceived to be so low that the fishery was closed to protect them. The large catches prior to the late 1970s are correlated with, and were likely due to, increased hatchery production. However, the decline starting in the late 1970s occurred despite a fairly stable rate of hatchery production.

Southern Oregon/Northern California Coast Coho ESU

The available information on coho salmon status discussed in the previous section is primarily in the form of presence-by-brood-year analyses, field surveys conducted in 2001, recent abundance trend information for several stream systems along the central and north coasts, and ocean harvest data. Considered separately, none of these lines of investigation provide conclusive evidence that coho salmon have experienced a substantial decline throughout the SONCC Coho ESU, either because they are limited in scope or are not particularly robust in detecting trends within specific watersheds. However, most of these indicators show declining trends, and in that respect, provide a high likelihood that populations have declined significantly and are continuing to decline. Some of the indicators show an upward trend in 2000 and 2001, but the overall trend is still downward in most cases, and most indicators of abundance show values that are much reduced from historical levels. Brown and Moyle (1991) estimated that there has been a reduction in natural spawner abundance of 85% to 94% since the 1940s.

The analysis of presence-by-brood-year indicates that coho salmon occupy only about 61% of the SONCC Coho ESU streams that were identified as historical coho salmon streams by Brown and Moyle (1991) so it does appear that there has been a fairly substantial decline in distribution within this ESU (Table 5). However, our data do not support a significant decline in distribution since the late 1980s, as evidenced by the comparison of brood year presence in streams common to both the 1986-1991 and 1995-2000 periods. These analyses and the 2001 presence surveys indicate that some streams in this ESU may have lost one or more brood-year lineages.

The 2001 presence survey data may also indicate a decline in distribution in the SONCC Coho ESU. These data show a substantial reduction in the number of historical streams occupied by coho salmon, especially for the Mattole, Eel, and Smith river systems, where coho salmon appeared to be absent from 71%, 73%, and 62% of the streams surveyed, respectively. These data should be interpreted with caution, however, because they represent only one year of surveying, and the drought conditions of 2001 may have affected distribution. Nevertheless, the inability to detect coho salmon in streams that were historically documented to have contained them and are considered by biologists to contain suitable coho salmon habitat is significant, especially to the high degree that coho salmon were not found in these surveys (59% of the all streams surveyed).

Adult coho salmon counts at Benbow Dam on the South Fork Eel River show a substantial decline in this system from the late-1940s to the 1970s (Figure 22). Other trend indicators show declining or stable trends, with the only exception being coho salmon counts at Sweasey Dam on the Mad River, which show a relatively large increase in the coho salmon population in 1962 (Figure 22). However, returns of adult coho salmon at Mad River Hatchery indicate a declining trend in this river in more recent years (CDFG unpubl. data).

Although stocks in the SONCC Coho ESU appear to be declining and distribution within the watersheds appears to be reduced, population structures within the larger systems does not show fragmentation as severe as that occurring in the CCC Coho ESU. All major stream systems within the SONCC Coho ESU still contain populations, hence it is likely that they are not as vulnerable to extirpation from adverse climatic or oceanic conditions or demographic effects of fragmented populations. Also, as discussed previously, the presence-by-brood-year analysis indicates that the decline in distribution appears to have stabilized since the mid-1980s.

Central California Coast Coho ESU

The 2001 presence surveys in the northern portion (Mendocino County) of the CCC Coho ESU show a level of occupancy of historical streams that is similar to the SONCC Coho ESU (Table 7). However, streams systems to the south of Mendocino County show a much greater proportion of streams in which coho salmon were not found. These surveys and other recent monitoring indicate that widespread extirpation or near-extinctions have already occurred within some larger stream systems (e.g. Gualala and Russian rivers) or over broad geographical areas (e.g. Sonoma County coast, San Francisco Bay tributaries, streams south of San Francisco). Only three streams in the Russian River system still contain coho salmon, and only one of these populations exists in appreciable numbers. In the Sonoma County coastal area, coho salmon appear to be extirpated or barely persisting. Coho salmon were last observed in the Gualala River system in just two tributaries in 1995, and surveys of these streams in 1999, 2000, and 2001 failed to find coho salmon. The last year of observation of coho salmon in San Francisco Bay tributaries was in 1981, despite intensive fishery surveys conducted from 1992 to 1998 (Leidy and Becker 2001). Coho salmon are now present in appreciable numbers in only three, possibly four streams south of San Francisco (NMFS 2001a).

Most abundance trend indicators for streams in the CCC Coho ESU indicate a decline since the late 1980s (Figures 16, 17, 18, and 19). However, some streams of the Mendocino County coast, such as Caspar and Pudding creeks and Little River, show a fairly substantial upward trend in 2000 and 2001 (Figure 17). In addition, there is anecdotal evidence that relatively large numbers of coho salmon adults returned to some Marin Coast streams (e.g., Lagunitas Creek) in 2001. However, time series analysis for Caspar Creek and Little River show a declining trend and predict that this trend will continue, despite the recent increases (Figures 20 and 21).

Coho salmon populations of streams in the northern portion of CCC Coho ESU seem to be relatively stable or are not declining as rapidly as those to the south. However, the widespread local extinctions that have occurred throughout the southern portion is a major and significant portion of the range of coho salmon in this ESU.

VI. FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Climatic Variation

California experiences wide variation in climatic and hydrologic conditions. Various climatic phenomena including severe storms, drought, seasonal cycles, El Niño/La Niña events, decadal events, and regime shifts can alter the physical, chemical, and biological aquatic environment (Parrish and Tegner 2001). These changes can, in turn, play a major role in the life cycle, productivity, and persistence of coho salmon populations. Climatic fluctuation can cause extreme conditions that can be catastrophic. Coho salmon evolved with, and have persisted in the face of, extreme variability in habitat conditions caused by these natural phenomena. However, catastrophic conditions combined with low population numbers, habitat fragmentation, anthropogenic impacts, and habitat destruction or loss can cause an unrecoverable decline of a given population or species (Moyle et al. 1995).

<u>Drought</u>

In California, coho salmon populations exist in many coastal streams where stream closures occur due to sand bar formation at their mouths, created through wave action and low summer flows. Coho salmon are able to identify their natal stream by the seepage of fresh water entering the ocean through the bars, but they can't enter the streams until fall or winter rains increase flows sufficient to breach the sand bars. Shapovalov and Taft (1954) found that streams south of San Francisco may not be passable until as late as March. When this happens, a large portion of the run may enter the stream over a short period. As much as 70% of the total escapement may enter the stream from the ocean in as little as a few days (Sandercock 1991). During prolonged droughts, sand bars may never open in a given season and spawners may not be able to enter those streams (Anderson 1995).

Evidence from tree growth rings and other sources suggest that droughts persisting for decades have occurred in California in the past 1,000 years (NMFS 1997; Dettinger 2001). During these periods, stream flows may decrease, constricting or separating available habitat (Spence et al. 1996). Reduced flows can cause increases in water temperature, resulting in increased heat stress to fish and thermal barriers to migration. Anderson (1995) noted that desiccation of rearing and holding areas could eliminate year-classes or entire populations. Drought conditions along the Pacific coast in recent years may have depressed freshwater salmon production (Myers et al. 1998). Droughts can have limited benefits to fish including stabilization of stream features by allowing encroachment of vegetation into the active stream channel.

<u>Flooding</u>

Flooding is usually caused by heavy precipitation in a given watershed over a relatively short period, though smaller storm events can cause flood conditions in urban watersheds due to increased surface runoff (Booth 1991). High flows associated with floods can cause complete loss of eggs and larvae as they are scoured from the gravel or buried in the sediment (Sandercock 1991; NMFS 1998). Juveniles, smolts, and adults can also be affected by flooding. Smolts and juveniles can be transported and stranded on the floodplain or washed downstream to poor habitat, out to sea prematurely, or into isolated side channels and off-channel pools. Adults can be affected by peak flows influencing them to move into isolated channels and pools, or preventing migration through excessive water velocities. Streams can be drastically modified by erosion and siltation in large flood flows almost to the extent of causing uniformity in the stream bed (Spence et al. 1996). After major floods, streams can take years to recover pre-flood equilibrium conditions. Flooding is generally not as devastating to salmon in the more morphologically complex streams, because protection is afforded to the fish by the variety of natural in-stream structures (LWD, boulders, root wads, etc.), stream channel types (pools, riffles, side channels, etc.), and a established riparian area (Spence et al. 1996). Some of the beneficial effects of flooding are: cleaning and scouring of gravels, transporting sediment to the flood plain, moving and rearranging LWD, recharging flood plain aquifers (Spence et al. 1996), allowing salmonids greater access to a wider range of food sources (Pert 1993), and maintaining the active channel.

Changes in Ocean Conditions

Salmon abundance is known to be extremely variable. Bisson et al. (1997) estimated that salmon population size can experience year-to-year variation from 40-70%. Numerous sources have concluded that variation of salmon run-size and spawner escapement are strongly affected by changes in the marine and freshwater environment (Pearcy 1992; Beamish and Bouillon 1993; Lawson 1993). Relatively short term El Niño events (occurring at approximately three- to four-year intervals) and longer decadal to inter-decadal shifts are both known to affect marine organisms including salmon (Parrish and Tegner 2001).

El Niño and La Niña events have had major impacts on the primary and secondary productivity of the North American Pacific coast through changes in the thermal regime which limit upwelling and nutrient replacement (Brown et al. 1994). The term El Niño describes complex and large scale changes in the atmospheric pressure system, trade winds, and sea surface temperatures that occur over the entire tropical Pacific (Parrish and Tegner 2001) that can affect salmon production (Appendix B2). La Niña oceanic conditions are characterized by unusually cold ocean temperatures, relative to El Niño conditions, in the Equatorial Pacific (NOAA 2001). Marine productivity depends on atmospheric and oceanic circulation which affects the abundance of salmonids and other fishes. These shifts in wind, upwelling, and ocean currents have caused declines in ocean survival and decreases in size of coho and chinook salmon (Johnson 1988; Spence et al. 1996; Tschaplinski 1999).

Holtby et al. (1990) indicated that large numbers of predatory fish move northward in these conditions, possibly causing a major impact on the smaller first-year ocean coho salmon. The 1983 El Niño event off the Pacific coast of North America resulted in increased adult mortality and decreased average size for Oregon's coho and chinook salmon (Johnson 1988). That paper also noted that coho salmon entering the ocean in spring of 1983 survived poorly, resulting in low adult returns in 1984, and that the average weight of coho and chinook salmon landed in 1983 by Oregon's commercial troll fishery was the lowest ever recorded. Another component of El Niño is the flooding conditions it often brings to inland areas. U.S. Geological Survey streamflow hydrographs show that, in California, El Niño years are more likely to exhibit high flows or flood conditions than normal or La Niña years (Cayan et al. 1997).

In a La Niña event, the West Wind Drift is diverted south towards California. Typically, this happens when a weak low pressure forms south of Alaska (NOAA 2001). Generally, ocean conditions are cooler and possibly more favorable to salmonids during La Niña events; however, inland conditions caused by this phenomenon can affect survival of juveniles. Colder weather conditions are generally descriptive of La Niña events, but, depending on its severity, there could be associated drought or flooding (Null and Monteverdi 1999). Data from the San Francisco monitoring station indicated that during the 1975 La Niña, total seasonal rainfall was well below 50% of normal, whereas in the 1973 event, it was over 130% of normal. Null (2001) noted that high total seasonal rainfall does not necessarily denote major flooding conditions, but rather it is the timing of the storms within the season that determine the impact. The storms that create the most flood damage are those that occur as high intensity-short duration precipitation events.

Spence et al. (1996) noted that any changes in surface currents and upwelling strength will influence temperature, salinity, and nutrients, thereby affecting the abundance of food available to juvenile salmonids, the number and distribution of predators and competitors, and the transport of smolts entering the ocean (along-shore versus off-shore). Recent evidence suggests that when ocean conditions are poor for salmonids in the Pacific Northwest, conditions are favorable to Alaskan stocks, and vice-versa.

Recent studies have shown that longer time-scale (decadal to multi-decadal) changes have affected, and are currently affecting, marine organisms in California, including coho salmon (Parrish and Tegner 2001). Hare and Francis (1995), Beamish et al. (1997), Beamish et al. (1999), Pearcy (1992), and Lawson (1993), among others, describe recent and historical correlations between large-scale physical ocean changes, ocean productivity, and Pacific salmon abundance. Several recent studies have related ocean conditions specifically to coho salmon production (Cole 2000), ocean survival (Ryding and Skalski 1999; Koslow et al. 2002), and spatial and temporal patterns of survival and body size (Hobday and Boehlert 2001).

The Pacific Decadal Oscillation, indicated by changes in winter-time North Pacific atmospheric circulation, is associated with regime shifts in the subarctic and California Current ecosystems. These shifts are out of phase with one another, such that when conditions are good in the subarctic they are poor in the California Current, and vice-versa (Koslow et al. 2002). Cole (2000, based on results in Francis and Hare 1994, Gargett 1997, and Mantua et al.1997) stated that warm conditions in the northeast Pacific generally favor Alaskan salmon stocks, whereas cooler conditions appear to favor stocks south of British Columbia. A major regime shift that occurred in 1976/77 resulted in warmer surface waters from Mexico to Alaska. Resultant changes in ocean production negatively affected most salmon stocks south of British Columbia, including coho (Myers et al. 1998).

Conclusions

Long-term trends in the ability of freshwater environments to support salmonids may not be evident during periods of favorable oceanic conditions (Spence et al. 1996). Stated differently, favorable marine conditions can mask the effects of freshwater environmental degradation on salmonid populations. The cyclic nature of marine productivity as outlined by Lawson (1993) shows how it can mask the decline of a salmonid population (Figure 23). The conceptual model he presents combines the effects of oceanic cycles and freshwater habitat degradation. As the habitat degrades, the salmon populations do not decline in a linear fashion. Instead, due to the long-term cycles of productivity in the marine environment, the downward trend can be masked by higher escapement due to more favorable oceanic condition. In periods when unfavorable ocean conditions coincide with freshwater habitat degradation, the consequences are more evident, and the possibility of local extinction becomes greater for salmonid populations in degraded watersheds.

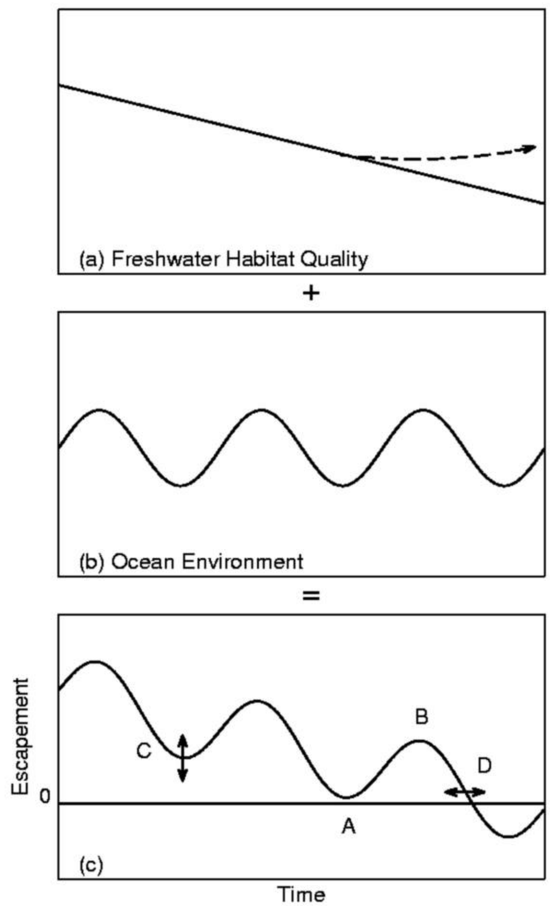


Figure 23. Conceptual model of effects of declining habitat quality and cyclic changes in ocean productivity on the abundance of coastal natural salmon. Top chart shows trajectory of habitat quality over time, with the dotted line representing possible effects of habitat restoration projects. Middle chart shows the cyclic nature of ocean productivity. Bottom chart shows the sum of top two panels where letters represent the following: A = current situation, B = situation in the future, C = change in escapement due to increasing or decreasing harvest, and D = change in time of extinction due to increasing or decreasing harvest (from Lawson 1993).

During periods of favorable environmental conditions, reproduction by individuals that colonize marginal patches might contribute to greater overall abundance and could buffer the effects of environmental variation when conditions worsen (McElhaney et al. 2000). However, a fragmented species consisting of small populations separated by large geographical distances and a high rate of loss of available habitat patches is vulnerable to catastrophic loss due to environmental fluctuations because each population is isolated and may be too small to be viable (McElhaney et al. 2000). In general, small populations with limited or fragmented distributions are more vulnerable to decline or extinction due to stochastic processes, cyclic events, and extreme climatic variation than larger populations with broad distributions. The National Research Council report on salmon in the Pacific Northwest (NRC 1996) recommended that maintenance of metapopulation structure with good geographic distribution should be a high management priority to ensure long-term perpetuation of salmon populations. Productivity of small populations may also be low due to depensation, which tends to prevent small populations from quick recovery from catastrophic events (McElhaney et al. 2000). Clearly some, if not many, California coho salmon populations are currently small and fragmented.

Shifts in salmon abundance due to climatic variation are known to be large and sudden (Beamish et al.1999). These changes may cause increases in local extinction rates. However, the Department believes that climatic variation (e.g. regime shifts) resulting in changes in ocean productivity and salmon abundance is generally not likely to threaten California coho salmon with extinction unless population sizes are low, distribution is limited, and metapopulation structure is fragmented. If these features are already compromised for other reasons, then natural shifts in abundance might increase local extinction rates and decrease potential for colonization enough to cause widespread extinction.

Changing ocean conditions, extreme climatic conditions, and natural variation can strongly impact salmon populations. However, salmon populations have not, until the past century or so, experienced these conditions in conjunction with the widespread human related degradation of their spawning streams (Brown et al. 1994; Anderson 1995). Anthropogenic factors can interact with natural variation to increase the frequency of catastrophic conditions (Bisson et al. 1997). Lawson (1993) concluded that the risks associated with poor climatic conditions may be exacerbated by human influence. Salmon evolved in a variable environment and are well suited to coping with it (Bisson et al. 1997). However, declines in population size, cohort loss, and population fragmentation likely reduce the ability of natural populations to respond to extremes of natural environmental variation. This may be especially true for species at the edge of their range like California coho salmon. Small populations can be forced to extinction by environmental variation when survival or productivity are frequently reduced over a long period of time (McElhaney et al. 2000)

Disease

Disease is a result of a complex interaction between the host, disease agents, and the environment. Natural populations of salmon have co-evolved with diseases that are endemic to the Pacific Northwest and have developed a level of resistance to these pathogens. Their resistance to different pathogens makes them unique and the most fit for that environment. For example, in the Columbia River system where ceratamyxosis, caused by the protozoan *Ceratamyxa shasta,* is prevalent, native salmonids have developed resistance to the pathogen and are not as severely affected as exotic stocks introduced by the hatcheries (Stoskopf 1993).

Generally, diseases and parasites do not cause significant mortality in native coho salmon stocks in natural habitats (Bryant 1994), and Shapovalov and Taft (1954) reported this to be the case in Waddell Creek during the 1930s and 1940s. Understanding mortality caused by pathogens in the wild is limited by the difficulty in determining the proximate and ultimate causes of death (e.g. when fish weakened by disease are consumed by predators). Currently, there is insufficient data from which to draw meaningful conclusions about the importance of disease in regulating wild populations (see comments, Appendix B2).

Coho salmon are susceptible to an array of bacterial, viral, parasitic, and fungal diseases found in salmonids of the Pacific Northwest. Symptomatic conditions appear when fish are stressed by high water temperatures, crowding, environmental contaminants, or decreased oxygen (Warren 1991). Diseases affect various life stages differently. Some of the diseases and disease agents in California that can cause significant losses in adult salmonids include: bacterial kidney disease (BKD) (*Renibacterium salmoninarum*), furunculosis (*Aeromonas salmonicida*), columnaris (*Flexibacter columnaris*), pseudomonas/aeromonas, and ichthyopthirius or “ich” (*Ichthyopthirius multifilis*) (William Cox pers. comm.). The diseases that are known to cause significant losses in juvenile salmonids are furunculosis, columnaris, coldwater disease (*Flexibacter psychrophilis*), pseudomonas/aeromonas, ichthyopthirius, nanophyetes, and ceratamyxosis (*Ceratamyxa shasta*) (William Cox pers. comm.). Although infectious hematopoietic necrosis virus (IHNV) can cause losses of up to 100 percent of juvenile chinook and sockeye salmon in hatcheries and has been found to be symptomatic in almost all Pacific salmon, coho salmon do not appear to be susceptible (Wolf 1988).

The introduction of disease into wild stocks is becoming an increasing concern. The transmission of diseases from hatchery to native coho salmon stocks is a potential threat, but the degree of risk and seriousness of such a problem are little known (Brown et al. 1994). Although wild coho salmon may be exposed to, and become infected by, numerous parasites and microbial pathogens, BKD (caused by the bacterium *Renibacterium salmoninarum)* is the pathogen of greatest concern in California (Anderson 1995). *R. salmoninarum* is an obligate intracellular bacterial pathogen of salmonid fishes. Species particularly susceptible to the disease include brook trout and Pacific salmon, and especially coho salmon (Austin and Austin 1987; Inglis et al. 1993). The bacterium is slow growing, usually producing chronic disease in fish older than six months of age (Post 1987). Bacteria replicate and survive within host defense cells (macrophages) and the yolk of eggs, and are thus protected from the fish's immune defenses (William Cox. pers. comm.). *R. salmoninarum* survives for short periods in freshwater and seawater (approximately 14 days) (Austin and Austin 1987). BKD is widespread throughout the Pacific Northwest, and in California it has been detected at one time or another at most salmonid hatcheries and in wild salmonid stocks (Austin and Austin 1987; Inglis et al. 1993; William Cox pers. comm.).

R. salmoninarum is transmitted vertically (mother to egg) and horizontally (in water from fish to fish, or orally in hatcheries via unpasteurized fish feeds) (Warren 1991). Eggs are often infected from females that have high concentrations of *R. salmoninarum* in their ovarian fluids at spawning (Warren 1991; William Cox pers. comm). The bacteria may infect eggs by passage through the micropyle. Probably less common, eggs may become infected while in the ovarian tissue, before exposure to ovarian fluid. Although males are infected by *R. salmoninarum,* they do not appear to play a role in vertical transmission (William Cox pers. comm.).

There are essentially no treatments for BKD in wild populations of coho salmon due to consumptive and water quality issues (William Cox pers. comm.). Hatchery stocks have been successfully treated, however, once BKD is detectable in the fish it is impossible to eliminate or cure the disease. At best certain antibiotics can prevent progression of disease and transmission to uninfected fish. Once therapy is discontinued the disease usually resumes. Erythromycin has been used with good results, since it deposits in fatty tissues (e.g. egg yolks) and has a long half life in tissues. Adults injected approximately one month pre-spawning have produced clean eggs at Big Creek Hatchery (William Cox pers. comm.), and in various other hatcheries in the Pacific northwest.

Predation

Freshwater Predation

Anadromous salmonids have historically coexisted with both marine and freshwater predators. Predation occurs on all life stages of coho salmon, and though predation does not appear to have a major impact on a healthy population, it can be detrimental on those with low numbers or poor habitat conditions (Anderson 1995). As the quality of riverine and estuarine habitat decreases, predation may increase, playing a larger role in reducing some salmonid stocks as the loss of refuge habitat (e.g., deep pools, estuaries, LWD, and undercut banks) increases. Low stream flows and warmer water temperatures due to water diversions, water development, and habitat modification can enhance predation opportunities. These conditions may effect salmon mortality directly through predation, or indirectly through stress and disease, making them more vulnerable. Reduced water flow through reservoirs has increased juvenile travel time and thereby increased their exposure to predators (Columbia Basin Fish and Wildlife Authority 1991, as cited by NMFS 1998).

Predators such as invertebrates, fish, and birds, depending on conditions, can reduce the survival of eggs and alevins (Sandercock 1991). The vulnerability of this life stage to these animals depends on their depth and placement in the redd. If they are washed free of the redd, usually both stages are consumed quickly.

Freshwater fish predators of coho salmon are both native and non-native. Some of the native fishes known to consume coho salmon are: sculpin (*Cottus sp.*), steelhead rainbow trout (*Oncorhynchus mykiss*), coastal cutthroat trout (*O. clarki clarki*), and coho salmon (Shapovalov and Taft 1954; Sandercock 1991; Anderson 1995). Non-native or introduced fishes such as Sacramento pikeminnow *(Ptychocheilus grandi*s), smallmouth bass *(Micropterus dolomieui*), and channel catfish *(Ictalurus punctatu*s) can consume significant numbers of juvenile salmon if the conditions are favorable for them (NMFS 1998).

For example, Sacramento pikeminnow, a species native to the Sacramento and Russian river basins (Moyle 1976), were illegally introduced to the Eel River basin via Lake Pillsbury during the early 1980s (NMFS 1998). In just over ten years, they have spread to most areas of the Eel River basin, reflecting the fact that this ecosystem has been so significantly altered that this species now appears to be better adapted than native salmonids due to the artificially warmer water conditions (Brown et al. 1994). As a result, introduced Sacramento pikeminnow constitute a serious problem for Eel River system native salmonid populations (Higgins et al. 1992; CDFG

1994a). If increased water temperatures and altered ecosystem trends continue, a shift towards the dominance of warmwater species can logically be expected (Reeves 1985).

Striped bass *(Morone saxatilis*) can also be a significant predator of juvenile salmonids, and have been observed in the Russian River system. However, there is no indication that they have had a significant impact on coho salmon.

Avian predators of juvenile salmonids include dippers (*Cinclus mexicanis*), gulls (*Larus spp.*), belted kingfishers (*Megaceryle alcyon*), herons (*Ardea spp*.), common mergansers *(Mergus merganser*), and osprey (*Pandion haliaetus*) (Sandercock 1991; Spence et al. 1996). Wood (1987) estimated that common mergansers were able to consume 10% of the coho salmon production in two coastal British Columbia streams. He also indicated the birds select fish by size, concentrating on girth rather than length, and feed primarily on hatchery fish, leaving the smaller native fish. As the quality of riverine and estuarine habitat decreases, avian predation will likely increase. Among mammalian predators that can impact salmonid populations, mink (*Mustela vison*) and otter (*Lutra canadensis*) can take significant numbers of the overwintering coho salmon juveniles and migrating smolts, although this is dependent upon conditions favorable to predators and the availability of other prey (Sandercock 1991).

Botkin et al. (1995) stressed that predation rates overall should be considered a minor factor in salmonid decline; yet as habitats are altered for both predator and prey, this may produce certain localized circumstances where predation has a greater impact.

Marine Predation

The relative impacts of marine predation on anadromous salmonids is not well understood, though documentation of predation from certain species is available. NMFS (1998) noted that several studies have indicated that piscivorous predators may control salmonid abundance and survival. Beamish et al. (1992) documented predation of hatchery-reared chinook and coho salmon by spiny dogfish *(Squalus acanthias*). Pacific hake (*Merluccius productus*) and pollock (*Theragra chalcogramma*)are known to consume salmon smolts (Holtby et al. 1990). Though not a major part of their diet, marine sculpins also consume juvenile salmonids.

There are many known avian predators of juvenile salmonids in the estuarine and marine environments. Some of these include belted kingfisher, gulls, grebes and loons *(Gavia spp*.), ardeids (herons, egrets, bitterns) cormorants *(Phalacrocorax spp*.), terns *(Sterna spp*.), mergansers *(Mergus spp*.), pelicans *(Pelecanus spp.*), alcids (auklets, murres, murrelets, guillemots, and puffins), sooty shearwaters *(Puffinus grisens*) (Emmett and Schiewe 1997; NMFS 1998). Bald eagles *(Haliaeetus leucocephalus*) and osprey are predators of adult salmonids (Emmett and Schiewe 1997). It is important to note that these animals are opportunistic feeders, meaning they will prey upon the most abundant and easiest to catch.

In the marine environment, the increase in marine mammal numbers, especially harbor seals *(Phoca vitulina*) and California sea lions *(Zalophus californianus*), has resulted in more encounters with the commercial and sport fishery and their gear (NMFS 1988). The effect of these interactions has at times been adverse to fishing harvest and equipment.

According to Bokin et al. (1995), investigators in the early 1900s believed that seals and sea lions had a minor impact on the salmon declines. Stomach contents of hunter-killed animals that were believed to be killing salmon, rarely contained any salmon. Further, they analyzed numerous, more recent pinniped-salmon studies, reporting their strengths and weakness, and dismissed many as not statistically valid. The studies that were not dismissed indicated that marine mammal predation on anadromous salmonid stocks in southern Oregon and northern California played only a very minor role in their decline.

Hanson (1993) reported that foraging of California sea lions and harbor seals on anadromous salmonids was minimal at the mouth of the Russian River. Roffe and Mate (1984) found that pinnipeds fed opportunistically on fast-swimming salmonids, yet found they took less than one percent of the returning adult summer steelhead in the Rogue River, Oregon. Williamson and Hillemeier (2001a, 2001b) indicated that in the Klamath River estuary, pinniped predation rate estimates on coho salmon in 1998 and 1999 were 0.2 % and 1.2 % respectively. Hanson (1993) stated that predation on salmonids appeared to be coincidental with their migrations rather than dependent upon it.

Hart (1987) and Stanley and Shaffer (1995) studied harbor seal and salmonid interactions in the Klamath River estuary to evaluate the feeding activity of the seals during the Department's chinook, coho, and steelhead seining and tagging operations. They observed that salmonid predation increased on days when seining occurred, with little to no predation on non-seining days. The estimated percentage of seined and tagged fish taken by seals was relatively constant, ranging from about 3% to 8%. Hart (1987) observed that a majority of the fish were consumed by as few as12 seals. This study exemplified pinniped opportunistic feeding habits: the seals consumed salmon that were likely made more vulnerable to predation through seining, handling, and tagging.

In most cases, salmonids appear to be a minor component of the diet of marine mammals (Scheffer and Sperry 1931; Jameson and Kenyon 1977; Graybill 1981; Brown and Mate 1983; Roffe and Mate 1984; Hanson 1993; Botkin et al. 1995; Goley and Gemmer 2000; Williamson and Hillemeier 2001a, 2001b). An analysis of scat samples of pinnipeds in the Smith, Mad, and Eel rivers found that salmonids had a relative abundance of 0.2% to 1.6% in the seals' scat (Goley and Gemmer 2000). Principal food sources of marine mammals include lampreys (Jameson and Kenyon 1977; Roffe and Mate 1984; Hanson 1993), benthic and epibenthic species (Brown and Mate 1983; Hanson 1993), and flatfish (Scheffer and Sperry 1931; Graybill 1981; Hanson 1993; Goley and Gemmer 2000; Williamson and Hillemeier 2001a, 2001b)).

Although salmonids appear to make up a relatively minor component of the diet of pinnipeds, this does not indicate conclusively that pinniped predation is not significant. The fact that coho salmon make up a small portion of an animal's diet could have no relation to the impact of that predation on the prey population. In fact, when a prey population is low, a very small amount of predation pressure can have a significant impact on the population. Predation may significantly influence salmonid abundance in populations when other prey are absent and physical habitat conditions lead to the concentration of adult and juvenile salmonids in small areas (Cooper and Johnson 1992). However, Cooper and Johnson (1992) also noted that based on catch data, some of the best catches of coho, chinook, and steelhead along the U.S. Pacific Coast occurred after marine mammals, kingfishers, and cormorants were fully protected by law.

Native predators are part of the natural environment in which coho salmon evolved. However, the combination of increased predator populations and large scale modifications of habitat that favor predators can shift the entire predator-prey balance. Adult salmonid injuries resulting from marine mammal attacks were thought to be on the order of a few percent annually prior to 1990 (NMFS 1998). Predation may have an impact on abundance of salmonid populations where altered ecological conditions (e.g. increase in water temperatures) favor an introduced predator or physical constraints (e.g. restricted entrance to a fish ladder) lead to the concentration of adults or juveniles in small areas.

Hatcheries

Hatchery- and natural-origin coho salmon are of the same species. Coho salmon runs that are influenced by a hatchery may contain any combination of natural-origin, hatchery-origin, and naturalized hatchery fish. Even if hatchery- and natural-origin coho salmon are different in some ways, hatchery-origin fish represent an important component of the total species' gene pool. Hatchery-origin and natural coho salmon are often indistinguishable genetically. Hatchery stocks can be important for recovery.

Hatcheries are inherently neither good nor bad. Hatcheries have for many years provided significant societal and economic benefits. Many of the effects that are discussed in detail in this section can be negative. These include changes that occur in fish taken into the hatchery, effects of hatchery fish on natural stocks, and complications to monitoring natural populations. However, hatcheries can also be beneficial in a number of ways, including:

- Conservation hatchery programs such as those at Warm Springs and Big Creek hatcheries have the potential to assist recovery of severely depleted coho salmon stocks in the Russian River and in streams south of San Francisco;

- Supplementation of natural stocks by hatcheries may reduce extinction risk over the short-term by a) buffering the effects of small population size against environmental variation and catastrophic cohort failure, and b) by potentially accelerating recovery;

- Carefully designed hatchery programs may increase the effective population size of a small population of natural spawners (e.g. Hedrick et al. 1995; 2000); and

- Hatcheries aid in successful recovery of natural stocks by providing fish for controlled research (e.g. on disease) that could not be done using naturally-produced fish.

The specific impacts of hatchery-origin fish and hatchery practices and management on California coho salmon have not been well studied. However, many studies from inside and outside of California have addressed the differences between hatchery and wild anadromous salmonids and potential hatchery impacts. Based on this documentation, classes of effects can be reasonably evaluated for California coho salmon. The majority of the information described below is from studies outside California. The Department believes that the classes of effects described here may apply to California coho salmon to the extent that conditions and practices described in these studies are similar to those in California. For example, some of the studies described below were conducted at enhancement facilities in Washington and Oregon, that release large numbers of juveniles. The effects of these large scale releases may be different than would be observed due to the limited releases from smaller mitigation facilities found in California. Where possible, we have attempted to qualify the available studies as to their applicability to California coho salmon hatcheries using this criterion.

The following review considers the possible effects of hatcheries on California coho salmon. The Department has in recent years made significant changes to its coho salmon hatchery programs in order to incorporate considerations for conservation. These measures include:

- Non-native source stocks and interbasin transfers were never as extensive in California as in other Pacific Coast states with coho salmon hatcheries. The department has since the 1980s stopped all interbasin and out-of-state transfers of coho salmon.

- Hatchery production of coho salmon in California is a small proportion of the total Pacific Coast hatchery production of coho salmon. Coho salmon production has been reduced or eliminated at most of the recently active hatcheries in California.

- The department participates in two state-of-the-art conservation hatchery programs for coho salmon that are an important part of the recovery planning for stocks in the Russian River and streams south of San Francisco. A third conservation hatchery program for coho salmon is planned at Mad River Hatchery.

- The Department is in the process of producing Hatchery and Genetic Management Plans (HGMP - see Chapter VII *Hatchery Operations*) for all of its hatcheries that will incorporate a conservation mandate into hatchery operations and practices.

- The Department continues to develop hatchery goals and constraints for coho salmon production at its facilities and modernize hatchery practices to minimize hatchery effects on both the hatchery and natural stocks. All coho salmon released from California facilities have been marked since 1996.

Legislative direction in FGC sections 6901 and 6902 and Commission policies on salmon state that natural production are the foundation of the state's salmon resources. The following discussion is presented for the purpose of examining the relationship between natural stocks and the hatchery stocks that may contribute to and interact with them, and the effects of hatcheries and their operation on both hatchery and natural fish. The long-term viability of both hatchery and natural stocks may be affected by the interactions between them. Lessons learned through review of this information will guide future hatchery activities to increase the recovery rate of depressed coho salmon stocks.

Overview of the Effects of Artificial Propagation and Non-native Source Stocks

There is a large body of theoretical and empirical evidence that supports the conclusion that artificial propagation itself can and sometimes does negatively affect natural and hatchery salmonid populations (Steward and Bjornn 1990; Hindar et al. 1991; Waples 1991b; Campton 1995; Flagg et al. 2000). Several published studies have found that hatchery stocks are generally less productive in the wild than locally adapted natural stocks, and that transplanted stocks are less productive than locally adapted natural ones (Leider et al. 1990; Waples 1991b; Meffe 1992; Fleming and Gross 1993; Reisenbichler and Rubin 1999).

In many cases, hatchery-origin salmonids differ in significant and often heritable ways from wild fish (Table 9; Flagg et al. 2000). Hatchery environments are very different from the natural environments of streams and rivers. Hatchery protocols often do not adequately mimic spawning, growth profiles, survival profiles, social and learning environment, or emigration timing of natural runs that can negatively affect post-release performance and subsequent fitness and productivity of both natural and hatchery stocks. The literature generally shows that hatchery-origin fish exhibit greater egg-to-smolt survival, poorer post-release survival, impaired foraging ability, rearing-dependent and genetically-influenced differences in agonistic behavior, differences in habitat preference, increased risk-taking behavior and associated increased vulnerability to predation, reduced fright response, alteration of stream-adaptive cryptic coloration, non-adaptive morphology and physiology, poorly developed secondary sexual characteristics and impaired mate competition, and altered spawning time. These differences can have potential negative consequences on the fitness and productivity of both hatchery and natural stocks (Weitkamp et al. 1995; Flagg et al. 2000; NMFS 2001a). Even if hatchery fish have reduced fitness in comparison with natural-origin wild fish, they can still negatively impact wild populations by their disruption of optimal natural **x** natural matings.

Non-native hatchery fish can come in contact with natural stocks in two ways. Imported stocks can be released onto natural stock and spawn with them, and/or imported stock can stray from the release stream to other streams and interbreed with natural stock. In addition, either natural-origin or hatchery-origin stocks may stray to another hatchery where they become incorporated into a hatchery stock that may subsequently commingle with a natural one. Based on what is known about stock transfers, sources, and outplanting, all of these could have potentially happened to California coho salmon.

Hatchery straying has recently been of concern to salmon biologists and managers (Grant 1997; CDFG/NMFS 2001). Whereas homing enables local adaptation and provides opportunity for divergence among spawning populations, migration between populations encourages convergence. Straying can be defined as naturally- and hatchery-produced fish spawning somewhere other than their natal area (CDFG/NMFS 2001). The term is also commonly used to describe hatchery-stocked fish returning to a spawning site in a stream other than the one in which they were planted. Sometimes hatchery-origin fish that spawn naturally instead of returning to the hatchery may also be called "strays". The proportion of a population that strays varies considerably among coho salmon populations, even over a small geographical area (Quinn 1997). However, even a small proportion of straying in a large hatchery stock can strongly affect the composition of salmon populations in receiving watersheds. The contribution of hatchery stock to the spawner population determines the level of impact, not the proportion of hatchery fish that stray (Nicholas and Van Dyke 1982; Grant 1997). This can affect not only the genetic composition of nearby stocks but can also severely compromise accurate stock assessment (see below, *Overharvest and Masking of Declines in Abundance).*

Table 9. Summary of differences between wild (W) and hatchery (H) salmonids (based on review by Flagg et al. 2000 with modification and additions).

General category	Specific category	Difference	Literature examples
Survival	Egg-to-smolt survival	H > W	Leitritz and Lewis 1980; Piper et al. 1982; Pennell and Barton 1996
	Post-release survival	H < W	Greene 1952; Salo and Bayliff 1958; Miller 1953; Mason et al. 1967; Fraser 1981; Fraser 1989; LaChance and Magnan 1990 a, 1990b; Reisenbichler and McIntyre 1977; Chilcote et al. 1986; Leider et al. 1990
Foraging behavior	Ability to effectively forage in natural environments	H < W	Sosiak et al. 1979; O'Grady 1983; Myers 1980; Mason et al. 1967; Uchida et al. 1989; Johnson and Ugedal 1986
Social Behavior	Agonistic behavior	Outcome depends on rearing environment	Symons 1968; Bachman 1984; Uchida et al. 1989; Grant and Kramer 1990; Olla et al. 1990; Berejikian 1995 a,1995 b; Olla et al. 1998; Moyle 1969; Swain and Riddell 1990 [h]
Habitat preference	Location in water column and orientation to the water surface	H higher than W H more surface oriented than W	Dickson and MacCrimmon 1982; Sosiak 1978; Mason et al. 1967; Uchida et al. 1989
Response/exposure to predators	Level of risk-taking behavior Fright response	H > W H < W	Uchida et al. 1989; Maynard et al. 1995; Olla et al. 1998; Johnsson and Abrahams 1991; Berejikian 1995b; Mason et al. 1967
	Cryptic coloration	H < W	Donnelly and Whoriskey 1991, 1993; Maynard et al. 1996
Morphology and physiology	Morphology	H morphology different from W, H swimming speed < W swimming speed	Taylor and Larkin 1986 [h]; Bams 1967; Taylor and McPhail 1985 [h]
	Physiology	Stress in presence of predators during smolting (H > W)	Järvi 1990
Reproductive behavior	Secondary sexual characteristics and ability to compete for mates Primary sexual characteristics	H < W H > W	Fleming and Gross 1989 [h], 1992 [h]; Berejikian et al. 1997 [h]
	Change in spawning time	H spawning time often earlier than W	Flagg et al. 2000; Nickelson et al. 1986 [h]

[h] Results specific to coho salmon

Although it is frequently assumed, it is unclear based on the available information whether hatchery salmon stray at a greater rate than natural-origin salmon; in some studies (all from outside California) they did and in others they did not (McIsaac 1990; Jonsson et al. 1991; LaBelle 1992; Potter and Russell 1994). Also, studies to date may have been too limited to draw accurate general conclusions from them (Waples 1999). Outplanted salmon might stray more than locally reared and released salmon, and straying fish may tend to enter nearby rivers more than distant ones, although there are many exceptions (reviewed in Quinn 1993; Grant 1997; CDFG/NMFS 2001). Quinn (1997) summarized the issue by saying that salmon tend to return to their release site, then on to their rearing site, if that site can be detected. If it cannot be detected, then they tend to spawn in the nearest appropriate place.

In a study specific to coho salmon, LaBelle (1992) did not find a significant difference in stray rates in coho salmon hatchery and wild populations on Vancouver Island. This author also observed age specific stray rates in coho salmon (older fish stray more), and suggested that coho salmon may home better to their natal site than to a new site. In a comparative study of straying, Shapovalov and Taft (1954) found that coho salmon strayed more than steelhead in two streams south of San Francisco. Stray rates for natural coho salmon in that study (15-27%) were considerably higher than for several Vancouver Island natural coho salmon populations (LaBelle 1992; 0-3.9%). Estimated stray rates of Trinity River Hatchery-produced coho salmon averaged 54.5% between 1997-1999 (reviewed in CDFG/NMFS 2001). The annual straying estimates were variable: 75.8% in 1997, 57.0% in 1998, and 30.8% in 1999. In several studies (Vreeland et al. 1975 [Washington], Solazzi et al. 1991 [Oregon]), coho salmon that were trucked from a hatchery to a release location tended to have impaired homing to the hatchery. Stray rates increased with distance between the rearing and release sites in Solazzi et al. (1991 [Oregon]). Stray-rate estimates from different studies are not directly comparable. However, to illustrate the kind of variation seen in these studies, some published stray rates for coho salmon are listed in Table 10.

Table 10. Some stray-rate estimates for hatchery and natural coho salmon populations.

Population	Range of Stray Rates Observed (Percent)	Literature Source
California, natural	15-27	Shapovalov and Taft 1954
Puget Sound, natural	1-65	Vander Haegen and Doty 1995
Washington coast, natural	0-67	Vander Haegen and Doty 1995
Columbia River, hatchery	0-12.4	Vander Haegen and Doty 1995
Washington coast, hatchery	< 0.5-4	Vander Haegen and Doty 1995
British Columbia, hatchery	0-27.7	LaBelle 1992

Overharvest and Masking of Declines in Abundance

In the presence of a large hatchery-origin component, natural-origin stocks can experience harvest pressure beyond that which they can support. High exploitation rates that minimally affect the hatchery stock component can overharvest the natural one (Ricker 1981; McIntyre and Reisenbichler 1986; Lichatowich and McIntyre 1987). Nehlsen et al. (1991) identified overharvest of natural stocks in mixed fisheries as a widespread factor in the decline of natural stocks; 100 of the 214 natural spawning stocks identified as being at risk of extinction were affected by overharvest in mixed fisheries. Coho salmon are not currently subject to an ocean harvest season in California waters, although they are included in by-catch in the chinook salmon ocean fishery. However, overharvest of natural-origin coho salmon in the mixed ocean salmon fishery may have been a significant factor in the history of the decline of California coho salmon prior to the fishery closure in 1993 (Brown et al. 1994).

Abundant hatchery-origin stocks can also mask the decline of natural-origin stocks. Historically, many, if not most, hatchery-origin coho salmon from California facilities were not marked before release. When these fish returned, they were superficially indistinguishable from natural-origin fish. Because of this, the true proportion of hatchery returns relative to natural-origin returns is not known for certain. Hatchery influenced runs may be composed of natural-origin, hatchery-origin, and naturalized hatchery-origin fish or a mixture. The composition of these mixtures is usually unknown (but see Nicholas and Van Dyke 1982, and discussion above).

The Department estimated that natural-origin coho salmon comprised 66% of their total Klamath River estuary juvenile coho salmon catch in 1997, 39% in 2000, and 27% in 2001 (CDFG 2000, 2001d). In addition, hatchery-origin coho salmon were larger (mean FL 150-160 mm) compared to natural origin coho salmon (mean FL 120-130 mm).

Hatchery supplementation[13] programs are designed to contribute spawners to the natural population, but have generally been unsuccessful. In the vast majority of examples (as reviewed in Flagg et al. 2000; Miller et al. 1990), salmonid supplementation programs have failed to produce a self-sustaining run. California coho salmon facilities are all either mitigation facilities (compensating for lost spawning habitat) or fishery enhancement, not supplementation. However, they likely do contribute some hatchery-origin spawners to the streams where they are located and those nearby. Brown et al. (1994) noted decreased abundance of coho salmon with increasing distance from production facilities. This suggests that hatchery-origin fish may inflate estimates of coho salmon abundance when hatchery and natural-origin escapement is combined, the effect being greatest near release sites and decreasing with increasing distance from the hatchery. At the same time, supplementation can theoretically enhance, and at times has demonstrated, an ability to support and contribute to small natural runs.

Modified supplementation programs based on the Conservation Hatchery Concept (Flagg and Nash 1999; Flagg et al. 2000) can overcome or minimize some of the problems associated with hatchery operations and hatchery fish to provide short-term, last-chance relief for

[13] Supplementation hatcheries are intended to contribute to the natural spawning population. Mitigation hatcheries are intended to make up for reductions in natural spawning due to human-caused habitat loss (e.g. dam construction). Enhancement hatcheries are intended to improve a fishery by increasing the number of catchable fish in the ocean or stream. Conservation hatcheries are experimental programs intended to supplement depressed natural populations or provide fish for artificial recolonization of streams that have experienced extinctions. Conservation hatcheries attempt to minimize or eliminate negative effects common to fish culture, resulting in as close to wild fish as possible.

populations on the brink of extinction. Currently, Warm Springs and Big Creek hatcheries in California are developing coho salmon conservation hatcheries based on captive broodstock.

With the exception of Trinity River and Iron Gate hatcheries, current coho salmon hatchery programs in California are either small, production has been terminated, or they are in the process of conversion to conservation hatcheries. However, NMFS (2001a) stated that past hatchery releases probably masked the true degree of decline of coho salmon populations in the CCC Coho ESU. NMFS (2001a) also stated that existing populations in CCC Coho ESU streams might only exist as a result of hatchery input.

Ecological Effects of Hatchery-Origin Fish on Natural-Origin Fish

Competition for food or space can occur when niches overlap, resources are limiting, and individuals are co-occurring in time and space. Intraspecific competition is generally thought to be more intense than interspecific competition because niches overlap more completely. Hatchery stocks, if released in large numbers relative to natural-origin juveniles in a limiting environment, may negatively affect natural-origin fish through competition. Many studies have found that hatchery-origin fish perform poorly after release (e.g., Miller 1953; Bachman 1984; Maynard et al. 1996; Flagg et al. 2000). However, other studies have suggested that hatchery-origin fish are competitively superior (e.g. when they are released at a larger size than the natural fish) and can displace natural-origin fish (Nickelson et al. 1986). Nickelson et al. (1986) reported that pre-smolt releases of Oregon hatchery-origin coho salmon were associated with displacement of natural coho salmon from their usual territories. Fraser (1969) reported depressed growth rates and increased mortality in coho salmon due to intraspecific competition for resources. Shapovalov and Taft (1954) found that for streams south of San Francisco the number of coho salmon outmigrants was inversely related to adult returns, suggesting that intraspecific competition somehow improves ocean survival of migrants. Emlen et al. (1990) and Ogura et al. (1989) discussed evidence for density-dependent factors affecting ocean survival in coho salmon. To the extent that these density-dependent factors hold in the ocean, increases in hatchery-origin coho salmon abundance have the potential to reduce the ocean survival of natural coho salmon. Competition can also occur among adults on the spawning grounds for space and mates.

Competition between Iron Gate Hatchery chinook salmon and natural coho salmon juveniles (as well as natural chinook and steelhead) due to early summer chinook releases was discussed in a recent review of California hatcheries (CDFG/NMFS 2001). Reduced river flows at this time of year and crowding of fish into the river from the hatchery increases the likelihood of competition among these stocks by concentrating fish at high densities within a few cold water refugia. The already high density of fish at these sites may be exacerbated by hatchery releases. Increased stress and disease transmission were other possible effects. Several alternate release strategies were proposed to alleviate these potential problems.

Other ecological factors that may impact coho salmon are cited in Flagg et al. (2000) and include predation by larger hatchery-origin fish on natural-origin fish, negative social interactions between hatchery and natural stocks, compromised fish health, and negative effects on migratory behavior. Waples (1991b) noted that wild fish are much more closely tied to climatic and environmental cues to outmigration than hatchery fish. Whereas large early flows may be sufficient to stimulate hatchery salmon to emigrate, wild or natural-origin salmon may respond better to prolonged or later flows that allow more variation in outmigration timing. Steward and Bjornn (1990) commented on the possibility of increased pikeminnow predation on coho salmon correlated with hatchery releases in the Columbia River.

A relatively common feature of hatchery stocks is alteration of run timing (Nicholson et al. 1986; Flagg et al. 1995). The normal cause is hatchery spawning of the first few fish that return rather than using broodstock collected over the entire run-time. This can change other ecological characteristics as well including body size and outmigration timing. Brown and Moyle (1991) noted that the Prairie Creek Hatchery coho salmon run returned earlier than the natural run. Precocious maturation, especially of males, is also a common negative feature of salmon propagation (Flagg et al. 2000).

Genetic Effects of Hatchery-Origin Fish on Natural-Origin Fish

Hatcheries are known to have the potential to affect the genetic integrity of natural populations when they come in contact with them (Simon et al. 1986; Withler 1988; Waples and Teel 1990). The genetic risks associated with hatcheries have been discussed extensively in the literature (Hindar et al. 1991; Waples 1991b, 1999; Busack and Currens 1995; Campton 1995; Allendorf and Waples 1996; NRC 1996). The fitness of natural-origin salmon can be decreased if they mate with hatchery-origin fish (Reisenbichler and McIntyre 1977; Reisenbichler 1997; Reisenbichler and Rubin 1999; Flagg et al. 2000). Campton (1995) noted that many of the effects attributed to hatchery fish are really due to hatchery and fishery management practice, rather than to the fish themselves. Over most of the history of hatchery influence on natural coho salmon stocks, genetic effects went unnoticed because they are subtle and hard to recognize unless genetic management is part of normal monitoring.

The effects of hatchery influence on wild population genetics are not always as severe or benign as expected since they depend largely on the differences between specific hatchery and wild stocks, and interbreeding or other interactions occurring between them. Hindar et al. (1991) and Skaala et al. (1990) in reviews of the genetic effects of hatchery stocks on wild salmonids cited examples of effects that ran the gamut from native stocks that had been largely or entirely displaced by hatchery stocks, to hybridization between native and hatchery fish, to examples in which repeated hatchery releases had no deleterious effect at all on the native population.

Waples (1991b) provides a framework for understanding the classes of impacts that hatchery fish/operations can have on the genetics of natural populations: 1) direct genetic effects due to hybridization of hatchery and natural fish and subsequent introgression; 2) indirect genetic effects due to altered selection regimes or decreases in population size caused by competition; predation, disease, or other factors not involving introgressive hybridization; and 3) genetic changes in hatchery stocks through artificial/natural selection in the hatchery, genetic drift, or use of non-native stock, which magnifies the consequences of hybridization when the stocks mix.

Introgressive hybridization between divergent hatchery and wild stocks is a direct genetic effect that can result in reduction of genetic variance between populations. In this case, the danger is that complete mixing of stocks will occur, resulting in a diversity of locally adapted wild stocks being replaced by a smaller number of relatively homogeneous ones (Allendorf and Leary 1988). Reisenbichler and Phelps (1989) found circumstantial evidence for the homogenizing effect of hatchery outplanting of steelhead in Washington.

Another direct genetic effect, outbreeding depression, is defined as the mating of individuals from divergent populations that results in loss of fitness in subsequent generations (Lynch 1997). As the genetic distance between populations increases, the probability of genetic incompatibility increases. Outbreeding depression results when a locally adapted wild gene pool is swamped by genes from divergent hatchery fish. In this scenario, displacement with immigrant alleles from hatchery adapted or non-native stock cause disruption of adaptive gene complexes (Dobzhansky 1955). As the distribution of a homogeneous stock becomes more widespread, its negative effects become greater as it encounters distinctive wild stocks. As summarized in Waples (1991b), Emlen (1991) determined through modeling that, if selective regimes are sufficiently different, reductions in fitness can occur even if mixture proportions are small (5-10%), and that recovery of fitness lost due to a single hybridization event may require many generations. Outbreeding depression due to hatchery influence is documented as a factor leading to reduced productivity in some coho salmon populations. Nickelson et al. (1986) in an experiment with hatchery influenced and non-hatchery influenced coho salmon in Oregon, documented decreased natural production in supplemented streams. NMFS (2001a) stated that potential outbreeding of large numbers of hatchery coho salmon from Trinity River Hatchery poses a significant threat to the genetic integrity of natural populations in the watershed.

Outbreeding can increase heterozygosity[14] in a stock. Mating with similar local stocks is sometimes suggested as a way to increase diversity within a reduced-diversity hatchery-origin stock (e.g., Simon et al. 1986). Bartley et al. (1992) reported a relatively high level of heterozygosity in hatchery influenced coho from Waddell Creek in comparison to the low heterozygosity reported for nearby Scott Creek, which had little hatchery influence.

Competition, predation, disease transmission, effects on ocean survival, and changing selective regimes can all affect genetic structure and cause changes in wild stocks indirectly through reduction of population size. Any factor that causes reduction in either total population size or effective population size (N_e)[15] can affect genetic structure. Reviews of these factors can be found in Steward and Bjornn (1990), Flagg et al. (2000), and above. Reduction of total population size can result in increased risk of local extinction and changes in genetic structure due to altered demographic factors.

Genetic changes occur in hatchery stocks in four major ways (Campton 1995; Busack and Currens 1995; Waples 1999): 1) intentional or artificial selection for a desired trait (e.g. growth rate or adult body size); 2) selection due to non-random sampling of broodstock; 3) unintentional or natural selection that occurs in the hatchery environment; and 4) temporary relaxation of selection during the culture phase that otherwise would occur in the wild.

Reduction in effective population size due to small numbers of breeders (N_b) causes "erosion of genetic variability through random extinction of alleles" (Waples 1991b). Small effective population size increases the proportion of individuals that are homozygous for deleterious recessive traits. The resultant reduction in fitness, called inbreeding depression, is defined as "exposure of the individuals in a population to the effects of deleterious recessive genes through matings between close relatives" (Lynch 1997). Substantial inbreeding depression

[14] In a population of organisms, the likelihood that an individual has different alleles for a given gene. A measure of genetic diversity.

[15] Used in management of genetic resources to express information about expected rates of random genetic change due to inbreeding and genetic drift. The size of a hypothetical ideal population with the same amount of random genetic change as the actual population experiences. Typically the effective population size is lower than the total population size.

has been reported in some hatchery stocks (reviewed by Allendorf and Ryman 1987). Utter et al. (1989) and Waples et al. (1990) did not find reduced heterozygosity in a survey of Pacific Northwest hatchery chinook. In California, Big Creek Hatchery used very small numbers of breeders (< 20 females and < 25 males per year) in their coho salmon hatchery program between 1994-1999 (see Chapter VII, *Hatchery Operations*).

Ryman and Laikre (1991) demonstrated that the overall effective population size of a mixed natural and hatchery population can be lower than that for the natural population alone. This decrease is especially likely if: 1) N_e of the natural population is small; 2) contribution from artificial production is large; and 3) N_e of the artificial population is small. With traditional hatchery operations and dwindling natural stocks, these conditions are often met. However, careful hatchery management (i.e. conservation hatchery management) can minimize reduction of overall N_e or even increase it (e.g. Hedrick et al. 1995, 2000).

Many of the differences between hatchery and wild salmonids (Table 9) that make hatchery fish different and less fit than wild fish in nature are due to different selective regimes in the hatchery, or substitution of selection leading to what is called domestication selection. Domestication selection can be defined as any change in the selection regime of a cultured population relative to that experienced by the natural population (Waples 1999).

Genetic change mediated by selection in hatchery populations is probably inevitable since selection will occur unless several unlikely coincidences occur that cancel differences in wild and hatchery mortality profiles (Waples 1991b, 1999). Some divergence between hatchery and natural stocks from which they were derived will always occur in hatcheries.

Natural selection that occurs in the hatchery includes selection for traits that are well adapted to hatchery conditions and avoidance of early life stage mortality that would normally occur in the wild. Early life-stage mortality may be as high as 50% in wild salmon, compared to 10% or less in hatchery salmon; but, post-release mortality of hatchery fish may be 99% or more, much higher than for wild fish (Howell et al. 1985). Artificial selection can also occur if broodstock are chosen to accentuate some trait that has perceived management or product value (e.g. age, size, time of return). Waples (1991b) states that, even if hatcheries attempt to control artificial selection, it will likely occur anyway since there is no way to mimic natural selection for reproductive success.

Conclusions

Brown et al. (1994) stated that most coho salmon stocks inhabiting large rivers in California are dominated by hatchery fish. Chapter VII, *Hatchery Operations*, reviews the available information on active coho salmon hatcheries in California, and this section reviews the possible and documented impacts associated with hatchery operations and hatchery fish. Based on this information, three conclusions can be drawn: 1) hatcheries have historically been active throughout the range of coho salmon in California; 2) California coho salmon hatcheries have produced numbers of fish that, while relatively small in a coastwide sense, are significantly large relative to natural production in places where large hatcheries have been active; and 3) stocks other than native ones, including out-of-basin and out-of-state imports, were propagated and released through California hatchery operations, and those returning fish clearly had the opportunity to interbreed with natural-origin coho salmon. These conclusions suggest that although hatcheries may have produced some benefits to local coho salmon populations, hatcheries have also had the opportunity to adversely affect natural California coho salmon populations.

Although the potential for negative hatchery impacts has existed in California for many years, and is implicated as a negative factor by available literature and documented production information, it is unclear exactly whether or how hatchery fish and/or hatchery operations have affected and are affecting California's natural coho salmon. First, the extent to which hatchery stocks interbred with natural stocks is not known. Second, the level of straying of hatchery stocks to streams with wild stocks is not known for all stocks[16]. Third, although many activities that have been shown to have negative impacts on salmonids in other places have occurred in California, specific negative impacts to coho salmon populations here are undocumented and therefore cannot unambiguously connect hatchery fish and/or hatchery practice to the decline of coho salmon in California.

Although no direct connection can be made due to lack of specific data, stock transfers from various sources from within and outside California have been implicated by several authors as a factor that might have contributed to the low diversity and weak population divergence observed in California coho salmon stocks (Brown and Moyle 1991; Bartley et al. 1992; Weitkamp et al. 1995; NMFS 2001a). Bartley et al. (1992) reported that hatchery influenced Waddell Creek coho salmon had the highest measure of heterozygosity of the 27 populations surveyed, possibly due to outbreeding with imported hatchery-origin stocks. They also suggested (and also discussed in Brown et al. 1994) that outbreeding with imported hatchery-origin stocks from within California, as well as from out-of-state sources, might have obscured whatever genetic differentiation formerly existed among California coho salmon populations. Waples (1991b) noted that historical mixing of stocks can often be detected as homogeneity of geographically distant populations. Bryant (1994) in a status review of coho salmon, noted that planting of non-native coho salmon in Scott and Waddell Creeks between 1950-70 likely contributed to the decline in returns and to the current genetic make-up of these stocks.

Hatcheries in California have dramatically reduced their production of coho salmon, limited outplanting, and stopped virtually all stock transfers in recent years. Therefore, current impacts of hatchery fish/operations on whatever remaining natural stocks still exist may be significantly less than in the past.

Widespread hatchery stocking should not be used by itself as documentation of wild stock extinction. Wild coho salmon stocks can persist in the presence of extensive hatchery stocking. Utter et al. (1995) reported the persistence of major ancestral regional patterns in Columbia River chinook salmon in the face of long non-native hatchery influence. Also, Phelps et al. (1994) unexpectedly found what appeared to be local native populations of rainbow trout in many places with long histories of non-native hatchery planting in Washington.

Many of the potential impacts reviewed here could have occurred given what is known about the universality of the results of research in this area. Hatcheries may have contributed to declines of coho salmon in California, although to what degree is unknown. Their potential to do harm is severely limited by decreased production and modern management policy.

[16] However, the few available estimates of stray rates of natural (Shapovalov and Taft 1954) and hatchery (CDFG/NMFS 2001) stocks are relatively high.

Genetic Diversity

Measures of Genetic Diversity

Genetic diversity within a species can be thought of in terms of the types and distribution of raw genetic material (i.e., alleles) that is present in individuals across the species' range. The structure of genetic diversity can be expressed at two levels: *within population diversity*—differences and similarities among individuals within a local breeding population, and *between population diversity*—differences and similarities among more or less separate breeding populations. The measurement and presentation of genetic structure has been discussed extensively in the literature leading to a number of more or less standard ways to interpret and present data (e.g. Nei 1987). *Within population* structure can be expressed using such measures as heterozygosity (see previous discussion) and number of alleles per locus. *Between population* genetic structure of wild populations is due mainly to the effects of reproductive isolation, genetic drift[17], gene flow, and local adaptation through selection, acting separately and together, on the available genetic variation in spawning populations. The structure of genetic variation within and among salmon populations is hierarchical: at the base are substantially reproductively isolated local breeding populations, together these form metapopulations typically connected by some small amount of gene flow among the members, then larger biological races, then subspecies/ecotypes, and culminating with the species as a whole (NRC 1996).

Loss of genetic variation can mean loss of alleles, loss of heterozygosity, or changes in allele frequencies. All of these have the potential to be non-adaptive, and can negatively affect the character and persistence of breeding populations. The risks associated with loss of genetic diversity have been explored in a number of published papers including Waples (1991b), Currens and Busack (1995), Busack and Currens (1995), Campton (1995), Grant (1997), and Utter (1998). In addition, it is also important to draw a distinction between total genetic diversity and adaptive genetic diversity. The ability of a population to respond to change can be negatively affected by unique but maladaptive genes that nonetheless add to total genetic diversity.

The Importance of Genetic Diversity

Genetic resource conservation is as important to species preservation and persistence as is habitat conservation. Conservation biologists argue that biodiversity (and its genetic underpinnings) should be conserved for three reasons (McElhany et al. 2000; Levin and Shiewe 2001). Firstly, diversity leads to greater abundance because different populations can exploit different habitats and resources. The diversity of salmon life history (e.g. run timing over the range of chinook salmon) and its underlying genetic components are a good example of this. Secondly, Diversity fosters enhanced long-term stability by spreading risk and providing redundancy in the face of unpredictable catastrophes, e.g. due to climatic or ocean condition fluctuation. Environmental challenges to natural populations are often dramatic and sudden (e.g. El Nino events). Because of this, loss of diversity can depress the potential of the entire resource to respond to environmental change. These factors clearly apply to salmon. Finally, genetic diversity provides a range of raw material that allows adaptation and increased probability of persistence in the face of long-term environmental change.

[17] Genetic drift is a random change in allele frequency that occurs in small populations.

Loss of variation due to inbreeding depression has been reported as a factor that may increase the probability of local extinction (Saccheri et al. 1998). Loss of variation has also been implicated as a factor limiting evolutionary potential (Frankham et al. 1999), and can affect the potential range of response to pathogens (O'Brien and Everman 1989).

<u>Factors That Reduce Genetic Diversity and Conservation Guidelines</u>

Many of the causes of genetic diversity loss are related to decreases in population size and associated decreases in effective population size and number of breeders (N_b). Per generation loss of genetic diversity is related to the effective population size of the spawner population. N_e is usually much less than total population size (N_t); N_e/N_t estimates of 0.1-0.33 are thought to be reasonable for salmonids (Hedrick et al. 1995, based on original estimates by Bartley et al. 1992; Robin Waples, pers. comm.) and are often used for purposes of estimating population size targets for conservation (McElhaney et al. 2000). Several authors have proposed N_e thresholds that can be used as guidelines in evaluating the severity of potential genetic diversity reductions. Effective population size of 50 was proposed by Franklin (1980) as the lower limit to avoid inbreeding depression. Waples (1990) suggested that short-term maintenance of genetic variation in salmon could be achieved with 100 effective breeders per year based on the probability of losing rare alleles. A minimum N_e of 500 is thought to be enough to avoid long term loss of genetic variation (Franklin 1980; Lande and Barrowclough 1987). Lynch (1990) wrote that an effective size of about 1,000 is usually large enough to maintain genetic variation in a population. N_e of 5,000 may be sufficient to maintain potentially adaptive genetic variation (Lande 1995).

Because salmon populations are usually connected by some small amount of gene flow, and gene flow between populations is a contributor to overall genetic variation, smaller than predicted effective sizes might be sufficient to maintain diversity. Also, estimates from two of the studies above (Franklin 1980 and Lande 1995) were based on study of a single species, the fruit fly *Drosophila melanogaster*, and might not be generally applicable to salmon (McElhaney et al. 2000).

Using the estimate of reasonable N_e/N_t ratios above and the average generation length for the species, one can arrive at targets for effective population sizes per generation and annual spawner abundance sufficient to avoid loss of genetic variation. Applying the lower end of the range of reasonable N_e/N_t ratios (0.1) to the range of minimum sizes from the literature cited above (500-5,000), the target minimum *population size per generation* sufficient to maintain long-term genetic variation ranges from 5,000 (Franklin 1980) to 50,000 (Lande 1995). Coho salmon in California almost all spawn at age 3 giving an average generation length of 3 years. Therefore, a rough estimate of the minimum number of coho salmon *breeders per year* necessary to maintain genetic diversity and ensure long-term persistence is 1,667 to 16,667. Clearly, many local breeding populations of coho salmon in California do not fall within this range. Therefore, the potential for loss of genetic variation in California coho salmon appears to be high.

Another factor that can reduce genetic diversity and fitness is introgressive hybridization[18] of different stocks due to straying and artificially high levels of gene flow which may cause locally adapted populations to be more similar to one another and less well adapted to the place

[18] Hybridization in which offspring of hybrid individuals mate with some level of success causing population mixing of extraneous genes with local ones.

where they live. Hybridization can also affect productivity. Much of the discussion in the literature regarding loss of diversity has been in the context of impacts associated with hatchery management and practice, and interactions of hatchery with natural fish. The extent to which introgressive hybridization has affected California coho salmon stocks is unknown.

Declines in abundance have undoubtedly resulted in losses of genetic diversity in salmon. For example, winter-run chinook salmon in the Sacramento River have the lowest genetic diversity (i.e. fewer alleles at most loci and lower average heterozygosity) of the four runs that exist there (Banks et al. 2000) likely due to severe historical reductions in abundance. Coho salmon have been reported to have the lowest genetic diversity of the five Pacific salmon species (Allendorf and Utter 1979; Waples et al. 2001). Some studies of California coho salmon have found evidence of low genetic diversity (Olin 1984; Bartley et al. 1992). One explanation of this may be that coho salmon have undergone one or more severe reductions in population size.

Habitat Condition

Forestry Activities

Introduction: Forestry practices have been shown to impact several freshwater habitat components important to anadromous salmonids in general, and coho salmon specifically. These impacts include: increased maximum and average summer water temperatures, decreased winter water temperature, and increased daily temperature fluctuations; increased sedimentation by fine and coarse sediments; loss of LWD; decreased DO concentrations; increased in-stream organic matter; and decreased stream bank stability (Salo and Cundy 1987; Meehan 1991; Moring et al. 1994; Murphy 1995; Monschke 1996). Even when some habitat conditions return to pre-timber-harvest levels, fish populations do not always recover, which may be due to other habitat conditions remaining sub-standard or having been permanently altered (Moring et al. 1994). Harvest-altered areas are further affected and aggravated by natural (e.g. blow downs, naturally-caused landslides) and other human-related activities, thus resulting in cumulative effects to coho salmon and their habitat.

Existing information combined with that from other states and that on effects to anadromous salmonids in general, reveals that forestry practices can have deleterious effects on coho salmon. Data from northern California corroborates research from other regions in the Pacific northwest. Nakamoto (1998) found that juvenile coho salmon density dropped the most during and after logging, did not recover after three years, and biomass was less after, rather than during, harvest operations. Krammes and Burns (1973) found that smolt biomass decreased, though fry biomass increased, after road construction. Clearly, there are effects that are legacy impacts (see below). These impacts include increased in-stream sediment load, upslope erosion, loss of LWD in streams and reduction of future upslope supply, and removal of stream-side vegetation.

The effects of forest activities on coho salmon are complex. Alterations to habitat and direct effects to this species arise from many factors, including the long history of logging in the coastal watersheds, the different activities affecting the habitat components, individual activities affecting multiple habitat components, the interrelatedness of the habitat components themselves, and the changes in timber harvest over the many years of logging. Forestry practices have been linked to important changes in watersheds and stream habitats that affect anadromous salmonids

(Meehan 1991; Murphy 1995). These changes include increased sedimentation and water turbidity, increased water temperature, loss of stream habitat complexity, loss of in-stream woody debris and upslope debris supply, and altered stream flow and water supply.

Identifying the relationships between forestry practices and habitat impacts is complicated for several reasons. First, there is a long history of timber harvesting, and some effects, such as sedimentation and slope instability, continue long after harvesting has occurred. These alterations are referred to as "legacy" effects, and recovery may take many decades (Murphy 1995). Legacy effects are a factor along the north coast of California (Monschke 1996). Second, there have been many technological and management changes in timber harvest, and it is difficult to differentiate legacy effects from recent or current effects. Third, the salmonid habitat elements affected by timber harvest are themselves intimately inter-related. The amount and distribution of LWD, water temperature, near-stream vegetation, sediment transport and deposition, landsliding, stream flow and supply, and turbidity are all linked to one another. Hicks et al. (1991), Seddell et al. (1991), Ligon et al. (1999) state that the lack of quantitative data, long-term studies, the varying temporal and spatial scales of harvest practices, and the sparse number of site-specific studies result in difficulty in interpreting the effects on anadromous salmonids. Nonetheless, these authors acknowledge that forest practices impact both anadromous fish habitat and fish populations directly.

Monschke (1996) found that different harvesting practices resulted in very different effects on salmonid habitat. He found that activity in the riparian zone, supply and delivery of LWD, sedimentation, and sediment transport were inter-related. He also found that recovery of canopy vegetation, upslope, and in-stream LWD components, and recovery from sedimentation and erosion effects took place at different rates. Canopy re-closure and stream-side revegetation of the riparian corridor was relatively quick. Conditions for stream sediment were variable. The natural removal of built-up, excess sediment, and effective reduction in sediment input from harvest activities was slow but measurable. However, sediment elements continued to impact both spawning and rearing habitat for anadromous salmonids. Lastly, the ability of a watershed to supply high-quality LWD (i.e. conifers) in the short-term was eliminated and long-term supply was thought to require considerable time. Thus, the total recovery of habitat components necessary for coho salmon was going to take considerable time.

The inter-relatedness of LWD, sediment storage and transport, water yield, and water quality complicate the interpretation of forestry practices and alterations in coho salmon. Lisle and Napolitano (1998) found that timber harvest resulted in sediment transport, increased delivery of LWD following blow-downs, and increased water yield. These factors resulted in a net increase of stored sediment and a greatly increased number and volume of pools, even without a net increase in bed transport. Complicating the observations was that the water yield was thought to be too modest to be the cause of sediment source or scouring of upstream pools. The key was thought to be the increased delivery of LWD. The LWD created more pools and trapped sediment from moving further downstream. The researchers went on to state that the current stream conditions beneficial to anadromous salmonids, high pool volume and frequency and stream diversity, were temporary. The stream conditions likely would be different under more extreme flows, and future LWD recruitment would be below normal. Hence, future pool habitat would be altered and degraded, affecting sediment accumulation, thermal refugia, and pool scouring. These findings reflect the complicated relationship of habitat components, the particulars of the timber harvest, and climate.

Timber harvest has been occurring in the northwestern region of California since the mid-nineteenth century and continues in the watersheds both historically and currently inhabited by northern California coho salmon. During the approximately 150-year history of timber harvest in coastal northern California, harvest practices have changed dramatically, primarily due to changes in technology and decreasing availability of larger or higher quality logs. Where historical harvest and milling were close to waterways, modern trucks and tractors enabled harvesting to occur in a wider variety of areas within a watershed. Logs were once primarily transported by river and are now transported by trucks along constructed roads. Logs used to be removed from the forest by mules and railroad, and these mechanisms have been replaced by tractors and cabling networks.

Forest practices that have resulted in increased fish production or improved habitat have not benefitted coho salmon. Current forest practices in California have been shown to sometimes result in favorable habitat modification, such as increased water yield (Keppeler 1998), increased insect productivity (Hicks et al. 1991), and increased salmonid productivity (Graves and Burns 1970; Nakamato 1998). The changes are associated with increased numbers of steelhead trout and improved steelhead trout habitat, and most likely, these environmental changes have had a detrimental effect on coho salmon habitat.

Current forestry activities that affect coho salmon habitat include: construction and maintenance of roads and stream crossings; tree felling; yarding felled trees to log landings; removal of stream-side vegetation; site preparation; and post-harvest broadcast burning in harvest units near watercourses. Table 11 describes forestry practices, changes to the landscape, and the potential effects on salmonid habitat conditions. The effect of historical practices is also significant because many now-discontinued practices have been implicated as still impacting salmonid habitat. Significant historical practices include construction and maintenance of splash dams, artificial flooding, removal of trees along the stream-side corridor, removal of in-stream debris, construction of roads and landings, use of equipment adjacent, near, or in streams, and clear-cutting.

Legacy impacts have been documented in northern California: in Mendocino County, Caspar Creek is still recovering from harvesting that occurred in the nineteenth and early twentieth centuries (Ziemer et al. 1991), and the North Fork Garcia River is still recovering from heavy harvesting during the 1950s, 1960s, and 1970s (Monschke 1996). The effects in the Garcia watershed were dramatic, with near elimination of rearing and spawning habitat, and stream flow sometimes becoming subsurface.

Table 11. Forestry activities and potential changes to stream environment, salmonid habitat, and salmonid biology. [i]

Forest Practice	Potential effects to stream environment	Potential effects to salmonid habitat	Potential effects to salmonid biology
timber harvest in the riparian zone	increased incident solar radiation	increased stream temperature, light levels, and primary production	decreased growth efficiency; increased susceptibility to disease; increased food productivity; changes in growth rate and age at smolting
	decreased supply of LWD	decreased cover, storage of gravel and organic debris, and protection from high flows; loss of pool habitat and hydraulic and overall habitat complexity	decreased carrying capacity, spawning gravel, food production, and winter survival; increased susceptibility to predation; loss of species diversity
	increased, short-term input of LWD	increase in number of pools and habitat complexity; creation of debris jams	increased carrying capacity for juveniles and winter survival; barrier to migration and spawning and rearing habitat
	increased influx of slash	increased oxygen demand, organic matter, food, and cover	decreased spawning success; short-term increase in growth
	stream bank erosion	reduced cover and stream depth	increased carrying capacity for fry; decreased carrying capacity for older juveniles; increased predation
		increased in-stream fine sediment; reduced food supply	reduced spawning success; slower growth rates for juveniles
timber harvest on upslope areas	altered stream flow	temporary increase in summer stream flow	temporary increase in survival of juveniles
		increased severity of peak flows during storm season; bedload shifting	increased egg mortality
timber harvest on upslope areas and road construction and use	increased erosion and mass wasting	increased in-stream fine sediment; reduced food supply	reduced spawning success, growth and carrying capacity; increased mortality of eggs and alevins; decreased winter hiding space and side-stream habitat
		increased in-stream coarse sediment	increased *or* decreased carrying capacity
		increased debris torrents; decreased cover in torrent tracks; increased debris jams	blockage to migration of juveniles and spawning adults; decreased survival in torrent tracks
	increased nutrient runoff	increased primary and secondary production	increased growth rate and summer carrying capacity
	stream crossings	barrier in stream channel; increased sediment input	blockage or restriction to migration; reduced spawning success, carrying capacity and growth; increased winter mortality
Scarification and slash burning	increased nutrient runoff	increased primary and secondary production	temporary increased growth rate and summer carrying capacity
	increased input of fine organic and inorganic sediment	increased sedimentation in spawning gravels and production areas; temporary increase in oxygen demand	decreased spawning success; increased mortality of eggs and alevins

[i] Adapted from Hicks et al. 1991

Water temperature: Alteration of water temperature regimes is considered one of the most important potential impacts from forest practices (Beschta et al. 1987; Murphy 1995; Ligon et al. 1999). Increased ambient air temperature and solar radiation due to the removal of stream-side vegetation and canopy are the causes of the increased water temperature. The change in solar radiation is the primary agent of increased water temperature, especially the daily temperature peaks. Average water temperature may not show as pronounced a change to solar radiation because the reduced canopy also facilitates re-radiation of heat at night. Increased water temperature, resulting from clear-cutting, has been linked to earlier-than-normal emergence of fry (Holtby 1988), increased growth rates because of greater availability of benthic invertebrates (Holtby 1988; Hicks et al. 1991), significant decreases in the number of emergent fry (Moring 1975; Hall et al. 1987; Hicks et al. 1991), and earlier and smaller out-migrating smolts (Moring 1975; Hall et al. 1987; Holtby 1988, Hicks et al. 1991). Increased water temperature does not have to be lethal to impact coho salmon. Sublethal temperature regimes, both low and high, impact anadromous salmonids and are considered as significant as lethal temperatures because sublethal temperatures impact the growth, physiological processes, and behavior of anadromous salmonids (Bjornn and Reiser 1991; Ligon et al. 1999).

Kopperdahl et al. (1971) studied water quality in logged and unlogged areas of six coastal streams in northern California and found that harvesting had its greatest effect on water temperature. Maximum summer temperatures in streams occurring in unlogged areas were below 15.5^0 C, while temperatures in logged areas approached 21.1^0 C (Kopperdahl et al. 1971). Temporal temperature data were short-term, only extending two to three years for any given stream, and temperature changes were not considered to be lethal or sustained long enough to affect growth and physiological maintenance of fish. Clear-cut harvesting and removal of vegetation for roads resulted in the greatest temperature increases, while either alternating clear-cut blocks with uncut blocks, or combining selective tree harvest and maintaining a non-cut stream buffer maintained lower water temperatures. Dorn (1969, as cited in Kopperdahl et al. 1971) found that removal of canopy resulted in as much as a 140% increase in solar radiation and a 11^0 C rise in water temperature in Caspar Creek in Mendocino County. Hall and Lantz (1969) found that clear-cut harvesting resulted in maximum stream temperatures exceeding the ultimate upper incipient lethal temperature for coho salmon (Brett 1952). Meehan et al. (1969) found that logging on Alaskan coastal streams resulted in a 5^0 C increase in maximum stream temperature. The extensive clear-cut harvesting that led to these types of temperature changes no longer occurs under current California Forest Practice Rules.

Increased water yield after logging has been hypothesized as a moderating factor for the loss of canopy. Removal of vegetation, and its effects on evapo-transpiration rates, results in greater water yield after timber harvest, and increased water yield and summer flow has been demonstrated in California (Krammes and Burns 1973; Keppeler and Ziemer 1990; Keppeler 1998). Keppeler (1998) found that both clear-cut and selective harvesting resulted in increased water yield, with greater yields from clear-cutting, and that the variation in precipitation has a major role in variation in yields. However, this yield is short-lived ($x< 5$ years) and sporadic (Keppeler and Ziemer 1990; Keppeler 1998). More importantly, the yield did not buffer water temperature (Krammes and Burns 1973), and in fact, moderation of summer water temperature was attributed to stream-side canopy and not increased water yield (Keppeler 1998). Hicks et al. (1991) also concluded that positive effects due to reduced canopy are more than offset by negative changes to thermal regimes.

Monschke (1996) believed that timber harvest from 1953 to 1988 in the riparian zone of the North Fork Garcia River likely increased water temperature, but that other impacts were far greater and made any increase a moot point. Impacts to LWD, sediment, and stream-side cover were considered to be such that anadromous salmonids were excluded regardless of increases in water temperature. From 1988 to 1994, conservation of the riparian area resulted in the recovery of the stream course canopy, resulting in water temperatures adequate for steelhead trout and coho salmon; but only steelhead trout were observed in 1995 and 1996 .

The relationship of water temperature to anadromous salmonids is not a simple one-to-one function, rather it is a function of temperature, available prey, thermal refugia, acclimation, life stage, and species. In their review of FPR and salmonid habitat, the Scientific Review Panel (SRP) (Ligon et al. 1999) stressed that the site-specific nature of these interactions is key to understanding what water temperature regimes represent the suitable, optimum, lethal, and sublethal for salmonid species that inhabit the watercourse. Temperature regimes both beneficial and deleterious to coho salmon as a species, vary across its northern Pacific range, and the suitable and optimum thermal regimes for northern California coho salmon probably differ from elsewhere within its entire range (Brosofske et al. 1997, as cited in NMFS 2000). SRP concluded that until thermal requirements studies take into account physiological conditions in the wild, site-specific thermal regimes, and the effects on local salmonid populations, the "impacts on salmonids as a result of timber harvesting will remain in the realm of conjecture." (Ligon et al. 1999). Welsh et al. (2001) also concluded that acquisition of such environmental temperature measures were needed in haste because many native fish and amphibians of the Pacific Northwest are threatened by habitat alteration.

One study showed that changes in water temperature alone did not necessarily lead to detrimental effects on coho salmon. In the Navarro River, Mendocino County, adequate sources of prey and cool-water refugia allowed coho salmon juveniles to survive. The increased prey, necessary because of elevated metabolism brought on by increased water temperature, and the thermal refugia, in the form of deeper pools, were thought to have allowed juvenile coho salmon to survive in waters thought to be physiological stressful and provided for good growth rates and apparent healthy condition (Rich 1991 as cited in Ligon et al. 1999).

Not withstanding this study and the importance and validity of the SRP's criticism (that much more work needs to be done in order to understand the relationship of water temperature across the range of northern California anadromous fishes), increases in water temperature have been shown to affect coho salmon (Beschta et al. 1987; Sandercock 1991) and elevated water temperature has been demonstrated to be a good, if not the best, indicator for the absence of juvenile coho salmon in timber harvested watersheds in northern California (Ambrose et al.1996; Ambrose and Hines 1997, 1998; Hines and Ambrose nd; Welsh et al. 2001). Ambrose et al. (1996), Ambrose and Hines (1997, 1998), and Hines and Ambrose (nd) studied water temperature and presence/absence of juvenile coho salmon, considered the most sensitive life-stage to water temperature, on Ten Mile River. Welsh et al. (2001) studied the same phenomenon in the Mattole River watershed, actually gathering data from 21 tributaries in the watershed. In each study, the researchers found that maximum temperature measures were good predictors of the presence or absence of juvenile coho salmon.

Ambrose et al. (1996) and Ambrose and Hines (1997, 1998) found that maximum weekly average temperature (MWAT) was a reliable predictor of coho salmon presence and that MWAT of 18.0-18.3EC was the critical measure. Hines and Ambrose (ND) refined the findings to state that a MWAT of 17.6EC was the best fitting MWAT value for predicting the presence or absence of the species. More importantly, they found that the number of days exceeding the MWAT, and not the value itself, was the defining point beyond which juvenile fish ceased to be present. They calculated four MWATs, ranging from 15.9EC to 18.3EC, that could be used to indicate the presence or absence of fish. Another important point these authors made was that persistence of juvenile fish "does not imply health or success", and rather, that temperature thresholds provide for a "reasonable way to rule out unacceptable temperature conditions". Welsh et al. (2001) measured MWAT and also measured maximum weekly maximum temperature (MWMT) to determine if either variable modeled the presence or absence of juvenile coho salmon. Both measurements correctly predicted the absence of the fish in 18 out of 21 streams sampled. Streams containing juvenile coho salmon had MWMT and MWAT of 18.0EC and 16.7EC or less, respectively. Morever, all streams with MWMT less than 16.3EC and MWAT less than 14.5EC had coho salmon present.

The data gathered thus far for California suggests coho salmon prefer cool waters, avoiding water above 14.5-17.6EC, and that timber harvest practices have negatively altered water temperature regimes, considered the most important habitat attribute for coho salmon. In some cases, local fish populations have survived or have at least persisted, but increases in water temperature have not translated in favorable conditions for the species. There are findings from water temperature field studies in northern California that may provide a basis for establishing maximum temperature thresholds for coho salmon along the north coast, and that these thresholds can be used to guide timber harvest practices to ensure essential water temperature regimes are maintained. Such an effort would not be unprecedented. Work done by Ambrose et al. (1996), Ambrose and Hines (1997, 1998), Hines and Ambrose (ND), Valentine (1994, 1996), and CDF (1998) was conducted, in part, to analyze water temperature suitability for salmonids on private and state forest lands.

Sedimentation: Forest practices increase sediment delivery to watercourses, resulting in increased fine and course sediment loads in streams and increased water turbidity (Furniss et al. 1991; Murphy 1995; Spence et al. 1996; Ligon et al. 1999). In California, the short-term and long-term effects to coho salmon and their habitat are complex. It is also acknowledged that sediment from poorly constructed roads and harvesting on unstable slopes is having legacy and current impacts in coastal California watersheds (Ligon et al. 1999). Increased sedimentation is a consequence of increased bare soil and disturbed ground from removal and yarding of trees; the design, construction, use, and maintenance of roads; and landslides associated with harvested areas. Increased sedimentation and mass-wasting has been linked to logging in western North American (Megahan 1972; Chamberlin et al. 1991; Furniss et al. 1991; Corner et al.1996; Spence et al. 1996) and specifically in coastal northern California (Burns 1970; Monschke 1996; Cafferata and Spittler 1998). Such changes are deleterious to spawning bed composition, egg incubation, fry survival, and juvenile growth and productivity (Ligon et al. 1999). Silt from poorly harvested areas and/or improper road construction can clog spawning gravels, suffocating eggs or alevins (Cordone and Kelly 1961). Sediment levels of greater than 40 g/L cause distal deterioration of gill filaments (Lake and Hinch 1999). Studying salmonids in a laboratory, Cordone and Kelly (1961) found that mortality occurred at 100 g/L. Though this concentration is approximately an order of magnitude higher than in natural salmonid streams, they noted that natural fluvial suspended sediments at much lower concentrations caused stress and mortality.

Burns (1970) investigated two species of trout and coho salmon in coastal streams and watersheds in Mendocino and Humboldt counties and found that most of the impacts were due to forest practices. Cafferata and Spittler (1998) specifically investigated differences in sedimentation that could be associated with old and new forestry practices, and they found that new practices resulted in a 75% reduction in erosion. Monschke (1996) also studied changes in sedimentation related to changes in forestry practices and concluded that selection harvesting conducted since the late 1980s did not contribute measurably to sedimentation, and staying out of the riparian area in conjunction with better road management was resulting in slow recovery from past, high levels of sediment.

Sediment from road construction, use, improper maintenance, crossings, and failures are sources of increased sedimentation in watercourses (McCashion and Rice 1983; Furniss et al. 1991; Murphy 1995). Road design, construction, maintenance, and use affect several stages of salmon, including migrating and spawning adults, eggs, fry, and rearing juveniles (Furniss et al. 1991). In four counties of northern California, McCashion and Rice (1983) found that roads, while the cause for only 20% of the total number of landslides, were responsible for 56% of the erosion, compared to natural slides being responsible for 80% of the total slides but only 44% of the erosion. This research also demonstrated two other significant aspects of road-erosion relationships. First, different types of roads contributed differently to the amount of erosion; seasonal roads, followed by main haul roads and secondary roads, produced the highest rates of erosion. Second, 38% of the erosion could have been prevented by improved road construction and maintenance. Monschke (1996) also concluded that poor road management was an important factor in excess erosion and landsliding and that changes in road management, due to the Z'Berg-Nejedly Forest Practice Act (FPA) of 1973, greatly improved this. However, he also found that both the quality and quantity of sediment transported to streams was impacting salmonids.

Timber harvest can result in increased suspended sediment, sediment deposition in pools and gravel, and reduced gravel permeability (Moring et al. 1994; Ligon et al. 1999). Suspended sediment can impact all life-stages, but especially juveniles and fry. Changes to the gravel conditions impact the survival to emergence of egg and alevin life-stages directly, and thus, reduce the spawning success of adults. There is some evidence that suspended sediment may return to pre-harvest concentrations within seven years (Moring et al. 1994) but this would be in the absence of stressing storm events or additional ground-disturbing activities subsequent to timber harvest. Krammes and Burns (1973) found that road construction increased suspended sediments in Caspar Creek watersheds and that levels were four times that of pre-construction concentrations after the first storm flows. However, they also found that turbidity decreased quickly and, although higher than pre-construction levels, was "not excessive."

Forestry practices are also tied to changes in course sediment transport. Monschke (1996) found that debris torrents and slides occurred because of harvesting and flooding events in the North Fork Garcia River between 1953 and 1988. Slides delivered considerable quantities of sediment and woody debris. The LWD contributed to debris jams that became effective migration barriers. Many of the torrents and slides were associated with roads, and recovery from the sedimentation is only now occurring.

Altered stream flow: Increased peak and storm flows due to road construction has also been considered a potential impact to anadromous salmonids. Such flows would both transport more sediment and alter the annual and seasonal hydrologic regimes of the watercourses. These linkages have been noted in other western states such as Washington (Cederholm and Reid 1987). The change in hydrology is usually directly proportional to the size of the watershed and the size of the area harvested and is also a function of the type of timber harvest activity, precipitation, geology, and soil type. Less intensive harvest practices, such as thinning and selective harvesting, results in less effect on water yield and altered stream flow. Disturbance during the wet season, or on more sensitive soil or unstable slopes, results in greater impacts. Considerable effects have been shown in British Columbia and the more northwestern states. However, in California, road construction and timber harvest has not been shown to effect large peak flows or change major, channel-forming flows (Ziemer 1981; Wright et al. 1990). In Caspar Creek, Mendocino County, low to moderate flow changes resulting from timber harvest have not shown to alter net bed-load transport (Lisle and Napolitano 1998).

Timber harvest also alters summer flow. The greatest increases have been documented in the Oregon Cascades (Spence et al. 1996), but in California, little research has been conducted to understand the changes or duration to summer flow or their effect on anadromous salmonids. Keppeler and Ziemer (1990) studied summer water yield increase on Caspar Creek, Mendocino County, and found that the increase was slight and disappeared five years after timber harvest ceased.

Large woody debris: Impact to LWD is considered to be another of the more important, potential impacts of forestry practices to anadromous salmonid freshwater habitat (Hicks et al. 1991; Murphy 1995). The potential results of harvesting activities include decrease of both in-stream and streambank LWD, and a decreased future supply of LWD from upslope sources. The role of LWD, the relationship of forestry practices, and rectifying existing depressed levels of in-stream LWD has been studied along the west coast (Bryant 1983), in Washington (Cederholm et al. 1997), and in Alaska (Lisle 1986), and specifically for coho salmon (Bryant 1983; Lisle 1986; Cederholm et al. 1997). In California, timber harvest has been shown to cause a short-term, greater contribution of LWD to streams, which resulted in increased number of pools and stream habitat complexity (Lisle and Napolitano 1998; Napolitano 1998). However, coho salmon did not respond positively to these improved habitat conditions, and Lisle and Napolitano (1998) theorized that the removal of the source of future LWD would result in a greater departure from the natural volume of LWD, decreased sediment storage capacity, a decrease in the number of pools, and an overall simplification of stream habitat. Monschke (1996) also concluded that a decrease in future recruitment of LWD would be an issue in the North Fork Garcia River, but he found that the short-term, greater supply of LWD due to harvesting was a habitat impact, not a benefit, that resulted in debris barriers to salmonid spawning and rearing areas.

The SRP summarized the impacts associated with decreased LWD due to forestry activities in California, and these impacts include loss and reduced complexity of pool habitat, reduced carrying capacity for juvenile fish, reduction in backwater and stream margin habitat important to emergent fry, more simple and less stable stream channels, reduction in refugia from high-velocity flows, reduced retention of spawning gravel, and loss of sediment important for macro-invertebrate prey (Ligon et al. 1999).

Historically, timber operations included removal of stream-side vegetation and in-stream woody debris to facilitate transport of logs via waterways. When harvesting moved upstream to streams too small to facilitate ready transport of logs, splash dams were built to hold logs and water until there was sufficient water to allow the logs to be sluiced downstream (Hicks et al. 1991). Once land routes became the primary means of transporting harvested materials, extensive removal of in-stream LWD and the use of splash dams effectively halted. In the 1950s and 1960s, and under the encouragement and recommendation of the Department, the practice of removing LWD from stream channels became common. Removal of LWD was done primarily to facilitate the removal of remnants of splash dams, but also because there was a belief that such removal would generally benefit anadromous salmonids and trout by decreasing the magnitude and frequency of migration barriers (Flossi et al. 1998). In hindsight, the former rationale was sound, while the latter was not. Research in western North America has demonstrated that removal of LWD impacts habitat and salmon populations (Hicks et al. 1991; Ligon et al. 1999).

Harvesting itself effects the future recruitment of LWD. Conversion of old-growth redwood forests to either younger second-growth forests and predominantly hardwood communities has resulted in smaller woody debris that decay more rapidly and provide less channel stability and salmonid habitat than conifer LWD (Bragg and Kershner 1999, as cited in Ligon et al. 1999; Ligon et al. 1999). Recruitment of LWD has been shown to be an issue in harvested watersheds of northern California. Lisle and Napolitano (1998) advanced the idea that short-term increased LWD would be followed by decades of decreased LWD supply due to logging. Monschke (1996) found that riparian recovery was dominated by alders (*Alnus* spp.), contributing little to the supply of high-quality LWD, and that recovery of conifers was going to take much more time.

Stream-side vegetation and canopy cover: Removal and alteration of vegetation along and near watercourses impacts salmonids (Cederholm and Reid 1987), and studies show that protection of stream-side vegetation benefits trout and anadromous salmonids, including coho salmon (Burns 1972; Hicks et al. 1991). Harvest of canopy-creating trees from stream-side habitat affects cover from predation, water temperature, the watershed's ability to absorb precipitation, water flow timing, erosion, bank stability, retention of in-stream woody debris, recruitment of LWD, and habitat complexity (Murphy et al. 1986; Meehan 1991; Moring et al. 1994; Monschke 1996). Removal of near-stream vegetation can result in increased water temperature, both short- and long-term (Moring et al. 1994). Prior to the changes in forest practices, clear-cutting of stream-side vegetation was shown to increase water temperature of salmon-bearing streams (Brett 1952; Kopperdahl et al. 1971; Hall et al. 1987, Holtby 1988). Upstream monitoring also has shown that clear-cutting increased sedimentation (Corner et al. 1996).

Monschke (1996) found many effects from the result of harvesting in the riparian areas of the North Fork Garcia River. Those effects included substantial increases in contiguous open river reaches, the length of canopy gaps, and stream width. Erosion and sedimentation resulting from exposed and disturbed soil resulted in sediment deposits that destroyed stream-side vegetation and entrainment of LWD, which, in turn resulted in knock-down of additional stream-side vegetation.

Physical barriers: Certain forestry activities can result in barriers that block or impede adult and juvenile fish movement. These activities include construction and maintenance of road crossings, debris dams, and debris jams. Road crossings, especially those using culverts, are elements of both historical and contemporary practices, and these crossings, unless properly designed and maintained, prevent fish passage. Historical timber harvest often resulted in debris dams, the larger of which became physical barriers to upstream spawning runs and downstream out-migration of juveniles. Although debris dams have been removed or targeted for modification since the 1960s and current forestry practices pay particular attention to allowing fish passage through road crossings, historical barriers may have caused fish to cease use of habitat upstream of barriers. The SRP advised that attention be given to barriers to habitat historically accessible to anadromous salmonids (Ligon et al. 1999). Debris jams are a result of excess LWD and slash being transported into stream channels and accumulating to the point of preventing anadromous fishes from passing. Monschke (1996) tied timber harvesting to such debris jams on the North Fork Garcia River.

Dissolved oxygen by life stage: Adverse changes to DO levels following timber activities vary in degree, and the effects due to changes in DO are influenced by interstitial flow, water temperature, and stream productivity. Hicks et al. (1991) summarized the effects to DO in small harvested streams in Oregon and found reduced levels of DO below that which is suitable for survival and growth, but that major changes to DO in surface water was not likely. More importantly, they found DO decreased in redds, where it is crucial for egg and alevin survival and development, and that reduced DO might impact juvenile size, viability, and fitness. They also believed that egg or alevin mortality from reduced DO was rare. Moring et al. (1994) also summarized several studies and found that logging resulted in decreases in DO levels that would threaten continued survival and growth of salmonids and stated the DO levels were “reaching critical values.” The few studies done in California streams inhabited by coho salmon found that timber operations either did not effect DO (Krammes and Burns 1973) or were not outside the normal DO range (Kopperdahl et al. 1971).

Effects on estuaries: Forestry activities can affect coastal estuaries inhabited by coho salmon. Some effects originate from activities within the estuary themselves, while others are a result of forestry activities upstream from the estuary. Within the estuary, forestry practices of storage, log handling, and transformation has taken place for over 100 years. In California, unlike other areas such as Alaska or British Columbia, these practices are much reduced from historical levels. The primary concern regarding upstream influence of forestry practices is sediment transport and filling-in of estuaries. Though this has obviously occurred in California, there is little documentation. Redwood Creek’s estuary has been affected, and the Mattole River estuary has also likely been impacted, but the degree is unknown (Steve Cannata, pers. comm.). There is less information on other estuaries within the range of northern California coho salmon. Consequently, the historical, cumulative, or current effects of forestry practices to estuaries and estuary habitat of coho salmon are not known.

Conclusions: Current forestry activities with the greatest impact on coho salmon appear to be the construction and maintenance of roads (especially when those roads are poorly designed, substandard, or not properly maintained) and timber harvest along the stream-side or on unstable slopes. These and other activities result in increased sedimentation, decreased LWD, increased water temperature, and decreased cover, and appear to be important. However, current information suggests that changes to DO, stream flow, and water turbidity resulting from forestry activities are ephemeral or negligible and have not been documented to impact northern California coho salmon and their habitat.

The Department’s conclusion is that historical forestry practices impacted watersheds inhabited by northern California coho salmon, and that current activities (e.g. road construction, use, and maintenance; activity near streams and on unstable slopes; removal of sources of future LWD) still affect important habitat elements essential to every life-stage of coho salmon that inhabit coastal streams and rivers.

Water Diversions and Fish Screens

A substantial amount of coho salmon habitat has been lost or degraded, due primarily to decreased flows because of water diversions and groundwater extraction, and unscreened or poorly screened diversions that entrain juvenile fish. Losses of coho salmon result from a wide range of conditions related to unscreened water diversions and substandard fish screens. Fish are entrained into the diversion channel and removed from their natural habitat. They are also killed or injured by diversion pumps or stranded in irrigation canals.

Primary concerns and considerations for fish at diversions that are unscreened or equipped with poorly functioning screens are:

- fish passage upstream (for adults) of all fish species;
- overall survival of downstream migrants;
- exposure time of downstream migrating juveniles to the face of the screen;
- screen bypass flow, which is a function of approach (perpendicular into the screen) and sweeping (parallel along the screen) velocities for fish moving in front of the screen;
- entrainment of juvenile fish into the diversion;
- impingement of juvenile fish on the screen due to high approach velocities in front of and/or low sweeping velocities past the screens;
- sediment accumulation patterns behind and in front of the screens, which modifies approach velocity, sweeping velocity, and predation patterns;
- predator holding areas that could be created by localized hydraulic effects of the fish screen and related facilities;
- entrapment of juvenile fish in eddies or other hydraulic anomalies where predation can occur;
- elevated predation levels due to concentrating juveniles at diversion structures;
- disruption of normal fish schooling behavior caused by diversion operations, fish screen facilities, or channel modifications; and
- loss of habitat due to decreased flows and water.

Instream Flows

Introduction: Large dams often alter the natural hydrograph that anadromous fish have evolved with and can preclude recruitment of spawning gravels from upstream sources to areas below the dam. Water impounded by dams can reduce the frequency and magnitude of flows necessary to transport sediment, allowing fines to accumulate and armoring spawning gravels below the dam. Dams alter flow regimes in downstream reaches, commonly reducing flood peaks (at least for moderate floods). Dams can also alter the temperature regime downstream of the dam, making the stream cooler or warmer depending upon whether the releases from the reservoir are hypolimnetic or epilimnetic. Base flow during dry months may be either decreased or increased, depending upon reservoir operation and whether water is diverted directly from the reservoir or from the channel downstream.

Smaller diversion structures can have similar impacts to anadromous fish, but generally these are reduced in scale and are more localized. In some streams, impoundments created by diversion structures can create conditions lethal for young salmonids. During late spring and summer months, water quality and temperature conditions can deteriorate making these areas unsuitable for juvenile rearing (CDFG 1997a). In nutrient rich waters, impoundments can create conditions favorable for aquatic plant growth and areas of increased organic decay and elevated aerobic bacterial activity. Wide ranging DO levels resulting from these conditions can be lethal to rearing salmonids.

Diversions for stockwater, domestic, and municipal purposes usually occur year-round while agricultural diversions are generally seasonal in nature (mid-spring to mid-fall). In some cases, agricultural diversions may continue into the winter to recharge water storage facilities that are used later for irrigation. Naturally low water conditions, such as that which typically occurs during the spring, summer, and early fall can be unfavorable for salmonids, however, these problems can be greatly exacerbated by agricultural water diversions (KRBFTF 1991). Resultant flows below diversion points decrease the amount of physical space available to juvenile salmonids. Water temperatures can change more dramatically, both diurnally and seasonally, due to decreased depth and reduced water volume. Agricultural return water can be higher in temperature and nutrient content than the receiving waters, further eroding water quality and habitat availability (CDFG 1997a).

In many rivers, summer and fall baseflow periods are particularly critical for survival of fish and other aquatic organisms. Reduction in these baseflows can have severe ecological impacts. In decreasing order of severity, these effects of reduced baseflows can range from completely drying the channel and lowering the water table (desiccating aquatic and hyporheic organisms, and potentially dewatering riparian vegetation), to drying shallower parts of the channel while maintaining isolated pools (eliminating connectivity of surface waters, increasing predation by terrestrial animals, and reducing water quality), or to reducing the flow and velocity (causing water temperatures to rise and/or DO levels to drop) (Kondolf et al. 1990).

Depletion and storage of natural flows can drastically alter natural hydrological cycles and create significant impacts to downstream reaches by: increasing juvenile and adult mortality due to migration delays resulting from insufficient flows or habitat blockages; reducing habitat due to deterring and blockage; stranding of fish due to rapid flow fluctuations; and increasing mortality due to higher water temperatures (CACSST 1988; CDFG 1991; Berggren and Filardo 1993; Reynolds et al. 1993; Chapman et al. 1994; Cramer et al. 1995; NMFS 1996). In addition to these factors, reduced flows negatively affect fish habitats due to increased deposition of fine sediments in spawning gravels, decreased recruitment of LWD and spawning gravels, and encroachment of riparian and non-endemic vegetation into spawning and rearing areas resulting in reduced available habitat (CACSST 1988; FEMAT 1993; Botkin et al. 1995; NMFS 1996).

The following is a description of impacts associated with instream flows in several river basins within the range of coho salmon in California. These impacts have been shown to effect salmonids in general but likely impact coho salmon.

Klamath River: Anadromous fish have been blocked from the upper Klamath River watershed since 1918 when Copco #1 Dam was constructed. Iron Gate Dam, constructed in

1962, re-regulates peaking flows generated by upstream facilities and is the present upper limit of anadromous fish distribution in the Klamath River.

Federal Energy Regulatory Commission (FERC) minimum flows at Iron Gate Dam have frequently not been met during the period 1961 to 2000 due to the fact that the United States Bureau of Reclamation's (USBR) Klamath Project controls most of the flow in the Klamath River. In the past, the water project has provided water to irrigation at the expense of downstream deliveries during below average water years. This situation is especially pronounced during droughts. For example, the monthly mean streamflow below Iron Gate Dam did not meet FERC minimum standards from February 1991 through February 1993, a period of 25 consecutive months.

Existing flows in the Klamath River below the Scott River confluence during the summer period can result in lethal combinations of high temperature and low DO, as evidenced by fish kills. Temperatures can reach a high of 80EF for up to 10 days each year. However, cold water refugia, especially at the mouths of a number of tributaries, are well documented and help ameliorate the effects of thermal stress (Bartholow 1995).

Long-term changes to flow patterns resulting from water impoundments and diversions can have huge impacts on anadromous fish. Historically, the Klamath River and its Salmon, Scott and Shasta river tributaries supported significant populations of spring-run chinook salmon (Snyder 1931). Today, spring-run chinook are considered extinct in the Klamath system upstream from the Salmon River due, in part, to inadequate summer flow conditions, which eliminated the deep, cool pools they require to over-summer (KRBFTF 1991). In the Shasta and Scott rivers, low flow conditions can impact the timing and distribution of adult salmon spawners. During dry years, the main run of adult chinook salmon into the Shasta River is delayed until October 1, which is the end of the summer irrigation season (CDFG 1997a). In wet years, salmon have access to over 38 miles of stream, but may only access 10-15 miles in dry years (CH2M Hill 1985). In some years, returning chinook spawners are unable to leave the canyon section of the Scott River to migrate to upstream spawning areas because of low flows (Mark Pisano, pers. comm.). Diversions of as little as 10-15 cfs for stock watering can be critical to migration access when the Scott River is only flowing at 35 cfs (KRBFTF 1991).

Diversions for agriculture occur in several other, smaller tributaries to the middle Klamath River. These are; Willow Creek, Little Bogus Creek, Bogus Creek, Horse Creek, Cottonwood Creek, and Grider Creek (KRBFTF 1991).

Shasta River: The Shasta River watershed consists of approximately 507,000 acres (793 mi^2) of which about 28 percent (141,000 acres) is irrigable and exists primarily below Dwinnell Dam (CDWR 1964). The Shasta River was dammed at RM 37 to form Dwinnell Reservoir (Lake Shastina) in 1928. In 1955, the height of the dam was raised, which increased the total storage capacity to 50,000 acre-feet. Seven major diversion dams and several smaller dams or weirs exist on the Shasta River below Dwinnell Dam. Numerous diversions and associated dams exist on other major tributaries as well, including Big Springs Creek, Little Shasta River, and Parks Creek. When all diversions are operating, flows are substantially reduced and, in the case of the Little Shasta River, stream flows cease entirely in the lower several miles of stream during the summer and fall period. There are over 100 known water diversions within the Shasta River watershed (State Water Resources Control Board 1996).

Agricultural return water is often considerably warmer when it flows back into the river. This runoff may be rich in organic matter, which can raise nitrogen and phosphorus levels in parts of the river. Diversion dams slow the river's flow, which allows the water to warm in the summer. The dams also create a pond-like environment, rich in nutrients, where algae bloom in abundance. This can cause the water to become super-saturated with oxygen during the day and cause oxygen depletion at night.

The onset of the irrigation season in the Shasta River watershed in some years can have a dramatic impact on discharge if large numbers of irrigators begin taking water simultaneously. This can result in a rapid decrease in flows below the diversions leaving fish stranded in shallow pools and side channels (CDFG 1997a). In some instances, channels can become entirely de-watered (KRBFTF 1991).

Scott River: The unstable granitic soils and past human activities (e.g. logging, roads) along the west side of Scott Valley have been contributing to the Scott River's problem of excessive fine sediment. This fine sediment comprises a large percentage of the Scott River's substrate. This, along with the relatively large amount of water diverted from the Scott River and its tributaries, has resulted in reduced river flows and relatively high annual water temperatures. Because of these water quality problems, the Scott River has been listed as an "impaired" waterway under section 303(d) of the CWA. A total maximum daily load (TMDL) plan will provide the method for assessing the environmental problems that resulted in the "impaired" listing of the Scott River and will develop a strategy to reach acceptable water quality standards within a set time frame. California's Regional Water Quality Control Board (RWQCB) for the Scott River region will establish TMDLs by the year 2005.

Agriculture is the single largest water user within the Scott Valley. It has been estimated that gross water use for agriculture is 98,100 acre-feet and net use is 78,000 acre-feet (taking into account evapo-transpiration and ditch loss). Most of the irrigation diversions on the Scott River operate from April 1 through October 15 pursuant to the 1980 Scott River Adjudication decree of the Superior Court of Siskiyou County. This decree recognizes 680 total water diversions, which cumulatively could divert 894 cfs from the Scott River and its tributaries (CH2M-Hill, 1985). Earlier adjudication decrees allocated water for irrigation, stock-water and domestic use from the Shackleford/Mill Creek drainage in 1950, and from the French Creek drainage in 1958. Previous riparian, pre-1914 claims, and appropriative water rights were included in all of the court adjudicated decrees within the Scott watershed.

Diversions from streams for both stockwater and domestic use were also allocated under these court adjudicated decrees. Many domestic users are scattered throughout the valley and foothills of the Scott watershed, most of these utilizing ground water from individual wells for their household and landscaping needs. Information on local residential and commercial water use is sparse.

Within the past six to 10 years, improvements in some city water delivery systems and the metering of users within some local municipalities have significantly reduced municipal and domestic usage. In 1990, the average domestic water use within Etna and Fort Jones, the two largest municipalities, was 266 and 170 gallons per person per day, respectively. The City of Etna diverts water directly from Etna Creek while Fort Jones pumps water from the underflow of Moffett Creek and the Scott River. Assuming an average local water demand of 200 gallons per person per day, the total urban (i.e., domestic/residential/municipal) water use in 1990 was estimated to be 1,800 acre-feet (SRWCRMP 1995). Stockwater use is estimated to be 504 acre-feet based on an estimated maximum 30,000 head of cattle within the Scott River watershed utilizing an average of 15 gallons per day. The gross use taken under a stock-water right, including ditch loss, is not known but is judged to be quite high in some instances.

In most years, low flows in the Scott River occur during the months of June to November in the mainstem and in some major tributaries. During periods of drought, large portions of the mainstem Scott River are completely dry (SRWCRMP 1997). Many thousands of juvenile salmon and steelhead are stranded in some years due to dewatering of streams in the Scott River Basin (SRWCRMP 1997). Stream flows usually go subsurface in the lower reaches of Etna, Patterson, Kidder (including Big Slough), Moffett and Shackleford creeks each summer through early fall. Redds are also sometimes dewatered in the fall when water levels rise and then subside as a result of rainfall patterns in conjunction with diversions (SRWCRMP 1997).

Trinity River: The anadromous portion of the Trinity River extends 112 RM starting at the confluence with the Klamath River at Weitchpec to the upstream limit of fish passage at Lewiston Dam. The major tributaries in this reach are the South Fork Trinity River, New River, French Creek, North Fork Trinity River, and Canyon Creek. The South Fork Trinity River is the largest sub-basin within the Trinity watershed. The Trinity River is impounded at Lewiston and Trinity dams, both operated by the USBR. The former serves as the main water storage facility and the latter as a control facility for regulating releases both in-stream and for export. Trinity Lake and Lewiston Reservoir have storage capacities of 2,448,000 and 14,660 acre-feet, respectively.

Temperatures in the upper 40 miles (64.4 kilometers) rarely exceed 70E F, due to cold releases from Lewiston Dam. However, lower river stream temperatures typically exceed 70E F during the summer months of late July through early September. The Trinity River has been classified by the United States Environmental Protection Agency (USEPA) as sediment impaired. This is partially due to the lack of unregulated flows required to mobilize and transport sediments.

Mad River: Ruth Dam (a.k.a. Robert W. Matthews Dam) was built in 1961 about 80 miles upstream of the mouth of the Mad River in Trinity County to provide water for industrial use (e.g. pulp mills), domestic use, and hydroelectric power. It is a barrier to adult salmonids, and has a considerable influence on streamflow for 80 miles (129 kilometers) downstream of the dam (CDFG 2001b). The Humboldt Bay Municipal Water District operates five Ranney collector wells in the lower portion of the Mad River that have a design capacity of 75 million gallons per day to supply drinking water to Eureka, McKinleyville, Blue Lake, Freshwater, Arcata, and other smaller surrounding communities (CDFG 2001b).

Eel River: Mainstem Eel River flows have been regulated and managed for hydroelectric power and exported for agriculture since 1922. There are two dams associated with the Potter Valley Hydroelectric Project located on the upper mainstem Eel River. Scott Dam forms Lake Pillsbury and Cape Horn Dam forms the Van Arsdale diversion reservoir. A diversion tunnel draws water from Van Arsdale reservoir through a mountain and delivers the water to the Potter Valley Powerhouse. Some of the diverted water is used in Potter Valley. The remainder is stored in Lake Mendocino and released to the Russian River where it is used for frost protection and irrigation of crops and other purposes (CDFG 2001b).

Regulated flow releases from Lake Pillsbury change the temperature regime between Scott and Cape Horn dams. Water temperatures become cooler in summer and warmer in winter. The change in water temperature enhances summer rearing for steelhead trout, but can delay juvenile chinook salmon emigration. The delay results in juvenile chinook salmon encountering marginal or lethal water temperatures as they migrate through downstream reaches of the Eel River towards the ocean. Over half the mainstem and tributary channels can be considered thermally lethal during some portion of the summer. There are two additional small hydroelectric facilities on the mainstem Eel River. One is located on Mud Creek (Dobbyns Creek tributary) and another on Kekawaka Creek (CDFG 1997b).

Two other reservoirs, Centennial and Morris, are located on Davis Creek, a tributary to Outlet Creek. These reservoirs provide water to the city of Willits. Lake Emily and Lake Adarose are located on Willits Creek, also a tributary to Outlet Creek. These reservoirs provide water to the community of Brooktrails. Benbow Lake is located on the South Fork Eel and is a seasonal impoundment closed only during the summer months. It is currently under review by NMFS to investigate the impact to salmonids.

There are approximately 260 licensed, permitted, or pending water rights within the Eel River watershed. This number does not include riparian users and other diversions that are not registered with the Division of Water Rights of the State Water Resources Control Board (SWRCB).

Russian River: In 1908, the flows of the Russian River were augmented by Eel River water diverted through the Potter Valley Tunnel to generate electricity. In 1922, Scott Dam on the Eel River was constructed to provide a more reliable year-round supply of water to the Potter Valley Powerhouse. Augmentation of the Russian River, via its East Branch, from the Potter Valley Project averaged 159,000 acre-feet per year (an average flow of approximately 21 cfs) between 1922 and 1992.

Coyote Dam, forming Lake Mendocino on the East Branch near Ukiah, was completed in 1959 to provide flood protection and store water for domestic use. Coyote Dam has no fish passage facility. During the winter the dam reduces storm flow peaks and extends the storm hydrograph. During the summer months water is released from Coyote Dam to maintain higher than natural flows for fish, recreation, and rediversion to agricultural and domestic consumers. Summer minimum flow releases in the Russian River between the East Branch and Dry Creek is 150 cfs. As a result, summer flows in Healdsburg are some 15 to 20 times greater than the unimpaired flows would be.

Warm Springs Dam, forming Lake Sonoma on Dry Creek near Healdsburg, was completed in 1984 and, similar to Coyote Dam, provides flood protection and water storage for domestic use. During the summer months water is released to Dry Creek, then to the Russian River for rediversion at Wohler and Mirabel as domestic water. Summer minimum flow release in Dry Creek is 75 cfs, although it is often significantly greater. The unimpaired summer flow in Dry Creek is significantly less.

In addition, there are five smaller impoundments on the mainstem Russian River, and approximately 500 licenced or permitted dams on the tributaries to the Russian River (SEC 1996). These diversions range from very small domestic use diversions to large agricultural diversions. The most significant impacts to fishery resources may be caused by frost protection diversions which can take large volumes of water in a short period of time. Irrigation diversions may individually take a much smaller volume of water than a frost protection diversion, but some irrigation diversions are still large relative to the flow of many tributary streams during the summer. In some areas the cumulative impact of several irrigation diversions may be significant. Reduced vegetation cover in much of the Russian River watershed appears to have increased the rate of run-off in the winter and reduced the flow of streams in the summer.

Walker Creek: In the late 1970s following the 1976-1977 drought, a dam was constructed on Arroyo Sausal just upstream of its confluence with Walker Creek to augment the domestic water supply of the Marin Municipal Water District. This dam, which forms the 10,000 acre-foot Soulajule Reservoir, was constructed just downstream of an older, small agricultural dam. Since its construction, the water from Soulajule Reservoir has never been used except for periodic test pumpings. To be used, the water from Soulajule Reservoir must be pumped a considerable distance to Nicasio Reservoir to the south, and from there to the water treatment plant in San Geronimo. Because of this, there has been no significant impact on the total flow of water in Walker Creek. There are, however, some reductions in peak flows, changes in the shape of the storm hydrographs, and increases in summer flow. There may also be some increase in summer water temperature in the area near the dam. Summer flow releases are intended to improve salmon and steelhead trout habitat in most years. Natural surface flows would often cease in many areas by midsummer.

The release of warm reservoir water and higher than natural flows could result in water temperatures above the optimum for coho salmon. Water temperatures recorded throughout the summer of 1998 in the three miles below the dam regularly reached highs between 68^0 and 74^0 F. Temperatures in the canyon near the confluence of Chileno Creek, where coho salmon are more likely to be found, would likely be significantly less.

Lagunitas Creek: Lagunitas Creek once supported large numbers of coho salmon and steelhead trout, but populations were significantly reduced by inadequate instream flows, prolonged drought, and habitat loss. There are five large reservoirs in the Lagunitas Creek system: Lagunitas, Bon Tempe, Kent, and Alpine reservoirs on the mainstream and Nicasio Reservoir on Nicasio Creek. Dams forming these reservoirs block access to about 25 percent of the habitat once used by coho salmon. These reservoirs are operated by the Marin Municipal Water District to provide domestic water to the heavily populated eastern Marin County. A small diversion on lower Lagunitas Creek is also used by the North Marin Water District to serve 1,000 to 1,500 residents in the Point Reyes Station area.

Artificial Barriers

Artificial structures on streams fragment aquatic ecosystems by blocking or impeding migration and altering nutrient cycling patterns, streamflows, sediment transport, channel morphology, and species composition. This reduces available habitat and changes habitat conditions for anadromous salmonids and reduces native biodiversity. Stream ecosystem fragmentation occurs when the river or stream continuum is disrupted by barriers such as road crossings, dams, severe pollution, or other land management practices, or when surface or subsurface hydrologic connections are severed between the stream channel and adjacent wetlands.

Structures that can potentially block or reduce fish passage include dams, road crossings (bridges, culverts, or low water fords), flood control facilities (concrete channels), erosion control structures (energy dissipaters), canal and pipeline crossings, pits from gravel mining, and other more unique situations. Instream structures have the potential to, depending on conditions, either entirely or partially block fish from accessing upstream reaches and block critical habitat necessary for survival.

Complete blocking occurs not only at large dams, but can also occur at small structures less than 10 feet high if there is not enough streamflow, if the downstream face or footing of the dam slopes away (making the horizontal distance too great to overcome), or if the jump-pool at the foot of the structure is too shallow or non-existent.

Even if stream barriers are eventually negotiated by fish, excess energy expended may result in their death prior to spawning, or reductions in viability of eggs and offspring. At temporal barriers, the delay imposed by one or more stream crossings can limit the distance adult fish are able to migrate upstream before spawning, which can result in under-utilization of upstream habitat and superimposition of redds in lower stream reaches. Migrating adults and juveniles concentrated below barriers with impassable culverts are also more vulnerable to predation by a variety of avian and mammalian species, as well as illegal harvest by humans.

While the upstream movement of adult salmon and the downstream movement of salmon smolts are familiar phenomena, other occasions of fish migration or movement are not generally as well known. Juvenile salmonids move both upstream and downstream in response to various environmental factors. These factors include seeking refuge from elevated stream temperatures, extreme flow conditions, and heavy predation, or seeking less densely populated areas with better opportunities for food and cover. For some juvenile fish, upstream migration is an important part of their life cycle.

Many studies indicate that a common strategy for over-wintering juvenile coho salmon is to migrate out of larger river systems into smaller streams during late-fall and early-winter storms to seek refuge from possibly higher flows and potentially higher turbidity levels in mainstem channels (Skeesick 1970; Cederholm and Scarlett 1981; Tripp and McCart 1983; Tschaplinski and Hartman 1983; Scarlett and Cederholm 1984; Sandercock 1991; Nickelson et al. 1992). There is evidence that coho salmon juveniles over-wintering in these areas have higher survival rates due to reduced water velocities in these microhabitats. Recent research conducted in coastal northern California suggests that juvenile salmonids migrate into smaller tributaries in the fall and winter to feed on eggs deposited by spawning adults as well as flesh of adult carcasses. Artificial impediments, such as road crossings or low flows, that restrict movement of juvenile coho salmon can reduce survival.

Numerous hydropower and water storage projects have been built that either block access to areas used historically by coho salmon or alter the hydrograph of downstream river reaches. NMFS (1995) identified a total of nine dams in California that currently have no fish passage facilities to allow coho salmon access to former spawning and rearing habitats. Blocked habitat constitutes approximately 9 to 11 percent of the historical range of each coho salmon ESU. There are five major dams within the California portion of the SONCC Coho ESU that currently block access to historical spawning and rearing areas of coho salmon. Combined, these blocked areas amount to approximately 11 percent of the freshwater and estuarine habitat in this region (Table 12). There are four major dams within the CCC Coho ESU that currently block access to historical spawning and rearing areas of coho salmon. Combined, these blocked areas amount to approximately nine percent of the freshwater and estuarine habitat in this region (Table 13). In addition to these, there are also five smaller impoundments on the mainstem Russian River, and approximately 500 licensed or permitted dams on its tributaries (SEC 1996).

Table 12. Major dams within the California portion of the Southern Oregon/ Northern California Coast Coho ESU, that block coho salmon from accessing historical spawning and rearing habitat (no passage facility available).

Name of Dam	Location	Upstream Habitat Blocked	Percent of Basin
Scott Dam	Eel River, approximately 169 miles (272 km) upstream from the Pacific Ocean, and forms Lake Pillsbury in Lake County, California	36 Miles (58km)	8% (Eel River Basin)
Matthews Dam	Mad River, approximately 79 miles (127 km) upstream from the Pacific Ocean, and forms Ruth Lake in Trinity County, California	2 Miles (3 km)	13% (Mad River Basin)
Lewiston Dam	Trinity River (tributary to the lower Klamath River), approximately 112 miles (179 km) upstream from the Pacific Ocean, and forms Lewiston Reservoir in Trinity County, California	109 Miles (175 km)	24%(Trinity Basin) 9% (Klamath Basin
Dwinnel Dam	Shasta River (tributary to the upper Klamath River), approximately 214 miles (345 km) upstream from the Pacific Ocean, and forms Dwinnell Reservoir in Siskiyou County, California.	17 Miles (27 km)	17% (Shasta basin) 2% (Klamath basin)
Iron Gate Dam	Klamath River, approximately 190 miles (306 km) upstream from the Pacific Ocean, and forms Iron Gate Reservoir in Siskiyou County, California.	30 Miles (48 km)	8% (Klamath basin)

Table 13. Major dams within the Central California Coast Coho ESU, that block coho salmon from accessing historical spawning and rearing habitat (no passage facility available).

Name of Dam	Location	Upstream Habitat Blocked	Percent of Basin
Peters Dam	Lagunitas Creek, approximately 14 miles (23 km) upstream from the Pacific Ocean, and forms Kent Lake in Marin County, California	8 Miles (13 km)	6%
Nicasio Dam	Nicasio Creek, (tributary to Lagunitas Creek), approximately 8 miles (13 km) upstream from the Pacific Ocean, and forms Nicasio Reservoir in Marin County, California.	5 Miles (8 km)	10%
Warm Springs Dam	Dry Creek (tributary to the Russian River), approximately 45 miles (72 km) upstream from the Pacific Ocean, and forms Sonoma Lake in Sonoma County, California.	50 Miles (80 km)	9%
Coyote Dam	Russian River, approximately 95 miles (153 km) upstream from the Pacific Ocean, and forms Lake Mendocino in Mendocino County, California.	36 Miles (58 km)	7%

Gravel Extraction

Introduction: As stated by Kondolf (1993), "The river can be likened to a conveyor belt, moving sediment eroded from the steep headwaters to ultimate deposition below sea level. By removing sediment from the active channel, instream gravel mining interrupts the continuity of this sediment transport and induces channel incision... ." The effects of gravel mining (instream and terrace) on aquatic resources is, therefore, very complex and cannot be adequately described unless the watershed as a whole is included in the study. This complex and interrelated nature of instream mining has made regulation of this activity extremely difficult. Kondolf (1995) asserts that state regulation of instream gravel mining "has been ineffective at preventing resource degradation, despite numerous permit requirements from various federal, state, and local agencies." Until very recently, lead agencies (largely counties) that govern mining did not regulate instream mining at the watershed level. While impacts to rivers from instream mining have been documented in the past, the level of impact that instream mining has had on aquatic and riparian resources lessened in the mid-1990s with increased regulation.

Instream mining was originally controlled through FGC 1603 (Lake and Streambed Alteration Agreement), which was adopted in 1961. Instream mining is also regulated by Section 10 of the Rivers and Harbors Act and Sections 401 and 404 of the CWA (formerly known as the Federal Water Pollution Control Act of 1899). State regulation of mining has largely been accomplished under the California Environmental Quality Act (CEQA) of 1970 and the Surface Mine and Reclamation Act (SMARA) of 1975. However, specific state-wide standards that require the regulation of instream mining on a watershed basis were not adopted until 1991, and only apply to those operations permitted after 1991. Those standards state (Article 9 Section 3710 (c) & (d)) that:

> "Extraction of sand and gravel from river channels shall be regulated to control channel degradation in order to prevent undermining of bridge supports, exposure of pipelines or other structures buried within the channel, loss of spawning habitat, lowering of ground water levels, destruction of riparian vegetation, and increased stream bank erosion (exceptions may be specified in the approved reclamation plan). Changes in channel elevations and bank erosion shall be evaluated annually using records of annual extraction quantities and bench-marked annual cross sections and/or sequential aerial photographs to determine appropriate extraction locations and rates... instream mining activities shall not cause fish to become entrapped in pools or in off-channel pits, nor shall they restrict spawning or migratory activities."

At a more regional scale and recent time frame, regulation and consideration of cumulative impacts are being considered through local aggregate management plans such as Sonoma County Aggregate Resources Management Plan and Environmental Impact Report (Sonoma County Board of Supervisors 1994), Humboldt County's Memorandum of Agreement and Programmatic Environmental Impact Report on Gravel Removal from the Lower Mad River (Humboldt County Board of Supervisors 1994) and the County of Humboldt Extraction Review Team, coupled with Lake and Streambed Alteration Agreements, and United States Army Corps of Engineers (USACE) Letters of Permission (LOP 96-1, 1996; LOP 96-2, 1997).

Potential impacts: Instream mining (the removal of sediment from the active channel) causes various impacts to salmonid habitat by interrupting sediment transport and often causing channel incision and degradation (Kondolf 1993). The classes of impacts that can result from instream mining include: direct mortality; noise disturbance; disruption of adult and juvenile migration and holding patterns; stranding of adults and juveniles; increases in water temperature and turbidity; degradation of juvenile rearing habitat; destruction or siltation of redds; increased channel instability and loss of natural channel geometry; bed coarsening; lowering of groundwater elevation; and loss of LWD and riparian vegetation (Humboldt County Public Works 1992; Kondolf 1993; Jager 1994; Halligan 1997). Terrace mining (the removal of aggregate from pits isolated from the active channel) has the potential to cause similar impacts to salmonids, when and if a flood causes channel capture by the gravel pits.

Direct impacts of gravel extraction: Direct impacts are those that are caused by the project and occur at the same time and place as the project. These include risk of direct mortality, impacts from noise, summer crossing construction, disruption of migration and holding patterns, and increased potential for stranding.

Direct mortality of salmonids may result from operations such as wet stream crossings by equipment, wetted channel dragline excavation, destruction of incubating salmonid eggs, and deposition of material into the rivers. The period for extraction operations coincides with the summer period of low flow, the end of the downstream salmonid migration run, beginning of the upstream spawning run, and low rainfall periods. Wet stream crossings are used only to facilitate the construction of summer bridges.

Improper location, timing, and type of summer crossing installation may have direct impacts on salmonids in a number of ways. Improper location may reduce rearing habitat by filling in downstream pools. Installation of bridges in May or early June could possibly result in disturbance or burial of incubating or emerging salmonids. Construction of dry summer crossings could result in burial of fry and interference with upstream and downstream migration (Williams and Bjornn 1997).

Stranding is one of the risks that migrating salmonids face and can be exacerbated by human activities such as rapid flow reductions downstream of power-producing dams or gravel extraction activities that leave depressions and low spots on the gravel bars. Stranding primarily occurs when river stages rise and allow fish to move into newly inundated areas. As flows recede, fish can become trapped in pools or depressions found in overflow channels, isolated meander oxbows, around LWD, extraction bars, or other features. Unless flows increase or the depressions are fed by sub-surface flow, the trapped fish can succumb to high water temperatures or predators. Stranding of adult salmonids (excluding coho salmon) has been observed in the past on shallow riffles on the lower Eel River (Arcata Redi-Mix 1993). Halligan (1997) observed stranded adult chinook on shallow riffles in the Van Duzen River upstream of the Leland Rock operation during the summer of 1996. The Van Duzen fish were trapped by receding stormflows. Improper reclamation and regrading of gravel bars after extraction may result in the stranding of adult or juvenile salmonids. Fish may get trapped in shallow depressions as storm flows recede. Unless rescued in a short time, these fish will likely succumb to desiccation or predation.

Indirect impacts of gravel extraction: Indirect impacts are those that are caused by the project and are later in time or farther removed in distance from the project site. Potential indirect impacts that may occur from gravel mining operations include increased water temperatures, elevated turbidity, degradation of juvenile rearing habitat, reduction in spawning habitat, degradation of tributary mouths that can inhibit upstream migration, and loss of LWD that could reduce habitat diversity.

The effects on water temperature caused by gravel operations result from changes in channel morphology. Gravel skimming creates a less confined, wider channel. If the water level rises during the summer months, it could spread out over wide gravel bars instead of being confined in the relatively deep, narrow low-flow channel. The greater water surface area absorbs more incoming short-wave solar radiation, and the water temperature rises. Furthermore, the incoming summer solar radiation penetrates the relatively clear, shallow water and warms the gravel substrate. The gravel substrate releases long-wave radiation and helps maintain warm water temperatures into the evening hours. Warm temperatures can reduce fecundity, decrease egg survival, retard growth of fry and smolts, reduce rearing densities, increase susceptibility to disease, and decrease the ability of young salmon and trout to compete with other species for food and to avoid predation (Spence et al. 1996; McCullough 1999).

Coho salmon are susceptible to problems related to increased stream temperature because they usually spend a year in fresh water, thus are subject to temperature impacts associated with summer and early-fall. They are also less tolerant of warmer water temperatures than steelhead trout (Frissell 1992). In northern California, both Welsh et al. (2001) and Hines and Ambrose (1998) found that coho salmon juveniles were absent in stream reaches where the moving weekly average water temperature exceeded 62.2E F, or the moving weekly maximum temperature exceeded 64.9E F.

Conclusions: While instream gravel extraction has had direct, indirect, and cumulative impacts on salmonid in the recent past, no direct impacts to coho salmon have been documented under the current (post-1995) mining regulations as implemented through SMARA, local aggregate management plans, and USACE's Letters of Permission. However, many of the rivers within the petition area continue to feel the effects of years of channel degradation from the millions of tons of aggregate removed from the systems over time (Collins and Dune 1990). Therefore, indirect and cumulative impacts to coho salmon caused by current instream mining activities, such as increased braiding resulting in increased temperatures, have not been demonstrated conclusively.

<u>Suction Dredging</u>

Suction-dredge placer miners extract gold from the river gravels by sucking the gold-bearing gravels into the floating dredges, pumping the gravel-water mixture across a settling table where the gold concentrates by gravity, then discharging the gravel and water back into the river. An annual permit from the Department (under Title 14 CCR, section 228) and, in some circumstances, a Lake and Streambed Alteration Agreement is required to engage in this activity.

Dredges use high-pressure water pumps driven by gasoline-powered engines. The pump creates suction in a flexible intake pipe with a nozzle no greater than six inches in diameter. Suction dredges vacuum the streambed (which is composed of rock, gravel, and finer sediment) with water through the hose into the sluice box. Both the pump and the sluice box are usually mounted on a floating platform, often positioned over the work area by securing to trees or rocks with ropes or cables.

The portion of stream bottom dredged ranges from a few small excavations to the entire wetted area in a section of the stream. Larger suction dredges have the capacity to excavate as much as several cubic yards of gravel from the river bottom, depending on the type of streambed material and the skill of the operator.

Dredging activities in freshwater environments can have a variety of direct impacts on the environment, including impacts to aquatic and riparian organisms (Griffith and Andrews 1981; Thomas 1985; Harvey 1986) and channel stability. Impacts can also result from the potential release of hazardous constituents (such as mercury) to marine and terrestrial environments. However, there are no studies that document such dredging-related impacts on coho salmon or their habitat within the petitioned area.

Conclusion: Suction dredging, in accordance with Title 14 CCR, section 228, is allowed within the waters of the petitioned area. The restrictions currently imposed by regulations on this activity are designed to eliminate the potential for impacts to coho salmon by restricting suction dredging actions to locations and times when such activities will not impact the species.

Streambed Alteration

In ecologically healthy watersheds, interactions between water flows, stream channels, and riparian vegetation produce habitat complexity and variety (Naiman et al. 1992). The complexity of these streams is used by a number of species at some point in their life cycle (Everest 1987). In forested areas, the LWD that falls into streams help create deep pools, trap sediment, stabilize stream banks, and produce varying water current (Bisson et al. 1987) which form additional habitat including side channel habitat or "flow shadows". The resulting complexity allows the stream and its biological communities to adjust to natural disturbances such as fires, windstorms, and landslides, and creates a dynamic, productive ecosystem for coho salmon.

Streambed alteration activities can result in simplification of stream channels and a loss of habitat complexity (Bisson et al. 1987). Simplification effects include decreases in the range and variability of stream flow velocities and depths, and reductions in the amount of large wood and other stream structures. Activities in the stream channel can cause excess sediment to fill-in the pools, as well as eliminate the source of LWD that creates pools. Straightening of channels, or "channelization", alters the geomorphology of the stream that creates channel complexity. Channelization that includes concreting the channel bottom permanently alters the substrate, and eliminates macroinvertebrate habitat, permanent in-stream vegetation, and natural substrate necessary for spawning.

Most of the coho salmon range in California consists of either pool-riffle or braided channels, or combinations of the two. Pool-riffle channels have an undulating bed which defines a rhythmic sequence of bars, pools, and riffles. Pools and riffles represent the topographic low and high points along the channel bed. Pools typically develop along one bank with an exposed bar along the opposite bank. The line of maximum depth (thalweg) commonly alternates from one bank to the other, crossing over at riffles.

Channel morphology adjusts to changing water and sediment discharges to maintain dynamic equilibrium. Often human activities induce changes by creating disequilibrium conditions which must then readjust to approach a new equilibrium. There are both direct and indirect changes. Direct changes include dam construction, water diversion, instream gravel mining, and channelization, while indirect changes include land use changes of many types. The time frame of recovery is dependent upon the sensitivity of the system to perturbation.

Gravel and cobble-sized sediment has tremendous ecological importance, as habitat for benthic macroinvertebrates and as spawning habitat for coho salmon. Sand and finer-grained sediment can degrade gravel and cobble habitats, especially when introduced to the channel at low flows, when they may accumulate on the bed. Most of the sediment transport occurs during floods, whether of short duration in rainfall-driven systems, or of longer duration but less intense snowmelt-driven systems. Sediment transported during high water flow episodes can move quickly through the system. When there is sediment deposition during low flows, sediment will remain in the channel substrate, thus impacting the gravel quality for coho salmon spawning and successful egg survival.

Loss of riparian habitat: Vegetation along streambanks exerts a strong control over bank stability, and thus has some influence on channel form. The role of riparian vegetation has, in general, been understated in part because of the additional complexity introduced by vegetative root patterns and problems in quantitatively defining the effects. The effects of vegetation are particularly evident in small channels where root masses from grasses may protect banks against even extreme flood events. In moderate-sized channels, the dense root mats formed by continuous bands of riparian vegetation such as alders, willows, and cottonwoods have been observed to maintain bank stability in 20-50-year events depending upon flow orientation relative to the bank. LWD in small, forested channels has been shown to be responsible for 50-90% of the pool formation and 60% of the total fall in stream elevation by creating “organic” riffles.

The community health of stream-riparian ecosystems requires periodic disturbance and renewal to create a wide diversity of habitats based on variable age and species composition. Natural mortality agents include dessication, inundation, erosion (undermining and damage by bedload), and breakage through debris impacts during high flows.

Loss of pool habitat: Activities that increase sediment yield from the watershed and deposition in downstream reaches can impact pool habitat as well as gravel quality. In many systems, pool habitat has been lost to filling by fine sediment, reducing the abundance of pools. The *pool-riffle ratio* provides one measure of this. Activities that decrease in-stream LWD or recruitment of LWD, affect the geomorphology of streams by decreasing the structures that help the formations of pools.

Navigational improvement activities: Most of the long-term damage to the aquatic environment from navigational improvement activities has already occurred in the form of habitat alterations. North and central coast streams and rivers in their natural state are littered with LWD, and their complex channels consist of oxbows, multiple channels, and small impoundments that create the complex habitat required for coho salmon reproduction and survival. Navigation, on the other hand, requires deep, straight channels, free of snags that could harm boat hulls and propellers.

Roads: Road building is a component of many different land-use activities, and the total amount of road surface area in California is substantial. Stream and riparian habitats are routinely damaged while building roads because many roads wind their way through stream corridors. In the process, many streams are channelized to prevent erosion of stream banks that have roads built on top. Roads contribute to increased runoff and increased delivery of contaminants and inorganic sediment to streams and rivers. Compacted gravel or dirt and paved asphaltic roads are nearly all impervious surfaces that allow no infiltration. Watershed-scale changes in permeability has been found to compromise flow regimes, essential physical characteristics, and water chemistry in lower-order spawning and rearing streams in the Pacific Northwest (May 1997).

Roads can also deliver large volumes of inorganic sediment to streams and rivers, especially from poorly maintained rural and forest roads. Mass-wasting or the delivery of large volumes of soil to the stream through land slides is a symptom of poorly built roads, or well-built roads on unstable geology. One large factor contributing to mass-wasting is when two or more channels upslope of a road are combined through one culvert under the road and directed into one of the stream channels downslope of the road. This is usually done with smaller streams, but doubling or tripling the flow through a channel will inevitably cause mass erosion of the channel that can take large sections of road with it, delivering enormous amount of sediment to a stream channel.

Water Quality

Under Section 303(d) of the 1972 CWA, states, territories and authorized tribes are required to develop lists of impaired waters that do not meet water quality standards, even after parties responsible for point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for water on the lists and develop action plans, including TMDL plans to improve water quality.

TMDLs in California are developed either by RWQCBs or by the USEPA . TMDLs developed by RWQCBs are designed as Basin Plan amendments and include implementation provisions. TMDLs developed by USEPA typically contain the total load and load allocations required by Section 303(d), but do not contain comprehensive implementation provisions. An implementation plan is required in order for the RWQCBs to incorporate any TMDL into their Basin Plans. In developing implementation programs for TMDLs established by the USEPA , it has often become necessary for the RWQCBs to justify or change the USEPA numbers. This process has resulted in the RWQCBs adopting TMDLs that are different from those established by the USEPA. Within the range of coho salmon, there are 74 water bodies that are on the section 303(d) list of impaired water bodies (Table 14).

Water pollution originates from point sources and non-point sources as listed in Table 14. The combined input and at times unknown origin of nutrients, biocides, metals and metalloids make it difficult to pinpoint specific pollutants to specific and direct effects on coho salmon. Mixed compounds have different effects on the biological community of a stream than would any single compound. In addition, effects vary with habitat alteration, temperature and the concentration of dissolved materials in the surface waters (Brown and Sadler 1989). Water quality within the coho salmon range is affected by industrial discharges, agricultural discharges, mineral mining wastes, municipal wastewater discharge, road surface discharge, and urban stormwater discharge.

The following discussion on water quality impacts generally applies to salmonids. These water quality impacts have not directly been shown to impact coho salmon in California.

Industrial discharges: There are many types of industry in California, primarily centered around urban areas. The types of discharges that industries produce are either chemical or organic. There are many industrial producers of chemical products and their discharge can contain several of the toxic pollutants listed in Table 14. Metal discharges such as cadmium, chromium, copper, iron, lead, mercury, nickel and silver are toxic to fish at low concentrations (USEPA 1986). McDonald et al. (1989) report a particular metal may be toxic to an aquatic organism because of its surface activity, in addition to any internal effects it might have. This difference in effect is due to the fact that aquatic organisms have more delicate external surfaces (in terms of structure and physiology) than the exposed surfaces of terrestrial animals. Amongst the ranked metals, copper was found to be the most toxic metal to trout, with nickel being the least toxic. Metals can also have dramatic effects in early life-stages of fish, both upon body calcium content and upon skeletal mineralization.

Table 14. List of Clean Water Act Section 303(d) impaired water bodies within the range of coho salmon in California.

WATER BODIES AND AREA AFFECTED	STRESSOR	SOURCE OF POLLUTION [j]
SAN FRANCISCO BAY		
Carquinez Strait, 6560 Acres; Richardson Bay, 2560 Acres	Chlordane; Copper; DDT; PCBs; PCBs (dioxin-like); Diazinon ; Dieldrin; Dioxin compounds; Exotic species; Mercury; Furan compounds; Nickel; Selenium; High coliform count	1, 5, 6, 7, 20, 26, 27, 28, 34, 38, 45
San Francisco Bay 172,100 Acres	Chlordane ; Copper; DDT; Diazinon ; Dieldrin; Dioxin compounds; Exotic Species; Furan compounds; Mercury; Nickel; PCBs; PCBs (dioxin-like); Selenium; High coliform count	1, 5, 6, 7, 20, 26, 27, 28, 34, 36, 38, 47
San Pablo Bay, 71,300 Acres; Suisun Bay, 25,000 Acres; Suisun Marsh Wetlands, 57,000 Acres; Suisun Slough, 10 Miles	Chlordane ; Copper; DDT; Diazinon ; Dieldrin; Dioxin compounds; Exotic Species; Furan compounds; Mercury; Nickel; PCBs; PCBs; (dioxin-like); Selenium; High Coliform Count; Metals	1, 5, 6, 7, 15, 20, 26, 27, 28, 34, 36, 38, 45
Tomales Bay; Calero Res.; Guadalupe Res.; Lake Herman; Merritt Lake; Alameda Cr.; Alamitos Cr.; Arroyo Corte Madera Delpresidio; Arroyo De La Laguna; Arroyo Del Valle; Arroyo Hondo; Butano Cr.; Calabazas Cr.; Corte Madera Cr.; Coyote Cr. (Marin and Santa Clara Cos); Gallinas Cr.; Guadalupe Cr.; Lagunitas Cr.; Laurel Cr.; Ledgewood Cr.; Los Gatos Cr.; Matadero Cr.; Miller Cr.; Mt. Diablo Cr.; Napa R.; Novato Cr.; Permanente Cr.; Pescadero Cr.; Petaluma R.; Pine Cr.; Pinole Cr.; Rodeo Cr.; San Antonio Cr.; San Felipe Cr.; San Francisquito Cr.; San Gregorio Cr.; San Leandro Cr.; San Lorenzo Cr.; San Mateo Cr.; San Pablo Cr.; San Rafael Cr.; Saratoga Cr.; Sonoma Cr.; Stevens Cr.; Walker Cr.; Walnut Cr.; Wildcat Cr. (Total: 8520 Acres and 759 Miles)	Metals; Nutrients; Pathogens; Sedimentation/ Siltation; Mercury, Floating material; Org. enrichment/ Low D O; Diazinon; Pathogens; Salinity	1, 4b, 10, 15, 25, 28, 38, 42, 44, 45
NORTH COAST		
Albion River, 14 Miles	Sediment	28, 39
Eel River Delta, 6350Acres	Sediment; Temperature	28, 31, 39
Eel River, 2508 Miles	Sediment; Erosion; Temperature	13, 16, 23, 28, 31, 32, 33, 34, 36, 39, 41
Elk River, 88 Miles	Sediment	39
Freshwater Creek. 73 Miles	Sediment	13, 16, 23, 28, 33, 34, 39
Garcia River, 39 Miles	Sediment; Temperature	13, 16, 23, 28, 32, 33, 34, 35, 39, 41

Table 14, continued		
WATER BODIES AND AREA AFFECTED	**STRESSOR**	**SOURCE OF POLLUTION**
Gualala River, 35 Miles	Sediment	13, 16, 22, 23, 28, 33, 34, 39, 20
Klamath River, 190 Miles	Nutrients, Org. enrichment/Low D. O.; Temperature	3, 11, 15, 17, 21, 26, 28
Mad River, 90 Miles	Sediment	28, 36, 39
Mattole River, 56 Miles	Sediment; Temperature	13, 17, 28, 31, 32, 35, 39, 40
Navarro River, 25 Miles	Sediment; Temperature	1,3, 8, 12, 13, 15, 16, 17, 21, 22, 23, 28, 31,32, 33, 34, 35, 36, 37, 39, 40, 41, 42
Noyo River, 35 Miles	Sediment	28, 39
Redwood Creek, 63 Miles	Sediment	28, 31, 39
Russian River, 105 Miles	Sediment	4a, 6, 8, 12, 15, 16, 17, 19, 22, 23, 28, 32, 33, 34, 35, 37, 39, 40, 41, 43, 45
Scott River, 68Miles	Sediment; Temperature	3, 12, 21, 25, 28, 30, 32, 36, 39, 41, 46
Shasta River, 52 Miles	Org. enrich/ Low D. O. Temperature	2, 3, 12, 15, 17, 28, 32, 35, 46
Stemple Creek, 17 Miles	Nutrients	28
Ten Mile River, 10 Miles	Sediment	28, 39
Trinity River, 250 Miles	Sediment; Temperature	17, 25, 28, 31, 32, 35, 36, 29, 41, 46
Van Duzen River, 63 Miles	Sediment	13, 28, 31, 39

[j] 1- Agriculture; 2 - Agriculture- irrigation tailwater; 3 - Agricultural Return Flows; 4a - Agriculture- storm runoff; 4b - Animal Operations; 5 - Atmospheric Deposition; 6 - Ballast Water; 7 - boat Discharges/vessel wastes; 8 - Bridge Construction; 9 - Channel modification,channelization; 10 - Construction/ Land Development; 11 - Dam Construction and Operation; 12 - Drainage/ Filling Of Wetlands; 13 - Erosion/ Siltation; 14 - Filling Of Wetlands; 15 - Flow Regulation/ Modification; 16 - Harvesting; 17 - Habitat Modification; 18 - Highway/ Road/ Construction; 19 - Hydromodification; 20 - industrial Point source; 21 - Irrigated Crop Production; 22 - Land Development; 23 - Logging Road Construction/ Maintenance; 24 - Manure Lagoons; 25 - Mine Tailings; 26 - Municipal Point Source; 27 - Natural Sources; 28 - Nonpoint Source; 29 - Other Urban Runoff; 30 - Pasture Land; 31 - Range Land; 32 - Removal of Riparian Vegetation; 33 - Residue Management; 34 - Restoration; 35 - Riparian Grazing; 36 - Resource Extraction; 37 - Road Construction; 38 - septage disposal; 39 - Silviculture; 40 - Specialty Crop Production; 41 - Streambank Modification/ Destabilization; 42 - Surface mining; 43 - Upland Grazing; 44 - Upstream Impoundment; 45 - Urban Runoff/storm sewers; 46 - Water Diversions; 47 - Water (groundwater), domestic use

Treated industrial waste can cause chronic effects when the combination of substances discharged causes low-level toxicity or when the aquatic community in the receiving waters are already stressed from environmental conditions or other land-use activities (Dickson et al. 1987) Excessive discharges of chemical wastes result in acute toxicity and fish kills. Excessive organic waste discharges cause high biochemical oxygen demand (BOD) which causes fish kills. Industrial waste is often warmer than the receiving waters and therefore high inputs elevate ambient water temperatures.

Agricultural discharges: Grier et al. (1994) reviewed a lengthy list of pesticides which are known to disable coho salmon behaviorally or interfere with their reproductive fitness in some way. Neurotoxic pesticides are known to contaminate surface waters that provide habitat for salmonids, including some listed for protection under the ESA (Sholtz et al. 2000). Despite their widespread use, the impacts of these pesticides on the neurological health of wild salmon are not well understood. Of particular concern are the organophosphate and carbamate insecticides that block synaptic transmission. Scholz et al. (2000) assessed the effects of diazinon, an organophosphate insecticide, on anti-predator responses and homing behavior in chinook salmon. Nominal exposure concentrations (0.1, 1.0, and 10.0 FgL^{-1}) were chosen to emulate diazinon pulses in the natural environment. In the anti-predator study, diazinon had no effect on swimming behavior or visually-guided food capture. However, the pesticide significantly inhibited olfactory-mediated alarm responses at concentrations as low as 1.0 FgL^{-1}. Similarly, homing behavior was impaired at 10.0 FgL^{-1}. Results suggest that olfactory-mediated behaviors are sensitive to anticholinesterase neurotoxicity in salmonids and that short-term, sublethal exposures to these insecticides may cause significant behavioral deficits. Such deficits may have negative consequences for survival and reproductive success in these fish (Sholtz et al. 2000).

Mineral mining wastes: California's historical mining industry was developed in a time of less-sophisticated mining methods and before modern environmental regulations. Abandoned mines and mine wastes resulting from the historical extraction of gold, silver, and mercury (among other metals) continues to plague California. An issue associated with such legacy problems within the State is metal-loading. Acid rock drainage can occur when sulfide minerals are exposed to air and water as a result of the mining activity. A chemical and biological reaction takes place resulting in the creation of sulfuric acid, which dissolves metals and which, in high concentrations, can be very harmful to aquatic life. It is the metal-loading that causes a greater environmental concern than the acidity.

The largest numbers of acid-producing abandoned mines are outside the range of coho salmon in the copper/gold belt of the Sierra Nevada, and the largest and most famous acid-producing mine is Iron Mountain Mine near Redding. Formations that contain gold and silver and are also often rich in sulfides, do occur within the Klamath/Trinity River watershed. Within the range of coho salmon, exclusive of areas draining into San Francisco Bay, only four mines are on the State's List of Mines with Potentially Significant Environmental Hazards (California Department of Conservation 2000): Grey Eagle Tailings, Buzzard Hill, and Siskon (all in Siskiyou County); and Altoona (Trinity County). Acid rock drainage has been documented to some extent at these four mines. Water quality impacts to Indian Creek (a tributary to the Klamath River) by the Grey Eagle Tailings caused a USEPA clean-up in 1998. Coho salmon had been detected in Indian Creek in the 1970s and 1980s; however, they were not detected in the 2001 surveys.

Mercury contamination by abandoned mines occurs within the mercury mining belt of the Coast Ranges, and within the large placer and hydraulic mines of the Sierra Nevada and Klamath Ranges. The mercury was mined from the Coast Ranges and then tons of elemental mercury (a potent neurotoxin) were used to extract the gold in placer and hydraulic mining operations. Within the watersheds that drain into San Francisco Bay, metal-loading and mercury impacts are known at many small mines in Napa, Santa Clara, and Alameda counties, with one of the largest mercury mines, the New Almaden, draining into the South Bay. While mercury impacts to the aquatic environment have been documented within the Bay, there are no data to connect impacts to the aquatic environment from these mines, to direct impacts on coho salmon.

The mercury that was used to recover the gold (and silver) from the large placer and hydraulic mines was lost to the environment and remains within the rivers and streams of the state, especially in the Sierra Nevada. Such large-scale placer and hydraulic mines occurred within the Scott, Salmon, Trinity, and Lower Klamath River watersheds as well. The total amount of mercury lost to the environment from all these operations may have been 3-8 million pounds or more (Churchill 1999). The bio-available form of mercury, methylmercury, has been detected in appreciable quantities in Sierra Nevada rivers, streams, and lakes; however, limited sampling by the U.S. Geologic Survey has yet to detect significant methylmercury within the drainages associated with the historical Klamath-Trinity hydraulic mines (Charlie Alpers pers. comm.).

While localized effects from metal-loading on fish and invertebrates have been documented in other areas of the U.S. (Rand and Petrocelli 1985) and within the Sierra Nevada watersheds (Charlie Alpers, pers. comm.), within the petitioned area, there are no data from the watersheds associated with the above referenced mines documenting direct or indirect impacts on coho salmon.

Municipal wastewater discharge: The most significant alteration that municipal wastewater has on stream hydrology is to increase the base flow of streams and small rivers with treated wastewater discharges. These discharges can result in increased algae production and eutrophication, which in turn alters the chemistry and ecology of the stream.

The primary components of municipal wastewater are nutrients and dissolved and suspended organic matter. Most of the nutrients are discharged as phosphorus and nitrogen in the form of NH_3 and NO_3. Acute effects to aquatic organisms usually occur when there is an accidental spill of chlorine, or when the system becomes overloaded and too much of the nutrients are in the form of ammonia. However, excessive plant growth stimulated by nutrients and excessive suspended organic matter can cause occasional high BOD and resulting fish mortality. Chemical contaminants from household use, or when industrial discharge is routed through a municipal wastewater treatment plant, can cause occasional acute and chronic effects to aquatic organisms in the receiving waters. Municipal wastewater is often warmer than the receiving waters and therefore can elevate ambient water temperature. The discharge may also have the ability to change the DO, pH, or other ambient water quality parameters.

Road surface discharge: The building of roads is a component of many different land-use activities and the total amount of road surface area in California is substantial. Because many roads wind their way through stream corridors, streams and riparian habitats are routinely damaged by delivery of contaminants and inorganic sediment to streams and rivers. Compacted gravel or dirt and paved asphaltic roads are nearly all impervious surfaces or land surfaces that allow no infiltration, and where virtually all the rain water is runoff. Rain water, especially during the first few storms of the season, carries with it the oil, fuel, grease, and other chemicals that have accumulated on the road surfaces during the dry season, as well as the herbicides used to maintain roadside areas.

Urban stormwater discharge: One of the major issues regarding the effects of urbanization on water quality is the discharge of storm water, and this is one of the leading environmental problems in the United States (USEPA 1983). Storm water in urban areas is the combination of runoff from all impervious surfaces including roads, parking lots, and other surfaces that do not have vegetation growing on them. Storm water contains contaminants that fall on road and parking lot surfaces and house and lawn chemicals that are used by homeowners.

In addition to water contamination, storm water can cause hydrologic impacts and sedimentation problems. Concentration of runoff into storm drains will cause increased episodic flow events with higher peak flows. Natural stream channels receiving storm water have higher erosion and sedimentation in downstream reaches of the stream.

Agricultural Impacts

Historically, agriculture has used lands near bodies of water such as streams, ponds, or lakes. These lands were used for both animal husbandry and for a variety of crops, usually requiring that they be cleared of most existing vegetation (Booth 1991). Due to their proximity to water, riparian habitat is lost through these direct conversions to agriculture (Terrell and Perfetti 1989), and crops are often planted close to the river's edge. For example, the majority of vineyards in the Russian River basin are located within 300 feet of the riparian zone (CDFG 2001c). Even if a riparian buffer was originally established, it may later be eliminated in order to remove habitat that could harbor agricultural pests. An example of this is the agricultural practice in Sonoma and Mendocino counties of removing riparian vegetation bordering vineyards to decrease host plants for the xylem feeding insects that carry Pierce's disease (CDFG 2001c).

Agricultural practices affect aquatic and riparian areas through non-point source pollution, since these areas eventually receive sediments, fertilizers, pesticides, and wastes from associated agricultural lands. Sediment is the most common type of non-point source pollution from agricultural lands (Knutson and Naef 1997). According to Terrell and Perfetti (1989) erosion of crop lands accounts for 40 to 50 percent of the sediment in the United States waterways. Storm runoff erodes the topsoil from open agricultural areas, and irrigation water from standard agricultural practices also carries significant amounts of sediment to the stream environment. According to Terrell and Perfetti (1989), two types of irrigation systems, sheet flow and rill, cause the greatest amount of surface erosion, while drip irrigation and piped laterals produce the least. Irrigation requires water that is drawn from the stream, lake, pond, or from the ground. Pumping from the water table reduces its level, decreasing flow to and in the river. The ability for a stream to diminish the effects of irrigation waste discharged into a stream decreases proportionally with the flow.

Small coastal streams often rely on springs to maintain flows throughout the summer months, however the aquifers that supply these streams are often utilized for irrigation. Many streams that once flowed year-round no longer do so, because of recent increases in hillside agricultural land conversion. The conversion of uplands from forest or grasslands to steep agricultural steppes, increases the erosion potential and ground water use (CDFG 2001c). Often these converted agricultural lands are for vineyards. In February 2000, Sonoma County adopted a vineyard ordinance to control sedimentation caused by vineyard erosion (Merenlender et al. 2000). The ordinance identified three levels of vineyards and seven types of "highly erosive" soils and provides corresponding requirements (CDFG 2001c).

Animal wastes carried by runoff can contaminate water sources through oxygen-depleting organic matter (Knutson and Naef 1997). Runoff from concentrated fecal sources can change water quality, causing lethal conditions for fish. As the BOD increases, DO decreases, and ammonia is released causing changes that are stressful to fish.

Grazing can affect riparian characteristics and associated aquatic systems, such as vegetative cover, soil stability, bank and channel structure, instream structure, and water quality and quantity. Behnke and Zarn (1976) and Armour et al. (1991) indicated that overgrazing is one of the major contributing factors for Pacific Northwest salmon declines. Trampling may compress or compact soils, decreasing water infiltration and increasing runoff. However, light trampling can break up surface soils that have become impervious, and allow for greater water absorption; however, this also makes the soil more susceptible to erosion (Spence et al.1996). According to Knutson and Naef (1997), some of the ways that poor grazing practices can impact fish and wildlife include:

- reducing or eliminating regeneration of woody vegetation;
- changing plant species composition in favor of more xeric species (trees, willows, and sedges replaced by brush and bare soil);
- reducing overall riparian vegetation;
- loss of protective vegetation that increases bank and instream deformation and stabilization;
- trampling and soil compaction;
- increasing stream bank erosion, which causes stream channel widening, shallowing, trenching, or braiding;
- reduced ability for riparian areas to trap and filter sediments and pollutants;
- increasing stream temperatures due to loss of cover;
- increasing the magnitude of high and low flows;
- lowering the water table, and associated loss of riparian vegetation; and
- loss of nutrient inputs, especially invertebrate food sources, to stream.

Impacts such as theses can be observed, to varying degrees, throughout the coho salmon California range.

Urbanization

Humans have traditionally settled near sources of water, such as streams, lakes, and bays. Though the effects of timber, livestock, and agriculture can be destructive, there is usually the chance for recovery of the landscape. In urban areas, recovery is unlikely, because once the natural vegetation is gone and the stream and riparian habitats are modified, the changes are usually permanent (Booth 1991; Spence et al. 1996). Booth (1991) indicated that urban watersheds could increase maximum discharge, associated with storm and flood events, as much as five times over natural stream conditions. Areas within the range of coho salmon where large-scale urban development has taken place include Arcata-Eureka, Fortuna, Willits, Ukiah, Santa Rosa, Marin County, and the San Francisco Bay Area.

Fishing and Illegal Harvest

Retention of coho salmon has been prohibited in ocean commercial fisheries south of Cape Falcon, Oregon beginning with the 1993 season. From Cape Falcon to Horse Mountain, California, coho salmon retention has been prohibited in ocean recreational fisheries since the 1994 season, and starting May 1995, the prohibition was extended to include sport fisheries south of Horse Mountain. California's inland waters have explicitly been closed by regulation to coho salmon retention since 1998.

Prior to these restrictions, fisheries for coho salmon occurred along the entire west coast of North America as far south as central California. Most coho salmon originating from Pacific coast states recruit to the fisheries after one year in fresh water and about 16 months at sea. Existing fisheries take place in coastal adult migration corridors, near the mouths of rivers, and in freshwater migration areas, largely targeting fish returning to streams with hatcheries. Trolling (hook-and-line) is the primary gear type used in commercial fisheries; however, gill nets and purse seines are used in some nearshore or in-river fisheries. Sport catches of coho salmon are typically taken by hook-and-line.

Coho salmon are also taken incidentally in fisheries directed toward other salmon species. When regulations prohibit the retention of coho salmon, the majority of released fish survive the hooking encounter. However, if large enough numbers are hooked, substantial mortality can be incurred. Substantial coho salmon bycatch can lead to restrictions on these non-directed fisheries.

<u>Ocean Harvest</u>

Coho and chinook salmon have historically constituted the major species taken in the Pacific coast commercial and recreational salmon fisheries. The fisheries off California had been directed toward and harvested primarily chinook, in contrast to those off Washington and Oregon which have largely targeted coho salmon.

Ocean commercial harvest of coho salmon in California peaked during the period 1961 through 1980, when five-year averages ranged from 150,280 to 361,660 fish. Since 1986, total harvest had not exceeded 83,000 fish annually (Table 15). Approximately 80% of the catch was landed in ports north of Point Arena. Since 1993, when non-retention was instituted, no known landings of coho salmon have been seen (PFMC 2001a).

Harvest of coho salmon was generally lower in California's ocean recreational fishery than in the commercial fishery. Since 1962, when reliable records were first taken, total harvest has not exceeded 70,000 fish (Table 16). As in the commercial fishery, most (88%) of the recreational coho salmon catch was landed from Point Arena northward. The salmon fishery in this area is characterized by large numbers of private boats and few charter boats, while in the fishery south of Pt. Arena, party boat operation is more prevalent. Non-retention of coho salmon, starting in 1994, has greatly reduced the harvest, although there continued to be a small number (less than 1000) of fish incidentally caught and illegally landed (PFMC 2001a).

Coho salmon harvested off California probably consisted of a mixture of fish originating from both Oregon and California streams and hatcheries. Federal regulation of the ocean fisheries recognizes this, and manages both states' stocks as an aggregate. One of the management tools used to determine salmon harvest rates is the recovery of coded-wire tagged salmon through statistically appropriate, randomized sampling programs. Tagged fish recoveries have been used to estimate the total occurrences of a particular release group in all of the fish caught. However, it has not been possible to determine the composition of California's contribution to the coho salmon ocean harvest from coded-wire tagged recoveries of landed fish because of inadequate and inconsistent tagging rates among its hatchery- and naturally-produced fish.

Table 15. Harvest of coho salmon in the California commercial fishery for major ports of landings, 1952 - 2000.[k]

Year(s)	Average number or number of fish landed					
	Crescent City	Eureka	Fort Bragg	San Francisco	Monterey	TOTAL
1952-1955	33,075	23,675	18,950	2,300	500	78,500
1956-1960	12,240	9,740	15,900	4,960	1,000	43,840
1961-1965	40,720	47,060	40,060	18,780	3,660	150,280
1966-1970	86,400	99,760	70,840	55,960	6,760	319,720
1971-1975	84,020	133,940	100,420	35,500	7,780	361,660
1976-1980	72,120	89,920	51,020	20,760	9,400	243,220
1981-1985	16,100	18,900	14,600	7,700	1,400	58,700
1986	4,800	4,300	20,800	5,100	1,300	36,300
1987	5,800	10,800	25,900	1,200	100	43,800
1988	2,800	10,100	30,900	6,700	400	50,900
1989	5,800	3,400	25,800	6,500	500	42,000
1990	-	1,200	26,600	27,400	5,700	60,900
1991	-	3,000	4,500	53,300	21,400	82,200
1992	-	-	-	400	2,100	2,500
1993	-	-	-	-	-	-
1994	-	-	-	-	-	-
1995	-	-	-	-	-	-
1996	-	-	-	-	-	-
1997	-	-	-	-	-	-
1998	-	-	-	-	-	-
1999	-	-	-	-	-	-
2000	-	-	-	-	-	-
TOTAL	363,875	455,795	446,290	246,560	62,000	1,574,520
% of harvest	23.1%	28.9%	28.3%	15.7%	3.9%	

[k] Retention of coho salmon has been prohibited since in 1993.

Table 16. Harvest of coho salmon in the California recreational fishery for major ports of landing, 1962 - 2000.[l]

Year(s)	Average number or number of fish landed					
	Crescent City	Eureka	Fort Bragg	San Francisco	Monterey	TOTAL
1962-1965	1,725	13,250	6,425	3,163	1,850	26,413
1966-1970	2,600	13,760	5,460	8,820	2,520	33,160
1971-1975	6,880	22,200	9,020	8,760	1,450	48,310
1976-1980	10,640	13,080	2,440	3,620	150	29,930
1981-1985	7,400	10,400	900	1,100	100	19,900
1986	8,100	8,600	1,600	400	50	18,750
1987	14,900	29,800	2,500	100	50	47,350
1988	12,200	18,300	3,200	400	200	34,300
1989	18,500	26,400	3,700	900	200	49,700
1990	15,500	24,600	4,500	5,800	1,200	51,600
1991	18,300	21,800	18,600	7,700	2,900	69,300
1992	2,800	3,600	3,300	1,600	200	11,500
1993	6,700	7,600	12,300	3,000	200	29,800
1994	100	---[m]	200	200	---[m]	500
1995	100	200	500	200	---[m]	1,000
1996	100	200	300	100	---[n]	700
1997	100	100	100	200	---[m]	500
1998	---[m]	---[m]	---[m]	---[m]	---[m]	100
1999	---[m]	100	200	300	---[n]	600
2000	100	100	100	100	100	500
TOTAL	126,745	214,090	75,345	46,463	11,170	473,913
% of Total	26.7%	45.2%	15.9%	9.8%	2.4%	

[l] Retention of coho salmon had been prohibited north of Horse Mountain, CA starting in 1994, and in 1995 was extended to south of Horse Mountain. Numbers shown for those years and subsequent represent estimated incidentally taken and illegally landed fish.

[m] Less than 50 fish.

[n] No data

The impact that commercial and recreational ocean fishing has had on the long-term decline of coho salmon populations is not clear. There are few historical or recent records to indicate that curtailment of fishing has increased coho salmon abundance. While curtailment of fishing seasons has been thought to have reduced harvest-related mortality rates on Oregon coastal coho salmon populations substantially, there has been no evidence of a corresponding increase in coho salmon spawner escapement there.

Inland Harvest

Sport fisheries for coho salmon in northern California coastal streams were not extensive and for the most part, were concentrated primarily in the estuarine areas. The fishery has not been monitored in most of the tributaries, and since 1977 the most consistent coho salmon harvest data is available only for the Klamath-Trinity river system (Pacific States Marine Fisheries Commission 2001). Highest annual catch in these rivers was estimated at about 3,600 coho salmon in 1987, but for the majority of the years less than 500 fish were caught (Table 17).

The Klamath basin's native American tribes (Yurok, Hoopa, and Karuk) also harvested coho salmon, and currently constitute the only existing sanctioned fishery directed toward the species. Both the Yurok and Hoopa Valley tribes have federally recognized fishery rights in the basin, and tribal subsistence, ceremonial, and minor commercial fisheries are prosecuted under regulatory authority of each respective tribe. Each tribe determines the level of fishing opportunity that will be provided its tribal members based on estimates of preseason abundance. Data for this review is only available for the Yurok tribe's harvest, resulting from subsistence and ceremonial fisheries within the tribe's reservation on the lower Klamath River (Weitchpec downstream to the ocean); these fisheries have only been monitored since 1992. Harvest has ranged from 27 to 1,168 fish caught annually (Table 17), and based on estimates of upstream escapement (in-river spawners and hatchery returns), is thought to be an average 4.4% harvest rate for the period (Dave Hillemeier pers. comm.).

Illegal Harvest

Illegal harvest can have an impact on populations of fishes in certain areas, although this depends on intensity, frequency and species of fish taken. The Wildlife Protection staff of the Department was queried regarding illegal harvest of coho salmon in California. Their responses indicated that illegal harvest of both juvenile and adult coho salmon does occur, although most of the illegal take is due to anglers mistaking coho salmon for some other species. Most of the violations involving the illegal take of adult coho salmon occur in the offshore sport fishery. Illegal harvest in inland waters is mostly opportunistic, meaning poachers will spear, net, gaff or snag whatever salmonid that happens to be in the stream (Tom Belt pers. comm.).

Overall, Department enforcement staff did not believe that many coho salmon are illegally harvested, and do not believe this is a significant impact on California populations. The major reasons cited as to why few coho salmon are illegally harvested in California are that coho salmon migrate during high flows and are not concentrated. The few fish that are retained by sport anglers are most often due to misidentification.

Table 17. Estimated harvest of coho salmon in the Klamath/Trinity River system..

Year	Number of fish caught: Recreational sport fishery		
	Trinity River	Klamath River	Yurok tribal fisheries [o]
1977	149	30	---
1978	0	13	---
1979	827	484	---
1980	0	---	---
1981	966	---	---
1982	476	---	---
1983	1,674	34	---
1984	182	---	---
1985	763	92	---
1986	750	60	---
1987	3,368	233	---
1988	1,961	489	---
1989	300	273	---
1990	47	54	---
1991	109	28	---
1992	24	44	122
1993	64	9	1,168
1994	0	4	27
1995	294	49	830
1996	248	160	953
1997	42	0	78
1998	0	---	181
1999	98	---	235
2000	---	---	91

[o] Consists of subsistence and ceremonial harvest, which has only been monitored since 1992.

VII. INFLUENCE OF EXISTING MANAGEMENT EFFORTS

Disease

State statute and code provide authority to the Department to curtail or minimize the impact of diseases on fish, amphibians and aquatic invertebrates within California. Implementation of this authority is achieved through: 1) inspecting imported fish and aquatic species or their gametes obtained from other states and countries; 2) inspecting aquatic species raised in state, private, and cooperative hatcheries prior to approval for planting into public waters; 3) inspecting wild fish and aquatic species captured for transport to a different location; 4) inspecting wild fish and aquatic species to acquire information, useful for fishery management decisions, on the geographical distribution of pathogens; and 5) recommending therapies and corrective measures, or stock destruction to minimize disease impacts.

Regulations granting authority to protect the state's resources from fish diseases and parasites are contained in the FGC (CFGC 2002), and the California Code of Regulations, Title 14 (Title 14). Most of these regulations are directed toward private individuals and aquaculture operations, but they also apply to state and federal hatcheries and cooperative rearing programs. The authority to curtail the spread of disease is located in the following sections of the FGC:

- Section 1008 - investigation of disease;
- Section 1174 - conditions regarding private nonprofit hatcheries;
- Sections 6300 through 6306 - infected or diseased fish;
- Section 6400 - prohibits placing fish without Department authorization;
- Sections 15500 through15516 - disease control.

Title 14 states the procedures for aquaculture diseases control. The regulations on aquaculture can be found in chapter 9, sections 236, 238.5, and 245. Section 238.5 deals with stocking of aquaculture products. This regulation covers proper licensing, permitting, exceptions and restrictions to stocking.

In section 245, the regulations are split into three parts: a) general conditions; b) definitions; and c) disease categories. These regulations are applied to protect aquaculture and the watersheds or geographic areas the Department determines could be threatened. General conditions deals with procedural guidelines. These guidelines involve:

- inspections and examinations, and how they are to be conducted;
- who is notified if a listed disease is identified;
- what to do upon confirmation of any listed disease;
- methods of disposal, and disinfection of equipment and facilities;
- certification, by a fish pathologist, prior to shipment from outside of the United States;
- disease research and who is contacted prior to the causative agent being brought to the facility.

Disease categories are broken down into four groups by level of threat. These categories are: significant diseases, serious diseases, catastrophic diseases, and "Q" diseases (a disease for which there is so little information, permanent classification cannot be given). Each group has a list of diseases, and procedures to follow for each disease. Also contained in the regulations is a list of aquatic diseases and their host organisms.

The above procedures, regulations and codes are designed primarily to benefit hatchery fish, but also to curtail the spread of diseases that may be inherent in hatchery populations to wild fish. Depending on the disease category, diseased fish are not to be stocked in waters where the disease is not known to occur. These steps should prevent the unnatural spread, or introduction of, diseases to non-infected waters of the state.

BKD is one of the more serious diseases affecting coho salmon in hatcheries. In the California portion of the SONCC Coho ESU, only Trinity River Hatchery has experienced problems with BKD (Mel Willis, pers. comm.), although Trinity River, Mad River, and Iron Gate hatcheries all spawn some infected adults. The problem was so severe at Trinity River Hatchery that a program to reduce infection from vertical transmission was implemented in 1991. This program involves taking ovarian fluid from each female spawned, assigning a number to the eggs, and keeping them separate until the eyed stage. The ovarian fluid is examined by the flourescent antibody technique, which uses a flourescent tagged antibody that reacts with the bacteria. Eggs from samples found to be positive are discarded. This type of program has not been necessary at either Mad River or Iron Gate hatcheries.

There have been no BKD problems in the coho production at Trinity River Hatchery since this program was implemented (Mel Willis, pers. comm.). At the start of the program, approximately 15% of the returning fish were infected with BKD. The level of infection ranged from low to severe. In recent years, less than 2% of returning fish are infected at low levels.

This program has been beneficial in allowing the hatchery to raise coho salmon free of BKD. Natural stocks are likely infected since BKD is a naturally occurring pathogen. However, this program is likely affecting wild stocks as well since the hatchery is not releasing infected fish and adding to the pathogen level in the river. The fact that the BKD level has dropped substantially in returning fish suggests the same may be true for natural stocks, especially in cases where hatchery and natural fish may interbreed.

Disease does not cause significant coho mortalities in Department hatcheries in the SONCC Coho ESU (Mel Willis, pers. comm.). BKD was the most problematic but is now being controlled with the above mentioned program. Other bacterial diseases, namely cold water disease, occur infrequently and are treated on a case by case basis with antibiotics added to the feed.

Hatchery Operations

Hatchery Production

California has a long history of coho salmon artificial propagation that dates at least to the 1890s (NMFS 2001a). Hatchery-produced coho salmon have been collected and planted in most, if not all, of the larger coho salmon-bearing waters of the state (Brown and Moyle 1991). Brown and Moyle (1991) conclude that all long-run coho salmon stocks, except the Eel River stock, were dominated by hatchery production. Seven facilities, consisting of private (i.e. cooperative) and State hatcheries, and an egg taking station, have recently produced coho salmon in California (Table 18).

A few facilities once produced coho salmon, but have not been active for some time. Silver King, an ocean salmon farming facility near Waddell Creek, produced an average of 95,094 coho salmon in 1984-85 (Streig 1991, as cited in Weitkamp et al. 1995). Prairie Creek Hatchery produced an average of 89,009 coho salmon from 1987/88 to 1990/91 (NRC 1995, as cited in Weitkamp et al. 1995). Prairie Creek Hatchery was closed in 1992. Humboldt Fish Action Council (Cochran Ponds) produced an average of 35,931 coho salmon in 1987/88 (Hull et al. 1989, as cited in Weitkamp et al. 1995).

Coho salmon production at many private North Coast facilities has been curtailed by the Department since coho salmon became listed under the ESA. Coho salmon production has not been permitted in recent trapping and rearing permits issued by the Department during 2000 for several of these operations.

In general, California hatcheries have released far fewer coho salmon than hatcheries in Oregon and Washington. NMFS (2001a) and Weitkamp et al. (1995) estimated that coho salmon production between 1987-91 (Table 19) in the CCC Coho ESU comprised less than 0.3% of coastwide releases. Releases in the California portion of the SONCC Coho ESU amounted to less than 1% of the coastwide coho salmon hatchery production.

Production of coho salmon at California facilities has drastically decreased in recent years (Table 19). Recent average production at Warm Springs, Mad River, and Iron Gate Hatcheries, and Noyo Egg Taking Station ranges from 11% to 44% of the average between 1987-91. Average recent production at the single private facility still in operation, Big Creek Hatchery, is only 22% of the five-year average between 1987-91. Releases from Big Creek Hatchery between 1996 and 2000 have been highly variable and dependent on spawner availability, ranging from 0 (BY 96/97) to around 25,000 (BY 95/96) fish released. Trinity River Hatchery is the only California coho salmon production facility to have maintained production at recent historical levels: average production between 1997-2001 was 106% of average production between 1987-91.

Iron Gate and Trinity River hatcheries have generally met their spawner quotas between 1997 and 2001. In several facilities, lack of spawners is the single factor most commonly responsible for limiting coho salmon artificial production in California (Weitkamp et al. 1995). At the time of this review, hatchery coho salmon production at several facilities has been severely curtailed or terminated for this reason. Big Creek Hatchery's production has been highly variable. In several years, number of spawners was limiting. This may be due largely to there being only one viable brood year lineage in the source population in Scott Creek (Dave Streig pers. comm.). In the years between 1994 and 1999 when coho salmon were spawned, Big Creek Hatchery used very small numbers of spawners (5 to19 females per year and 7 to 22 males per year) as broodstock. This hatchery program is in the process of being converted to a captive broodstock program under direction of NMFS' Southwest Fisheries Science Center.

Warm Springs Hatchery has not produced coho salmon in the last three years because of low spawner abundance (e.g. 2 to 3 returns in 1999/00, no returns in 2000/01). It is currently developing a captive broodstock program for restoration of the Russian River coho salmon using broodstock from a variety of sources in the Russian River and Marin County streams. The Noyo and Rowdy Creek facilities did not produce coho salmon in 1999 or 2000 due to lack of spawners. However, coho salmon did return to Rowdy Creek Hatchery in 2001 (Bob Will, pers. comm.). Mad River and Iron Gate hatcheries have drastically reduced production in recent years. Iron Gate Hatchery reductions have been due to decreases in production goals. However, weak returns during the 1999 brood year resulted in the hatchery not quite meeting production goals (46,254 yearlings produced out of a target of 75,000). Coho salmon production at Mad River Hatchery was terminated in 1999 by management decision. The hatchery may develop a role in assisting coho salmon recovery. In the last two years Rowdy Creek Hatchery has not taken any coho salmon spawners (Jerry Ayers, pers. comm.).

Table 18. Recent coho salmon artificial production facilities in California.

Facility Name	Operator	Type of Facility	Stream	Location (County)	ESU	Ops. Began
Big Creek Hatchery	Private [p]	Cooperative Enhancement	Big Creek (Tributary to Scott Creek)	Santa Cruz	CCC	1986
Warm Springs Hatchery	CDFG	Mitigation/ Conservation	Dry Creek (Tributary to Russian River)	Sonoma	CCC	1970
Noyo Egg Taking Station	CDFG	Enhancement	South Fork Noyo River	Mendocino	CCC	1962
Mad River Hatchery	CDFG	Enhancement	Mad River	Humboldt	SONCC	1970
Trinity River Hatchery	CDFG	Mitigation	Trinity River	Trinity	SONCC	1958
Iron Gate Hatchery	CDFG	Mitigation	Klamath River	Siskiyou	SONCC	1965
Rowdy Creek Hatchery	Private	Cooperative Enhancement	Rowdy Creek (Tributary to Smith River)	Del Norte	SONCC	1972

[p] Monterey Bay Salmon and Trout Project

Table 19. Comparison of coho salmon artificial production (average number of fish released annually) at recently active California facilities.

Facility	ESU	5-year Average 1987-1991[q]	Most recent 5-year Average (years)[r]
Big Creek Hatchery	CCC	26,808	5,883[s] (1996-2000)
Warm Springs Hatchery	CCC	138,208	14,527 [t] (1997-2001)
Noyo Egg Taking Station	CCC	170,171	55,604 [u] (1994-1998)
Mad River Hatchery	SONCC	370,907	134,870 (1995-1999)
Trinity River Hatchery	SONCC	496,807	525,512 (1997-2001)
Iron Gate Hatchery	SONCC	160,193	70,954 (1997-2001)

[q] 5-year average 1987-1991 (CDFG unpubl. data)
[r] (CDFG unpubl. data)
[s] Production = 0 in 1998 included in average.
[t] Production = 0 in 1999, 2000, 2001 included in average.
[u] Production = 0 in 1995, included in average.

Only Iron Gate and Trinity River hatcheries are currently producing relatively large numbers of coho salmon consistently. Iron Gate has a production goal of 75,000 coho salmon yearlings per year. However, this is only about 44% of the hatchery's 5-year average annual production between 1987 and 1991 (Table 19). The most recent hatchery release consisted of 46,254 brood-year 1999 yearlings, which were released into the Klamath River at the hatchery. All of these were marked with left maxillary clips.

Trinity River Hatchery produces the largest number of coho salmon of any California facility. Most of the coho salmon returning to the Trinity River are thought to be of hatchery origin. Although natural production of coho salmon occurs in the mainstem Trinity River and several tributaries, in-river spawners upstream of the South Fork Trinity River confluence are dominated by Trinity River Hatchery strays (85% to 95% for the years 1997 through 2001; Wade Sinnen pers. comm.). Trinity River Hatchery's annual production goal is 500,000 coho salmon yearlings. The current production goal is similar to both 5-year averages shown in Table 19. The brood year 1999 production consisted of 513,400 coho salmon, all with right maxillary clips, which were volitionally released at the hatchery.

Source Stocks and Stock Transfers

Stock transfer and source stock data over the history of coho salmon artificial production in California are sufficient to indicate patterns from which limited conclusions can be drawn. Planting records for private production facilities are incomplete (Weitkamp et al. 1995). The available information, based on Department and private hatchery records and published reviews, is summarized below.

Between brood years 1986-87 and 1994-95, Big Creek Hatchery frequently included broodstock from the Noyo River and Prairie Creek in its coho salmon production. This practice was terminated after 1994. Also, in the 1970s Waddell Creek was likely planted with coho salmon from Washington and other places by a commercial ocean farming operation (Taylor 1991; Brown et al. 1994).

Eggs collected at Noyo Egg Taking Station are reared to yearlings at Mad River Hatchery. These yearlings are then planted in the Noyo River with the object of maintaining the run to the station. Since 1976, yearling coho salmon planted in the Noyo River have all been from Noyo River coho eggs. Between 1967 and 1975, the majority of coho salmon planted in the Noyo River were from Noyo River coho salmon eggs with only one year when the source is listed as Trinity River. Between 1962 and 1967, coho salmon stocked in the Noyo River were from a mix of Noyo, Pudding Creek, Alsea (Oregon), and Klaskanine (Oregon) egg sources. Single sources tended to dominate the source stock for any given year during this time. Coho salmon from Noyo River broodstock were also occasionally planted in various other locations (Brown et al. 1994).

Prior to 1971, coho salmon returns to Trinity River Hatchery were about 1,000 fish. Coho salmon returns in subsequent years have varied greatly, but are generally more than 1,000 fish. Annual returns of over 5,000 coho salmon occurred in 1973 and between 1984 and 1988. Over 10,000 coho salmon returned in 1988, and over 20,000 returned in 1987. Between 1963 and 1969, Trinity River Hatchery received stock from the Eel, Noyo, Klaskanine (Oregon), and Alsea (Oregon) rivers.

Iron Gate Hatchery began an intensive coho salmon hatchery program in 1966 to mitigate for habitat lost due to the construction of Iron Gate Dam. Prior to this program, annual adult returns to Iron Gate Hatchery were 500 or fewer coho salmon (1963 to 1968). After the stocking program, hatchery returns ranged from 500 to1500 fish with the exception of 1987, when returns numbered over 2000 (Hiser 1991). Initial source stock for this intensive program was from the Cascade River, Oregon. In 1967 and again in 1969, the hatchery used Cascade River source stock. Numerous other stocks were also used at this hatchery (Table 20).

Source stocks for the Mad River Hatchery have been the most diverse of any of the hatcheries reviewed here (Table 20). Initial plantings in 1970 were of Noyo River-origin stock. Out-of-basin and out-of-state sources were used in many production years (e.g. 1972, 1973, 1978, 1979, 1981,1982, 1986, 1987, 1989).

Since its inception in 1980, coho salmon production at Warm Springs Hatchery has used Cascade River, Noyo River, and Prairie Creek stocks. Hatchery records show that Klamath coho salmon eggs were used in 1980 to produced 79,300 fingerlings that were released into Dry Creek (Brett Wilson; pers. comm.). In 1981 the hatchery received coho salmon eggs from the Klamath and Noyo Rivers. This pattern continued until 1986 when Warm Springs Hatchery received 30 adult fish from Hollow Tree Creek. Fourteen females were spawned. Klamath, Noyo, Dry Creek, (returns from the aforementioned fingerling release and yearling plants) and Hollow Tree Creek eggs were received through 1990. After 1990, Noyo River and Dry Creek eggs made up the total production at Warm Springs Hatchery. Prairie Creek Hatchery also historically used exotic stocks from Washington and Oregon, as well as Noyo River stocks.

Conclusions

The pattern that emerges from the available data suggests that California coho salmon hatcheries historically used eggs from out-of-basin and out-of-state broodstock. The majority of stock transfers were likely from sources within California (Table 20), and most coho salmon released from Department hatcheries historically were and currently are within-basin. However, some of the California origin hatchery stocks were originally derived from out-of-basin sources (Brown et al. 1994). Large transfers of distant origin (i.e. out-of-basin or out-of-state) stocks were common aspects of historical coho salmon hatchery operations. Stock transfers between ESUs, which have some level of currently observable reproductive isolation, appear to involve movement in both directions. Out-of-state stocks involved appear to be from Oregon and Washington. Such transfers were relatively common until the 1980s, but occur currently only on an exception basis (CDFG/NMFS 2001; NMFS 2001a). Now, out of basin transfers are only allowed in very restricted circumstances, and for all intents and purposes, have stopped. Data for planting of out-of-basin stocks are incomplete, but suggest that many streams in addition to those with production facilities were planted with excess hatchery production (Brown and Moyle 1991).

Several coho salmon hatcheries have had difficulty obtaining native broodstock over the past several years. While Department limits on production have been a large factor limiting coho salmon production at some facilities, the largest natural factor limiting production has been inability to collect broodstock.

Table 20. A partial list of the coho salmon stocks used at selected artificial production facilities in California. (Modified from Weitkamp et al. 1995, figure 36). Coho ESU abbreviations are CCC: Central California Coast, SONCC: Southern Oregon/Northern California Coasts, OC: Oregon Coast, LCRSWC: Lower Columbia River/Southwest Washington Coast, PSSG: Puget Sound/Strait of Georgia, NA: ESU designation is not applicable.

Facility (ESU)	Stocks used	State of origin of stocks used	ESU of origin of stocks used
Warm Springs Hatchery (CCC)	Warm Springs Hatchery	California	CCC
	Noyo River	California	CCC
	Mad River	California	SONCC
	Prairie Creek	California	SONCC
	Iron Gate	California	SONCC
	Cascade	Oregon	LCRSWC
	Other	California	NA
Noyo Egg Taking Station (CCC)	Warm Springs Hatchery	California	CCC
	Noyo River	California	CCC
	Mad River	California	SONCC
	Other	California	NA
Mad River Hatchery (SONCC)	Warm Springs Hatchery	California	CCC
	Noyo River	California	CCC
	Humboldt State University	California	SONCC
	Mad River	California	SONCC
	Prairie Creek	California	SONCC
	Trinity River	California	SONCC
	Iron Gate Hatchery	California	SONCC
	Alsea/Fall Creek	Oregon	OC
	Trask	Oregon	OC
	Klaskanine	Oregon	LCRSWC
	Sandy	Oregon	LCRSWC
	Skagit	Washington	PSSG
	Green River	Washington	PSSG
	Minter Creek	Washington	PSSG
	Other	California	NA
Trinity River Hatchery (SONCC)	Noyo River	California	CCC
	Eel River	California	SONCC
	Trinity River	California	SONCC
	Alsea/Fall Creek	Oregon	OC
	Cascade	Oregon	LCRSWC
	Other	California	NA
Iron Gate Hatchery (SONCC)	Trinity River	California	SONCC
	Iron Gate	California	SONCC
	Cascade	Oregon	LCRSWC

Hatchery and Genetic Management Plans

Hatchery and Genetic Management Plans (HGMP) are conservation mechanisms designed to allow employment of hatcheries in traditional and conservation roles while minimizing or eliminating certain risks associated with them. HGMP guidelines must:

- Contain clear goals, performance objectives, and performance indicators that state and apply the purpose of the program, its intended results, and its evaluation;
- Make use of the concepts of viable and critical salmonid population threshold as described in NMFS (2000). Listed populations may be taken for broodstock only according to certain criteria;

- Ensure that broodstock collection reflects appropriate priorities, taking into account fish health, abundance, and trends in the donor population. The primary purpose of broodstock collection of listed species is reestablishment of indigenous populations and for conservation purposes consistent with ESU recovery;
- Include protocols for fish health, broodstock collection, spawning, rearing, and release of juveniles, deposition of hatchery adults, and catastrophic risk management;
- Evaluate, minimize, and account for the program's genetic and ecological effects on natural populations;
- Describe interrelationships and interdependencies with fisheries management, providing as many benefits and as few biological risks as possible for listed species;
- Provide for adequate facilities to rear natural broodstock, maintain population health and diversity, and avoid hatchery-influenced selection or domestication;
- Provide for adequate monitoring and evaluation of success and risks that might impair recovery, and to allow revisions of program.

Warm Springs Hatchery is the only California state coho salmon production facility that has a HGMP drafted. This plan is currently under review by NMFS and the Department. Big Creek Hatchery is the only private hatchery currently permitted. At the time of this review it has submitted a HGMP and is awaiting ESA permitting from NMFS (Dave Streig, pers. comm.). In a recent hatchery review (CDFG/NMFS 2001), the Department and NMFS agreed that HGMPs will be developed for all California hatcheries. The conclusions and recommendations in the hatchery review will be used as interim guidelines for hatchery operations during the period when the Department develops the HGMPs and NMFS completes the ESA 4(d) Rule regulatory process relative to HGMP take limits.

State Policies on Wild Fish Management and Restoration

The Commission policy places management emphasis and priority on natural rather than hatchery-origin stocks. For example, FGC section 6901 states:

- Proper salmon and steelhead trout resource management requires maintaining adequate levels of natural, as compared to hatchery, spawning and rearing.
- Reliance upon hatchery production of salmon and steelhead trout in California is at or near the maximum percentage that it should occupy in the mix of natural and artificial hatchery production in the state. Hatchery production may be an appropriate means of protecting and increasing salmon and steelhead in specific situations; however, when both are feasible alternatives, preference shall be given to natural production.
- The protection of, and increase in, the naturally spawning salmon and steelhead trout of the state must be accomplished primarily through the improvement of stream habitat.

Also, Commission policy on Cooperatively Operated Rearing Programs for Salmon and Steelhead (CFGC 2002) states, "The bulk of the state's salmon and steelhead resources shall be produced naturally. The state's goals of maintaining and increasing natural production take precedence over the goals of cooperatively operated rearing programs." The Commission policy on salmon states that "Salmon shall be managed to protect, restore, and maintain the populations and genetic integrity of all identifiable stocks. Naturally spawned salmon shall provide the foundation for the Department's management program." Clearly, the Department's management emphasis is on natural production.

Fish and Game Commission Policy on Salmonid Genetic Resources

It is the policy of the Commission (CFGC 2002) that the population and genetic integrity of all identifiable stocks of salmon and steelhead be maintained, with management emphasis placed on natural stocks. The Department focuses on protecting the genetic integrity of stocks through evaluation of salmon or steelhead streams and classification of their stocks according to probable genetic source and degree of integrity. By policy, natural stocks are preferred over hatchery stocks. Management and restoration efforts and the role of artificial production are guided by this classification system.

The goal of the Department's hatchery system to maintain genetic integrity of local stocks is accomplished through limitation of inter-basin transfer of eggs or fish and development of mating protocols appropriate to each facility. Guidance on, or limitations of, straying by hatchery produced salmonids is not specifically provided by state policies. It is a general objective of hatchery operations to minimize interactions between artificially and naturally produced fish. However, this goal is primarily intended toward interactions of juveniles (e.g. competition and predation) rather than to returning adults.

Forestry Activities

Timber harvest has been scrutinized in the latter portion of the twentieth century with regard to its effect on anadromous salmonids of the Pacific Northwest, including those inhabiting coastal watersheds in California (Burns 1972; Meehan 1991; Murphy 1995). Currently, many agencies are taking actions in an attempt to: (1) understand the direct and indirect effects of forestry activities on coho salmon; (2) more effectively implement current FPR; (3) reduce impacts to potential or occupied coho salmon habitat; (4) restore degraded coho salmon habitat; (5) estimate the status of coho salmon in harvested watersheds; and (6) increase coho salmon populations. Besides the Department, state agencies addressing timber harvest-coho salmon issues include the California Department of Forestry and Fire Protection (CDF), BOF, the California Regional Water Quality Control boards (RWQCB), and the California Geological Survey (CGS). The two federal agencies primarily involved in timber harvest and coho salmon issues are the NMFS and the USFS.

California Forest Practice Act, California Department of Forestry and Fire Protection, and California Board of Forestry and Fire Protection

The FPA and FPR (California Code of Regulations, Title 14, section 895 et seq.; FPR) regulate timber harvest on private and state timberlands in California. The BOF is responsible for implementing laws, adopting regulations and provisions, overseeing the licensing of registered, professional foresters (RPF), and directing the CDF's activities regarding timber harvest. The CDF is the state's lead agency under CEQA and Z'Berg-Nejedly FPA responsible for implementing FPR, working with RPFs, and coordinating state agency review. The CDF is the primary agency responsible for ensuring that timber harvest practices are properly planned and implemented and that harvest impacts are properly analyzed and addressed.

The first forest practice act in California was enacted in 1945, and forestry practices have been regulated since that time. In 1971, the 1945 act was found unconstitutional because of the manner for which it provided for the promulgation of the FPR (Berbach 2001). In 1973, the Z'Berg-Nejedly FPA (Division 4, Chapter 8 Public Resources Code, Section 4511 et seq.) was passed and signed and went into affect in 1975. BOF regulations, adopted to implement FPA 1973, lay out the provisions for the implementation of timber harvest through Timber Harvest Plans (THP), Sustained Yield Plans (SYP), Nonindustrial Timber Management Plans, and Program Timberland Environmental Impact Reports. Prior to 1973, there was not any specific protection of streams and riparian areas. FPA 1973, and regulations promulgated by the BOF, resulted in stream and lake protection zones, defined as 100 foot buffers along water bodies that supported salmon and trout and 50 foot buffers along all other water bodies. There were several other provisions to these regulations:

- Timber operation could remove up to 50% of stream or lake side canopy, and this allowance was for each harvest entry on a site, allowing for the possibility that less than 50% of the canopy might be present if more than one harvest occurred in a given site.
- Stream crossings created for harvest activities must be able to handle 25-year flood events.
- Soil quantities deleterious to fish could not be discharged into water bodies.
- Stream- and lake-beds could not be used for landings, roads, or skid trails except as allowed by the FGC.

In 1983, the BOF revised FPRs to increase protection for water and aquatic resources, resulting in groups of measures referred to as watercourse and lake protection (Title 14 CCR Article 6). The important change was the addition of protection of beneficial uses of water and riparian function (Title 14 CCR section 916.2, 936.2, 956.2). Changes in FPRs to benefit fish and wildlife uses included:

- Stream- and lake-side protection was based on watercourse type and slope, the greater the slope, the greater the buffer width;
- maximum buffers ranging from 50-200 feet;
- class I streams could have 50% of over-story canopy removed, but under-story canopy had to be retained;
- class II streams could have 50% of over- and under-story canopy harvested[19];
- discharge of deleterious pollutants was prohibited; and
- stream crossing created for harvest activities had to be able to handle 50-year flood events.

The BOF further refined stream and riparian protection, primarily for the biological needs of fish and wildlife species, in 1991. Important changes included:

- Measures to protect restorable uses of water for fisheries and measures to protect biological needs of fish and wildlife species provided by riparian habitat.
- For class I and II streams where there is less than 50% of canopy, only removal of trees for sanitation salvage is allowed.

[19] For both class I and II watercourses, subsequent harvest could remove up to 50% of existing canopy, resulting in the possibility that more than 50% of the initial canopy existing at the first entry would be removed.

- The first measures to retain and recruit LWD for class I and II streams and considerations for regarding streambed and flow relationships to LWD.
- Specific measures for water temperature control, upslope, bank, and stream channel stability; filtration of both organic and inorganic material before entry in watercourses, and maintaining upslope vegetative diversity for wildlife habitat and tree snag supply.
- The maximum buffer protection zone for class I streams was reduced from 200 feet to 150 feet.
- Canopy retention for class II streams was changed to overall retention of 50%.

In response to the listing of coho salmon under the ESA, the CDF issued considerations for addressing coho salmon in THPs (CDF 1997b). The intent was to provide background about coho salmon that would enable RPFs to prepare, and CDF inspectors to review, THPs with emphasis on avoiding significant impacts to the species. The document included coho salmon life history, potential impacts of timber harvest to different life history traits, and possible measures above and beyond the FPRs that could be applied to any pertinent harvest impacts. The information was advisory only and designed to identify and mitigate site-specific impacts to coho salmon. Its effectiveness was based on the quality and attention given to plan preparation, review, and monitoring. Also, in 1997 and again in 2000, the CDF revised its policy guidance and field application of identifying habitat for non-fish aquatic species and the FPR's class II stream designation and conservation. The purpose of improving stream classification skills was to assure that sensitive amphibian habitat was correctly identified and protected (CDF 1997a, 2000); these measures would also benefit downstream habitat for anadromous salmonids.

In 1998, the California Resources Agency and NMFS established a blue ribbon panel of scientists to evaluate the relationship of California FPRs and salmonid habitat in northern California and the Klamath Mountains Province Steelhead ESU. The SRP released its findings as its *Report of the Scientific Review Panel on California Forest Practice Rules and Salmonid Habitat* (Ligon et al. 1999). The report considered biological requirements of salmonids, proposed strategies for improving the timber harvest planning process for anadromous salmonids, and perhaps most importantly, evaluated timber harvest effects, and recommended improvements for specific FPRs. The rules specifically addressed included watercourse and lake protection zones, LWD recruitment, geological concerns, road construction and maintenance, watercourse crossing structures, harvest site preparation, winter harvest operations, and harvest limitations. Based upon the SRP's findings and recommendations, the BOF adopted interim FPRs that went into effect in the summer of 2000. The interim rules established the following provisions for better protecting salmonids and their habitat:

- Watercourse transition lines used to identify channel zones are measured using full bank width for confined channels rather than riparian vegetation.
- No harvest can occur in channel zones.
- Minimum buffer protection for class I streams is 150 feet.
- Minimum over-story canopy retention be increased from 50% to 65-85%.
- More LWD recruitment potential by retaining the largest trees available, and measured in 330' segments and not per acre.
- Increased buffer protection for streams in inner gorges and increased sediment control.

These interim rules are referred to as the Threatened and Impaired Watershed Rules (FPR Sections 916.9, 936.9, 956) and were extended at the end of 2000 with minor modifications, again in 2001, and are set to expire on December 31, 2002. Another primary finding of the SRP was that a significant deficiency of FPRs is the absence of watershed analysis, specifically analysis that lends itself to assessing cumulative effects that could be attributed to forestry practices or any other activities in a watershed. The BOF responded to this critique in November 2001 by adopting additional interim rules in an attempt to identify and mitigate forestry practices that affect anadromous salmonids. The BOF adopted the Interim Watershed Mitigation Addendum (IWMA) as an approach for timber landowners and state agencies, including the CDF, the Department, the CGS, and the RWQCBs, to work together on specific timber harvest plans[20]. The IWMA was proposed to expire on December 31, 2002.

Under the IWMA, the landowner could consult with state agencies to identify limiting factors to anadromous salmonids within a specific watershed, identifying specific mitigation measures to address the limiting factors, and conduct initial effectiveness monitoring of these measures. The IWMA would be attached to a THP proposal and subject to the THP review process when the THP is submitted to the CDF. However, in December 2001, the Office of Administrative Law rejected the IWMA rule package because the rules lacked clarity.

Though current permanent and interim rules affect all native fishes and other amphibious and aquatic wildlife, the emphasis and focus is clearly on understanding and improving forest practices that affect coho salmon.

Pacific Lumber Company Habitat Conservation Plan

Since its inception in March 1999, the Department has actively participated along with other agencies in assisting the PALCO implement its 50-year Habitat Conservation Plan (HCP). The PALCO HCP covers approximately 210,000 acres of PALCO's lands in Humboldt County. Among 17 terrestrial and aquatic species, PALCO's incidental take permits cover steelhead rainbow trout, cutthroat trout, chinook salmon, and coho salmon.

The goal of the Aquatic Conservation Plan (ACP) of the PALCO HCP is to maintain or achieve, over time, a properly functioning aquatic habitat condition. This condition, as defined by NMFS, is essential for the long-term survival of anadromous salmonids and is described in a matrix with habitat variables necessary to achieve this goal.

The main thrusts of the ACP include control of sediment from roads, landslides, and other sources; restrictions on timber operations in riparian management zones along watercourses; a governor on forest management activities within hydrologic units; and aquatic monitoring. PALCO must complete watershed analyses of all covered lands within five years of the beginning of the HCP period, through which, the interim prescriptions of the ACP are to be modified to address watershed-specific habitat conditions. The types of monitoring under the ACP aquatic monitoring program include trend, hillslope, instream effectiveness and compliance monitoring.

[20] Staff from these agencies already work together in teams, under the leadership of the CDF's harvest inspectors, to review THPs.

PALCO is required to fund an HCP Monitor under contract to the Department. The Department coordinates a six-member HCP Monitor team that monitors PALCO's compliance with HCP conservation measures. Particularly during the winter period, the HCP Monitor focuses on compliance with restrictions on wet weather road use, road construction, and road storm-proofing. The HCP Monitor prepares compliance monitoring reports, which are provided to PALCO and federal and state agencies, and maintains information on databases and in a geographic information system (GIS). The Monitor's post-harvest monitoring, in particular, has given insights to the effectiveness of both HCP conservation measures and the FPR. PALCO has a programmatic streambed alteration agreement with the Department that provides it with a streamlined approach for watercourse crossing construction.

The Department's efforts to help implement the PALCO HCP stems from commitments that the signatory agencies (USFWS, NMFS, CDF and the Department) made to help the PALCO HCP succeed while meeting the company's operational needs. The Department and the other agencies also have a responsibility to their other stakeholders to help ensure PALCO complies with the provisions of the HCP. As the first forest land HCP in California, the agencies have an interest in its success and presenting it as an example of how HCPs can be a viable option for other large landowners.

The strengths of the aquatic component of the PALCO HCP lie in its reliance on robust stream buffers, its measures pertaining to forest roads, and opportunities to modify its conservation measures through watershed analysis. The PALCO HCP provides "no cut" vegetated buffers on all classes of watercourses, including along Class III watercourses, which is both unprecedented and controversial from the perspective of the timber industry. Wet weather road uses, including hauling, maintenance when the soil is saturated, and construction, have been implicated as important sediment discharge and impact mechanisms to coho salmon and its habitat; hence many of the ACPs includes conservation measures that pertain to road inventory, maintenance, storm-proofing and wet weather road restrictions. The PALCO HCP watershed analysis process holds promise that the ACP conservation measures can be modified to address salient conditions in watersheds that affect the quality and extent of salmonid habitat.

The Department staff assigned to help implement and monitor the PALCO HCP activities includes a senior environmental scientist (supervisor), four environmental scientists, and an office technician. One environmental scientist is dedicated full-time to implement and review watershed analysis and the aquatic monitoring program. The other environmental scientists complete a large number of consultations, mostly in conjunction with THP review, which the PALCO HCP mandates: botanical, marbled murrelet (*Brachyramphus marmoratum*) disturbance minimization; and risk assessment of road construction across unstable areas. They also process many BOF sensitive species consultations (e.g. osprey, golden eagle [*Aquila chrysaetos*], northern goshawk [*Accipiter gentilis*]). The Department staff screen, review, and inspect PALCO HCP timber harvesting plans; PALCO has submitted on average some 100 plans each year. They also review and comment on PALCO's annual reports for four HCP operating conservation plans: aquatic, sensitive plant, northern spotted owl (*Strix occidentalis caurina*), and marbled murrelet. Other activities include assisting PALCO with implementing its marbled murrelet monitoring and research programs and review of PALCO's proposals for adaptive management and HCP amendments.

Fish and Game Regulations and Protection of Stream and Riparian Areas

Though the Department is not the lead agency for timber harvest oversight, under CEQA it is a trustee agency or a responsible agency when it will issue a permit or enter into an agreement. The Department has several responsibilities regarding timber harvest including protection of state-listed plants and animals, protection of fish and wildlife resources, consultation with the CDF and RPFs on BOF-listed sensitive species, identification of needs of fisheries, and regulation of activities in and along the lakes, streams, and rivers. The State codes and related Department activities are the means and manner of the DFG's involvement in timber harvest and protection of coho salmon and other anadromous salmonids.

The first such protection occurred in 1951, when the State Legislature passed and the Governor signed into law FGC Section 5948 which prohibited log jams or debris dams in the North Coast District of the CDF that would prevent fish passing up and down streams, or were determined to be deleterious to fish by the Commission. In 1957, FGC Section 5948 was applied to the entire state. In 1961, FGC Section 1600-1602 was enacted, requiring notification for diversion, obstruction, or changes to water bodies, including lakes and streams. This section of the FGC is cited in the FPRs. However, this did not result in reducing the concern over effective stream protection from the effects of logging practices of the period, and the Department, BOF, Legislature, and others continued to look for meaningful protection for another decade (Arvola 1976).

Currently, the Department is undertaking several activities in an attempt to better understand the effects of timber harvest activities on coho salmon and their habitat and to ensure that THPs are being implemented properly. First, within six north coast counties (Sonoma, Mendocino, Humboldt, Del Norte, Trinity, and Siskiyou), the Department is budgeted to conduct desk review of every THP and full review for 25% of those THPs. Full review includes participation in field inspections and interagency review teams. Second, the Department is monitoring THP implementation to ascertain the effectiveness of the Department recommendations within the range of northern coho salmon. Third, the Department is working with the CDF and timber companies along the north coast in an attempt to learn the practices that may best protect or benefit coho salmon habitat.

Other California State Agencies

Two other state agencies, the RWQCBs and the CGS, participate in the review of THPs, SYPs, and Nonindustrial Timber Management Plans. They are official members of the review teams along with the Department and the CDF. Each agency attempts to address some potentially significant timber harvest effects. The RWQCBs primarily are interested in protecting the beneficial uses of water, which includes cold-water fishes such as coho salmon, from impacts caused by modified water quality, water flow, water pollution sources, and sediment loads. The CGS primarily focuses on preventing mass wasting events, many of which impact salmonid habitat. They often recommend measures to minimize sediment loads by reducing erosion, landslides, and mass wasting events.

Federal Agencies

NMFS is responsible for protection of coho salmon on federal lands, and the USFS and the Bureau of Land Management (BLM) are responsible for timber sales on federal lands. NMFS also is responsible for federal protection of coho salmon on state and private lands and is currently working with state agencies to address forest practice effects. Consequently, these federal agencies work together to integrate the protection of coho salmon with forestry activities on federal lands in northern California.

In 1993, the federal government released the *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment (Report)*, of the Forest Ecosystem Management Assessment Team (FEMAT). Six agencies, including the USFS, BLM, National Park Service, National Oceanographic and Atmospheric Administration, USFWS, and USEPA participated. The primary reason for this effort was to develop a management plan to protect the northern spotted owl across its entire range, but the FEMAT Report addressed the comprehensive management needs for federal lands within the owl's range. The assessment was an effort to develop a forest management plan for the Pacific Northwest that would address the multitude of biological, economic, and social issues plaguing forest management in this region. FEMAT focused on maintenance and restoration of biodiversity, particularly of late-successional and old-growth ecosystems (FEMAT 1993). FEMAT was developed by several panels composed of experts from across the northwest. Two panels, the aquatic and watersheds groups, are pertinent to coho salmon conservation. They recommended that watershed analysis, watershed restoration, and the establishment of riparian reserves be integrated in silviculture and other management activities on federal forested lands.

In February 1994, the USFS and the BLM released the Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forests Related to Species Within the Range of the Northern Spotted Owl (SEIS). Amongst its many components, the SEIS presented the FEMAT Report recommendations, with slight modifications, and included 10 action alternatives. The Aquatic Conservation Strategy incorporated in alternative1, 4, and 9 provided the greatest levels and opportunities for salmonid habitat and species stabilization, reversal of habitat degradation, riparian and aquatic ecosystem recovery, and reduction of silvicultural disturbance to late-successional and riparian reserves (SEIS 1994). The federal agencies adopted Alternative 9, which includes the following conservation and riparian reserve elements:

- 2,627,500 proposed acres for riparian reserves (out of a total of 24 million acres);
- buffer protection area[21] for fish-bearing streams of 300 feet or two times the height of a site-potential tree[22];
- buffer protection area for non-fish bearing streams of 150 feet or the height of a site-potential tree;
- buffer protection area for intermittent streams of 100 feet or the height of a site-potential tree;
- protection for 100-year flood plains, inner gorges, and unstable slopes;
- identification of key watersheds to provide refugia for at-risk anadromous salmonids;
- watershed analysis; and

[21] Buffer distance is on both sides of the watercourse and is the greater of the two values.
[22] Site-potential tree is defined as a tree that has attained the average maximum height possible given site conditions where it occurs.

- a comprehensive watershed restoration program.

In April 1994, the Record of Decision on the Final Environmental Impact Statement was published and implementation of the management plan commenced. Currently, the standards for the riparian reserves are applied on USFS and BLM lands, and a monitoring program is tracking the results of the implementation of management plan standards.

In 1995, the National Oceanographic and Atmospheric Administration released an analysis addressing forestry practices and protection and restoration requirements in Alaska and the northwest Pacific states (Murphy 1995). California coho salmon ESUs were listed under the ESA in 1996 and 1997. NMFS designated critical habitat for both ESUs in 1999. Also in 1999, the NMFS was sued over four "no jeopardy" biological opinions, one programmatic and three site-specific, submitted for 23 timber harvest sales on federal lands in Oregon. The plaintiffs asserted that the NMFS did not properly evaluate site-specific, watershed, or cumulative effects in its consideration of impacts to the federally-listed coho salmon and the implementation of the ACS. Both the federal district and appellate courts agreed with the plaintiffs and found that the NMFS had acted arbitrary in its finding of "no jeopardy"[23] biological opinions for 20 of the 23 timber sales. Both courts stated that the NMFS had failed to 1) evaluate short-term habitat degradation; 2) sufficiently incorporate watershed analysis; and 3) assess cumulative effects (USCA 2001). The court rulings affected these biological opinions but also enjoined 170 federal timber sales in Washington, Oregon, and northern California.

Since the ruling, the NMFS has ceased its consultations on timber sales in northern California other than those submitted under the National Fire Plan[24]. At this time, the Department does not know the immediate or longer-term ramifications of these court rulings on forestry practices and protection of coho salmon on federal lands in northern California.

In 2000, the NMFS released guidelines for forestry practices in California (NMFS 2000). These guidelines were intended to aid the State and the BOF in revising FPRs such that forestry practices would maintain ecosystem functioning in upslope, riparian, and instream habitats on non-federal lands where federally-listed anadromous salmonids occur. Their recommendations included seven major points: 1) proper stream classification; 2) developing strategies to address adverse impacts to riparian areas; 3) improving road construction and maintenance and addressing impacts from roads; 4) developing strategies for unstable and steep slopes; 5) implementing only sound restoration activities; 6) conduct watershed analysis and cumulative effects assessment; and 7) implement monitoring and adaptive management programs. Currently, the NMFS is working with the BOF and state agencies in an effort to find the best means to protect coho salmon where timber harvest occurs on state and private lands.

Water Diversion and Fish Passage Remediation

<u>Fish Screens</u>

The Department and the NMFS have established fish screen design criteria to protect juvenile salmonids in proximity to water diversions from injury, migration delay, or mortality. The swimming ability of fish is the primary consideration in establishing the criteria. The screen

[23] Jeopardy is defined as actions the would jeopardize the continued existence of a listed species or adversely modify or destroy critical habitat; federal Endangered Species Act, Section 7(a) (2).

[24] Consultations on these sales are continuing because the timber sales are associated with reducing hazardous fuel loads.

hydraulics are designed to allow fish to voluntarily be guided and/or to escape the screen. Voluntary guidance means a fish is under control and able to be guided or move away from the screen. This minimizes the threat of impingement on, or entrainment through, the screen. Swimming ability, however, varies depending on multiple factors relating to fish physiology, biology, and the aquatic environment. These factors include species, physiological development, duration of swimming time required, behavioral aspects, physical condition of the fish, water quality, and lighting conditions. The fish screen criteria provide non-regulatory, non-binding construction and operation guidance for screens on all new and existing diversions [25].

The Department's Fish Screen and Fish Passage Program has initiated an inventory of water diversions and fish passage problems on coastal streams and rivers. The first of these inventories was conducted on the Russian River between July 2000 and May 2001 and covered the river from Lake Mendocino near Ukiah downstream to the mouth. A total of 196 diversions, dams, and weirs was identified. Approximately 64% of the diversions were between 1 and 10 inches (outside diameter) and approximately 20% were between 11 and 20 inches (outside diameter). The remaining 16% consisted of unknown size and were greater than 20 inches. Recently, there has been a major cooperative effort between the diverters and Natural Resources Conservation Services to screen many of these diversions. Approximately 36% of the diversions were screened in accordance with the Department's salmon or steelhead screening criteria. The remaining 64% are unscreened or unknown.

Sponsored by several government agencies, fish screen installations began in the 1920s in Trinity and Siskiyou counties. There are numerous early accounts of thousands of juvenile salmon and steelhead lost in irrigation diversions in this region. Early fish screen designs were crude and caused many problems for water managers. In 1945, the Department began a fish screening program that would eventually lead to the screening of many water diversions in high-priority coho salmon streams in these counties. Because most of the existing screens and greatest fish losses were in the Klamath River drainage, it was decided to establish a fish screen headquarters in Yreka, Siskiyou County in 1946. This shop now maintains 68 fish screens in Siskiyou County. Department screen shops build and repair screens but are limited by budget constraints.

In 1956, a fish screen headquarters was established in Red Bluff that maintains fish screens in the Central Valley and operates 22 screens in Trinity County. In 1992, a shop was constructed in Lewiston to maintain the Trinity County screens. The majority of the screens operated by these three installations in Siskiyou and Trinity Counties are on streams presently or historically containing coho salmon. However, many water diversions remain unscreened in these counties. As an example, the Siskiyou Resource Conservation District (RCD) has received grant funding from the Wildlife Conservation Board to screen the remaining 31 diversions in the Scott River drainage that are within the range of coho salmon.

Most Department fish screens in coho salmon habitat, except two in Trinity County and two in Siskiyou County, are located on gravity flow surface diversions. The most common fish screen type on gravity diversions is the vertical or inclined diagonal flat-plate design. The screen guides juvenile coho salmon to a bypass structure connected to a pipe or open ditch to carry the fish back to the stream. If the stream flow below the diversion is not capable of providing

[25] The Fish Screen Criteria have regulatory effect in the 2084 order applicable during the coho candidacy period, (Cal. Code regs. tit. 14 section 749.1).

habitat, a trap is installed in the bypass structure and the fish are recovered and moved to an area of the watershed capable of providing suitable habitat. Water diversions are generally opened about the first of April and remain operating until the end of October. On some diversions, water for livestock is diverted throughout the winter period.

In Humboldt County, the Humboldt Bay Municipal Water District pump station at Essex on the Mad River is screened but may need to be modified to adequately protect coho salmon juveniles. Mad River Hatchery still pumps some water from the Mad River although most of the hatchery water supply is from wells. The hatchery screens may also need to be upgraded. The Hoopa Tribe operates several smaller screens on tributaries to the Trinity River near Hoopa. There are numerous smaller unscreened diversions throughout the area, particularly in the Eel and Mattole drainages. These diversions are mainly small pumps for domestic water use or small agricultural operations and they have the potential to take coho salmon.

Instream Flows

The importance of adequate instream flows for the protection of anadromous fish has long been recognized. FGC Section 5937 requires that diverters "....allow sufficient water to pass over, around or through [a] dam, to keep in good condition any fish that may be planted or exist below the dam." However, the Department does not regulate or permit water rights, hence many of the state's waters have inadequate minimum flows. In larger regulated river systems such as the Trinity, long-term flow studies have been conducted to identify in-river flows needed by the various life stages of anadromous fish.

Trinity River: A twelve-year flow study culminated in a recommendation, supported by the Department, that instream flows be increased to approximately 47% of the inflow above Trinity Dam and be based on five water-year types ranging from *critically dry* to *extremely wet*. This recommendation was adopted by the Secretary of the Interior in a Record of Decision, in January 2001. Subsequent to the signing of the ROD, several water and power users challenged the decision. A ruling was issued that prevented the implementation of the new flow regime until such time as a supplemental EIS/EIR could be completed that more fully considered issues such as economic impacts from lost water and power generation, and the effect on Central Valley threatened and endangered species from reduced diversions into the Sacramento River.

Klamath River: In the Klamath River below Iron Gate Dam, a flow study is currently underway to determine anadromous fish flow needs. Current minimum instream flow releases at Iron Gate Dam were established by the FERC as part of the 1956 Klamath Hydroelectric Project license (FERC No. 2082). These minimum flow releases have frequently not been met during the period 1961 to 2000 because the USBR's Klamath Project controls most of the flow in the Klamath River. In the past, the Klamath Project has provided water to irrigation in lieu of downstream deliveries during below average water years. Since 1995, the Klamath Project has been operated based on an annual operations plan that considers threatened and endangered fish species needs in the watershed.

In a recent response letter to the USBR's "*Draft Biological Assessment of the Effects of Proposed Actions Related to Klamath Project Operations April 1, 2002 - March 31, 2012, on Federally Listed Threatened and Endangered Species*", the CDFG provided a comparison of flow recommendations contained in Hardy and Addley (2001) and current FERC flow minimums contained in the federal power license for operating Iron Gate Dam (Table 21). The Department supports the Hardy Phase II flows to develop a flow regime in the Klamath River over five water-year types that would adequately consider California's anadromous fishery resources and allow for recovery of California coho salmon populations.

Table 21. Recommended draft Hardy Phase II (HP II) flows for five water-year types vs. Federal Energy Regulatory Commission (FERC) minimum flows in the Klamath River at Iron Gate Dam (all flows in cfs).

Water Year Type [v]						
	Critically Dry	**Dry**	**Average**	**Wet**	**Extremely Wet**	**All**
Time Period	HP II [w]	HP II	HP II	HP II	HP II	FERC [x]
Oct.	1100	1200	1470	1660	1900	1300
Nov.	1200	1400	1710	1970	2200	1300
Dec.	1300	1600	2030	2400	3500	1300
Jan.	1500	2000	2400	2970	4200	1300
Feb.	1600	2200	2720	3500	5000	1300
Mar. 1-15	1600	2400	3400	4300	5400	1300
Mar. 16 -31	1600	2400	3400	4300	5400	1300
Apr. 1-15	1600	2200	3300	4100	5200	1300
Apr. 16-30	1600	2200	3300	4100	5200	1300
May 1-15	1600	2100	3100	3700	4500	1000
May 16-31	1600	2100	3100	3700	4500	1000
June 1-15	1350	1800	2300	2900	3800	710
June 16-30	1350	1800	2300	2900	3800	710
July 1-15	1000	1250	1530	1970	2300	710
July 16-31	1000	1250	1530	1970	2300	710
Aug.	1000	1000	1250	1470	1800	1000
Sept.	1000	1100	1350	1570	1840	1300

[v] Water Year Types are defined by the following exceedance values for inflow at Iron Gate Dam: Extremely Wet - 10% exceedance; Wet - 30% exceedance; Average - 50% exceedance; Dry - 70% exceedance; Critically Dry - 90% exceedance

[w] HP II are the recommended minimum instream monthly flows at Iron Gate Dam contained in the November 21, 2001 Draft Phase II Final Report: *Evaluation of Interim Instream Flow Needs in the Klamath River* prepared by Hardy and Addley (2001).

[x] FERC are the current FERC minimums that apply to all water year types.

The Department anticipates that the draft Hardy Phase II flow recommendations will be modified as appropriate based on further analysis and new data developed during preparation of the final report due in April 2002. The Department is uncertain how the Final Hardy Phase II Report will reflect the conclusions and recommendations within the Final Interim Report being prepared by the Natural Resource Council's Committee on Endangered and Threatened Fishes in the Klamath River Basin. Their report is entitled "*Scientific Evaluation of Biological Opinions on Endangered and Threatened Fishes in the Klamath River Basin*" and is scheduled for completion in April 2002.

In Siskiyou County, a fish rescue program has been in place since the Department's screen shop in Yreka was established. As stream flows diminish in late spring, coho, chinook and steelhead juveniles become trapped in isolated pools and subsequently perish. The reduction in stream flow coincides with increased extraction of water in irrigation diversions through most coho salmon streams in this area. Fish are trapped or seined from the desiccating pools, transported in aerated tanks, and released in an area of the stream that is capable of sustaining the fish through the summer months. Fish rescue records show a steady decline in fish numbers. In 1972, personnel at the Yreka shop rescued 743,669 juvenile salmonids. In 2001, 57,627 fish were rescued, of which 69 were coho salmon juveniles.

Eel River: State and federal agencies, Pacific Gas and Electric Company, local Native American tribes, and interested parties are developing a water management strategy aimed at mimicking natural flow patterns of the upper Eel River. There has been substantial voluntary interim increases in water releases from Scott and Cape Horn dams during the fall and spring seasons. The fall releases are needed for adult chinook salmon to gain access to the upper Eel River watershed during spawning migrations. Spring release flows are intended to mimic natural flow patterns that salmon and steelhead trout smolts use as a cue to initiate downstream migration. Summer minimum bypass flows are currently set at five cfs (CDFG 2001b).

Russian River: Minimum flows in the Russian River and Dry Creek were established by the State Water Resources Control Board in Decision 1610 issued in April 1986. Summer minimum flow in the Russian River between the East Branch and Dry Creek is 150 cfs. Downstream of the Dry Creek confluence the summer minimum flow is 125 cfs. Summer minimum flow in Dry Creek is 75 cfs. During dry years and critically dry years the minimum flows are less; during a critically dry year the minimum flow in the Russian River between the East Branch and Dry Creek is 25 cfs. The classification of the water-year is based on the cumulative inflow to Lake Pillsbury on the Eel River that is determined on the first of each month between January and June.

There are no recommendations pending at this time to change the flow release pattern from either Coyote Dam or Warm Springs Dam. There is currently in progress a formal consultation, pursuant to Section 7 of the ESA, between the NMFS, the USACE, and the Sonoma County Water Agency. Flow release patterns for both flood control operations and summer minimum flows are a part of this consultation. Options that will be considered include: changes in the ramping rates for flood control releases; developing a "natural flow" schedule that would, as nearly as possible, mimic the flow patterns that would have occurred naturally in the Russian River; and piping water directly from Warm Springs Dam to either the Russian River or to the Mirabel pumping facility to reduce flows in Dry Creek to a more natural level. Once the Section

7 consultation has been completed, the NMFS or the Department may recommend some changes in the flood control release or minimum flow schedule for the Russian River.

Walker Creek: According to a 1985 agreement between the Department and the Marin Municipal Water District, winter releases of 10 to 20 cfs, and summer releases of 2 to 5 cfs are made, depending on reservoir storage. In exceptionally dry years, a minimum release of 0.5 cfs is made. There are no recommendations at this time to change the flow release pattern from Soulajule Reservoir. Future studies might find, however, that the higher than natural flows could result in water temperatures above the optimum for coho salmon. Lower flows might result in less habitat for steelhead trout and other species, but also lower temperatures in the pools used by coho salmon.

Lagunitas Creek: Prior to 1979, there were no instream flow release requirements for the dams on Lagunitas Creek. A small quantity of water, however was released to meet the needs of downstream users. In 1979 an agreement was reached between the Marin Municipal Water District and the Department to release from Kent Lake, 10 cfs in winter and 3 cfs in summer in normal years, to maintain salmon and steelhead in Lagunitas Creek. In 1983, the SWRCB adopted Decision 1582 which set these minimum flow releases as an interim requirement and required further investigation of instream flow needs and measures to reduce sediment in the stream. After ten years of study, the SWRCB conducted a new set of hearings and adopted Order WR 95-17 in 1995. This order established the current set of minimum flow releases and other conditions to improve fish habitat in Lagunitas Creek. Current summer minimum flow is 8 cfs in a normal year and 6 cfs in a dry year; current winter minimum flows range from 20 to 25 cfs. There are also attraction flow pulses required in the fall to encourage upstream migration of coho salmon.

Fish Passage

Reestablishing access to former habitat above artificial barriers is a fundamental approach to anadromous fish restoration and has met with considerable success. The Department is involved in several efforts to provide fish passage for coho salmon and other salmonids in the north and central coast. Removal or retrofitting existing barriers to allow for fish passage can be an extremely cost-effective method of recovery planning. The key physical characteristics of the stream which inherently affect salmonid migration should be understood before any attempt is made to remove or modify an obstruction.

Fish Passage Forum: In November 1999, the California Resources Agency convened a group of state, local, and federal agencies, fisheries conservation groups, researchers, restoration contractors, and others to discuss ways to restore and recover anadromous salmonid populations by improving fish passage at artificial barriers. This forum is part of the Resources Agency's effort to implement an eight-point California Coastal Salmon and Watersheds Program, which includes an objective to coordinate fish passage activities.

A Fish Passage Work Group identified the need for improved efforts to identify barriers, evaluate and prioritize restoration opportunities, and implement projects in a timely fashion. It identified administrative, financial, and technical impediments to addressing these issues, including information gaps, lack of watershed-level assessment and planning, and poorly coordinated project review and permitting processes. Short-term solutions were developed for these types of problems for several known high-priority fish passage projects. Subgroups were established for coordinating activities related to fish passage inventory and assessment protocols, data format and access protocols, information and literature collection, training, and public education and outreach.

The Fish Passage Forum established that there is a critical need for improving coordination of existing agency programs and private sector activities across jurisdictions to improve the timeliness and cost-effectiveness of fish passage restoration efforts. An interagency memorandum of understanding (MOU) is being developed that will identify agency roles and responsibilities. The Department anticipates that this MOU will support voluntary, cooperative efforts to pursue some or all of the following goals:

- Protect, restore and maintain watershed, stream, and estuary conditions for passage by anadromous fish.
- Identify passage barriers, opportunities to remedy them, and priorities for implementing restoration projects.
- Improve the State's ability to implement fish passage restoration projects by coordinating agency and private sector efforts.
- Secure adequate funding for fish passage restoration.
- Expedite implementation of on-the-ground projects by coordinating and, where possible, streamlining agency permitting processes while ensuring that restoration programs comply with CESA and ESA requirements for protecting listed species.
- Educate and increase public awareness of fish passage issues to develop support for solving problems and preventing new ones.
- Attempt to ensure that any new structures created are properly designed to allow fish passage.

Gravel Extraction

Properly planned and conducted gravel extraction can avoid, minimize, or mitigate adverse impacts to fisheries resources. It is possible that fisheries resources can realize beneficial effects by combining adaptive planning and extraction methodologies with flexible and site-specific mitigation measures. The river beds are constantly changing and adjusting whether or not gravel extraction is occurring. Therefore, it is imperative that any extraction planning and mitigation effort remain flexible. Measures taken to avoid or minimize stranding of fish include adherence to specified post-extraction slopes. Determination of these slopes is an end product of the review process and incorporates pre-extraction reports and approval by the USACE.

NMFS has developed a national policy on gravel extraction. The objective of the NMFS Gravel Policy is to ensure that gravel extraction operations are conducted in a manner that eliminates or minimizes to the greatest extent possible any adverse impacts to anadromous fish and their habitats. Gravel extraction operations should not interfere with anadromous fish migration, spawning, or rearing, nor should they be allowed within, upstream, or downstream of anadromous fish spawning grounds. The intent is to conserve and protect existing viable anadromous fish habitat and historical habitat that is restorable. Individual gravel extraction operations must be judged in the context of their spatial and temporal cumulative impacts; i.e. potential impacts to habitat should be viewed from a watershed management perspective.

Gravel operators are generally required to comply with FGC section 1600 et seq. before commencing their operations. The USACE may require a permit for dredge and fill operations and other activities associated with gravel extraction projects under Sections 401 and 404 of the CWA, and/or Section 10 of the Rivers and Harbors Act of 1899. Under the Fish and Wildlife Coordination Act, NMFS reviews Section 10 or Section 404 permit applications for environmental impacts to anadromous, estuarine, and marine fisheries and their habitats. Gravel extraction projects not subject to Section 404 or Section 10 permits may still be reviewed by NMFS pursuant to the applicable County/State public hearing processes. The Magnuson Fishery Conservation and Management Act also addresses the effects which changes to habitat may have upon a fishery**.**

NMFS has made recommendations in a national policy on gravel extraction that provide specific guidelines described below:

Abandoned stream channels on terraces and inactive floodplain should be used preferentially to active channels, their deltas and floodplain. Gravel extraction sites should be situated outside the active floodplain and the gravel should not be excavated from below the water table. In other words, dry-pit mining on terraces or floodplain is preferable to any of the alternatives, in particular, wet-pit mining instream, but also bar skimming and wet-pit mining in the floodplain. In addition, operators should not divert streams to create an inactive channel for gravel extraction purposes, and formation of isolated ponded areas that cause fish entrapment should be avoided. Also, all gravel extraction activities for a single project should be located on the same side of the floodplain. This will eliminate the need for crossing active channels with heavy equipment.

Larger rivers and streams should be used preferentially to small rivers and streams. Larger systems are preferable because they have more gravel and a wider floodplain, and the proportionally smaller disturbance in large systems will reduce the overall impact of gravel extraction (Follman 1980). On a smaller river or stream, the location of the extraction site is more critical because of the limited availability of exposed gravel deposits and the relatively narrower floodplain (Follman 1980).

Braided river channel-types should be used preferentially to other river channel-types. The other channel-types, listed in the order of increasing sensitivity to physical changes caused by gravel extraction activities, are: split, meandering, sinuous, and straight (Rundquist 1980). Because braided river systems are dynamic and channel shifting is a frequent occurrence, theoretically, channel shifting resulting from gravel extraction might have less of an overall impact because it is analogous to a naturally occurring process (Follman 1980). In addition, floodplain width progressively decreases in the aforementioned series of river systems. If gravel extraction is to occur in the adjacent floodplain, it is likely that the other four channel-types will experience greater environmental impacts than a braided river channel-type (Follman 1980).

Gravel removal quantities should be strictly limited so that gravel recruitment and accumulation rates are sufficient to avoid extended impacts on channel morphology and anadromous fish habitat. While this is conceptually simple, annual gravel recruitment to a particular site is, in fact, highly variable and not well understood. (Recruitment is the rate at which bedload is supplied from upstream to replace the extracted material.) Kondolf (1993, 1994b) dismisses the common belief that instream gravel extraction can be conducted safely so long as the rate of extraction does not exceed the rate of replenishment. He also states that this approach to managing instream gravel extraction is flawed because it fails to account for the upstream/downstream erosional effects that change the channel morphology as soon as gravel extraction begins. In addition, he reiterates that flow and sediment transport for most rivers and streams is highly variable from year-to-year, thus an annual average rate may be meaningless. An "annual average deposition rate" could bear little relation to the sediment transport regimes in a river in any given year. Moreover, sediment transport processes are very difficult to model, so estimates of bedload transport may prove unreliable. These problems and uncertainties indicate a need for further research.

Gravel bar skimming should only be allowed under restricted conditions. Gravel should be removed only during low flows and from above the low-flow water level. Berms and buffer strips must be used to control stream flow away from the site. The final grading of the gravel bar should not significantly alter the flow characteristics of the river during periods of high flows (OWRRI 1995). Finally, bar skimming operations need to be monitored to ensure that they are not adversely affecting gravel recruitment downstream or the stream morphology either upstream or downstream of the site. If the stream or river has a recent history of rapidly eroding bars or stream bed lowering, bar skimming should not be allowed.

Pit excavations located on adjacent floodplain or terraces should be separated from the active channel by a buffer designed to maintain this separation for two or more decades. As previously discussed, the active channel can shift into the floodplain pits, therefore Kondolf (1993, 1994a) recommends that the pits be considered as potentially instream when viewed on a time scale of decades. Consequently, buffers or levees that separate the pits from the active channel must be designed to withstand long-term flooding or inundation by the channel.

Prior to gravel removal, a thorough review should be undertaken of potentially toxic sediment contaminants in or near the stream bed where gravel removal operations are proposed, or where bed sediments may be disturbed (upstream and downstream) by the operations. Also, extracted aggregates and sediments should not be washed directly in the stream or river or within the riparian zone. Turbidity levels should be monitored and maximum allowable turbidity levels for anadromous fish and their prey should be enforced.

Removal or disturbance of instream roughness elements during gravel extraction activities should be avoided. Those that are disturbed should be replaced or restored. As previously stated, instream roughness elements, particularly LWD, are critical to stream ecosystem functioning.

Gravel extraction operations should be managed to avoid or minimize damage to stream/river banks and riparian habitats. Gravel extraction in vegetated riparian areas should be avoided. Gravel pits located on adjacent floodplain should not be excavated below the water table. Berms and buffer strips in the floodplain that keep active channels in their original locations or configurations should be maintained for two or more decades. Undercut and incised vegetated banks should not be altered. LWD in the riparian zone should be left undisturbed or replaced when moved. All support operations (e.g. gravel washing) should be done outside the riparian zone. Gravel stockpiles, overburden and/or vegetative debris should not be stored within the riparian zone. Operation and storage of heavy equipment within riparian habitat should be restricted. Access roads should not encroach into the riparian zones.

The cumulative impacts of gravel extraction operations to anadromous fishes and their habitats should be addressed by the federal, state, and local resource management and permitting agencies and considered in the permitting process. The cumulative impacts on anadromous fish habitat caused by multiple extractions and sites along a given stream or river are compounded by other riverine impacts and land use disturbances in the watershed. These additional impacts may be caused by river diversions/impoundments, flood control projects, logging, and grazing. The technical methods for assessing, managing, and monitoring cumulative effects are a future need outside the scope of this gravel policy. Nevertheless, individual gravel extraction operations must be judged from a perspective that includes their potential adverse cumulative impacts. This should be a part of any gravel extraction management plan.

An integrated environmental assessment, management, and monitoring program should be a part of any gravel extraction operation, and encouraged at federal, state, and local levels. Assessment is used to predict possible environmental impacts. Management is used to implement plans to prevent or minimize negative impacts. A mitigation and restoration strategy should be included in any management program. Monitoring is used to determine if the assessments were correct, to detect environmental changes, and to support management decisions.

Mitigation and restoration should be an integral part of the management of gravel extraction projects. Mitigation should occur concurrently with gravel extraction activities. In terms of National Environmental Policy Act (NEPA) regulations, mitigation includes: 1) avoidance of direct or indirect impacts or losses; 2) minimization of the extent or magnitude of the action; 3) repair, rehabilitation or restoration of integrity and function; 4) reduction or elimination of impacts by preservation and maintenance; and 5) compensation by replacement or substitution of the resource or environment. Thus, restoration is a part of mitigation, and the aim of restoration should be to restore the biotic integrity of a riverine ecosystem, not just to repair the damaged abiotic components. An overview of river and stream restoration can be found in Gore et al. (1995). Koski (1992) states that the concept of stream habitat restoration as applied to anadromous fishes is based on the premise that fish production increases when those environmental factors that limit production are alleviated. Thus, an analysis of those "limiting factors" is critical to the restoration process. He further states that effective stream habitat restoration must be holistic in scope, and approached through a three-step process:

- first, a program of watershed management and restoration must be applied to the watershed to ensure that all major environmental impacts affecting the entire stream ecosystem are addressed (i.e. cumulative impacts). Obviously, an individual gravel extraction project is not expected to restore an entire watershed suffering from cumulative effects for which it was not responsible. Rather, needed mitigation and restoration activities in a riverine system should focus on direct and indirect project effects and must be designed within the context of overall watershed management;

- next, restore the physical structure of the channel, instream habitats and riparian zones (e.g. stabilize stream banks through replanting of riparian vegetation, conserve spawning gravel, and replace LWD). This would reestablish the ecological carrying capacity of the habitat, allowing fish production to increase; and

- finally, the fish themselves should be managed to ensure that there are sufficient spawning populations for maximizing the restored carrying capacity of the habitat.

NMFS recommends that either a mitigation fund, with contributions paid by the operators, or royalties from gravel extraction be used to fund the mitigation and restoration programs as well as for effectiveness monitoring.

Habitat protection should be the primary goal in the management of gravel extraction operations. Resource management agencies acknowledge that, under the right circumstances, some gravel extraction projects, whether commercial or performed by the agencies themselves, may offer important opportunities for anadromous fish habitat "enhancement". That is, gravel removal itself can be used beneficially as a tool for habitat creation, restoration, or rehabilitation (OWRRI 1995). However, stream restoration and enhancement projects should be regarded with caution. While it is tempting to promote gravel extraction as a means to enhance or restore stream habitat, the underlying objective of this gravel policy is to prevent adverse impacts caused by commercial gravel extraction operations. Therefore, gravel extraction for habitat enhancement purposes done in conjunction with commercial gravel operations will not take precedence over, and is not a substitute for, habitat protection.

Suction Dredging

The Department requires a permit to use any vacuum or suction dredge equipment in any river. Strict adherence to the regulations and requirements pursuant to Section 5653 of the Fish and Game Code is necessary to prevent impacts to salmonids and their habitat. Considering the uncertainty surrounding dredging effects, declines in many aquatic animal populations, and increasing public scrutiny of management decisions, the cost of assuming that human activities such as dredging cause no harm deserves strong consideration by decision makers (Mapstone 1995). Dayton (1998) suggests that, where threatened or endangered species exist, managers need to assume activities such as dredging are harmful unless proven otherwise.

Habitat Restoration and Watershed Management

Introduction

Restoration of California's anadromous fish populations has been supported by private, local and state interests for many years. The Salmon, Steelhead and Anadromous Fisheries Program Act of 1988 and other programs have generated considerable restoration efforts initiated at the local level.

Restoration of coho salmon populations requires restoration of watersheds, restoration of instream habitat, and restoration of species. Watershed restoration focuses on sustaining the appropriate environmental conditions and ecological processes that influence streams and rivers. Stream restoration focuses on sustaining and enhancing fish habitat. A potential fishery restoration project may include instream fish habitat improvement structures, riparian zone revegetation, bank stabilization, and/or upslope improvements such as road rehabilitation or decommissioning.

Increased development and incompatible land uses can negate existing protections and restoration actions for key coho salmon habitat. This is especially important for riparian lands that have water rights, stream reaches that support depressed native stocks, and estuaries. Establishing conditions, constraints, and practices to maintain watershed integrity and restoring problem areas that degrade or block aquatic habitat are of the utmost importance.

In 1994, the Department developed a "*Coho Salmon Habitat Impacts, Qualitative Assessment Technique for Registered Professional Foresters*," (CDFG 1994b). This was in response to a request by the BOF to assist in determining the cumulative impact of timber harvest and to design mitigation measures. The method involves information gathering, site analysis, and looking for forensic evidence of past problems. The Department uses a habitat assessment method described in the "*California Salmonid Stream Habitat Restoration Manual*" (Flosi et al. 1998) to assess the condition of stream habitats and determine the need for restoration projects.

Restoration Programs

California Department of Fish and Game's Fishery Restoration and Grants Program: The Department, through the Fishery Restoration Grants Program (FRGP), restores or enhances salmon and steelhead habitat throughout the anadromous waters of California. Restoration projects generally consist of rearing and spawning habitat restoration, bank stabilization projects (using bioengineering techniques), and riparian and upslope projects. Upslope projects largely consist of activities directed toward road improvements to alleviate sediment delivery to water courses, and revegetation of hill slopes to alleviate erosion. In addition, the FRGP provides funding for projects that will lead to salmon and steelhead habitat protection and restoration such as public school and technical education, research that will advance the science of restoring anadromous salmonids, monitoring to determine trends, watershed organization support, and planning and assessment. All restoration projects conducted under the FRGP are constructed using methods and procedures described in the Department's "*California Salmonid Stream Restoration Manual*" (Flosi et al. 1998)

Funding is provided through various account sources managed by the Department, such as Commercial Salmon Stamp, Steelhead Trout Catch Report-Restoration Card, Salmon and Steelhead Restoration, Proposition 271 funds, and accounts managed by the Wildlife Conservation Board. Grants can be made for: instream, watershed and riparian habitat restoration; watershed evaluation, assessment, and planning; project maintenance and monitoring; watershed organization support and assistance; private sector technical training and education projects; California Forest Improvement Program (CFIP) projects; cooperative fish rearing; and public education, including watershed and fishery conservation education projects. The Department solicits potential projects through a Request for Proposals which is distributed in February of each year. Total funds granted and number of projects funded since the FRGP began is shown in Table 22.

Coastal Watershed Restoration Program: SB 1087 (Salmon and Steelhead Trout Restoration Account), was passed and signed by the Governor in 1997. This bill earmarked $43 million over six years ($3 million in FY 1997/98 and $8 million for each of the following five years) for anadromous fisheries habitat restoration and watershed planning efforts. The Department developed a coastal watershed restoration program startup plan for this effort to coordinate efforts of all state agencies that have programs that protect or help to restore anadromous fish habitat. Key elements of this plan include:

- Establishing statewide and watershed-specific recovery goals.
- Developing a coast-wide watershed planning interface with local watershed groups, city, county, and state agencies, and tribal governments.
- Developing measurable targets to assess fishery and watershed recovery.
- Developing watershed assessment plans and implementation plans to accomplish goals.
- Establishing a clearinghouse to review restoration contract and grant proposals from all funding sources to avoid project duplication and to focus activities into high priority areas.
- Establishing an integrated technical information system to collect fish and habitat information for baseline conditions and trend analysis.
- Developing an adaptive management ethic for all restoration activities.

Table 22. Total funds granted and number of projects funded through the Department's Fishery Restoration Grants Program, 1981 to present.

FISCAL YEAR	AMOUNT APPROVED	TOTAL No. PROJECTS
1981/1982	$611,670	16
1982/1983	$856,574	70
1983/1984	$1,465,287	90
1984/1985	$1,810,998	98
1985/1986	$6,862,758	168
1986/1987	$6,114,120	123
1987/1988	$2,678,885	108
1988/1989	$2,974,171	111
1989/1990	$3,522,223	104
1990/1991	$2,248,405	96
1991/1992	$3,382,935	111
1992/1993	$3,601,442	140
1993/1994	$3,313,297	161
1994/1995	$1,596,221	173
1995/1996	$1,568,305	160
1996/1997	$1,776,842	117
1997/1998	$4,726,373	221
1998/1999	$6,062,498	257
1999/2000	$7,323,887	178
2000/2001	$20,458,701	301
TOTAL	$82,955,592	2803

Americorps Watershed Stewards Project (WSP): WSP is a comprehensive community-based watershed restoration and education program, established in 1994. The WSP mission is to conserve, restore, and sustain anadromous watersheds for future generations by linking high-quality scientific practices with education. The 53 WSP members are recruited from colleges throughout the United States and are assigned to serve with 25 resource professionals from state, federal, local and non-profit agencies.

Gravel restoration projects: In cooperation with the Department, the California Department of Water Resources (DWR) - Northern District has carried out major salmon spawning gravel restoration projects on the Trinity and Klamath rivers. These projects were intended to restore salmon spawning gravel below dams.

Urban Streams Restoration Program: The Urban Streams Restoration Program was established by DWR to address flooding and erosion on urban streams using environmentally-sensitive methods. The program provides grants for projects that clean-up streams, stabilize banks, and improve riparian habitat in urban areas. Project benefits include reduced bank erosion and reduced sedimentation downstream, increased canopy cover, improved water quality, and improved summer flows. Since the program began in 1985, it has provide a total of $9,374,057 for projects throughout the range of coho salmon.

California Conservation Corps (CALCC): The CALCC has performed several million dollars of reimbursement work for the Department, USFWS, the Wildlife Conservation Board, Americorps, and numerous local fisheries management agencies. In addition, funding from Proposition 204 provided the CALCC with additional fisheries projects. CALCC has received over $7 million for fisheries restoration work through the Department's FRGP

From 1981 to 2000, the CALCC has undertaken restoration projects on over 720 miles of tributaries to the Eel, Van Duzen, Mattole, Russian, and South Fork Trinity rivers, tributaries to Humboldt Bay, and numerous coastal streams. Barriers have been modified in 200 streams, nearly five miles of stream bank have been stabilized in 90 streams, over 2,700 instream structures have been constructed in 100 streams, and approximately 1,330,000 trees have been planted in the riparian zone of 120 streams. These projects have resulted in stream habitat improvements such as more numerous and deeper pools, restoration of spawning gravel, and increased canopy.

Klamath River Basin Conservation Area Restoration Program: The Klamath River Basin Conservation Area Restoration Program was authorized by Congress in 1986 under Public Law 99-552 (also known as the Klamath Act). The goal of this program is to restore the anadromous fisheries of the Klamath Basin. The Klamath Act authorized $21 million for the program. It also created two advisory committees, the Klamath River Basin Fisheries Task Force (Task Force) and the Klamath Fishery Management Council (Council), to help guide the program. These two advisory committees consist of members representing federal, state, county, and tribal governments, as well as commercial fishing and angling groups.

The Task Force has developed and implemented a long-range plan for restoring anadromous salmonids, based largely on restoration of key habitats and watersheds in the basin. From the beginning, the Task Force has funded locally-managed subbasin groups like the Scott River Watershed Council, the Salmon River Restoration Council, and the Shasta River

Coordinated Resource Management Planning (CRMP) group to identify restoration needs and implement projects. The Task Force has also provided funding to local watershed groups to help develop subbasin restoration plans. To date, more than $7.7 million has been provided for watershed restoration projects such as riparian restoration, livestock exclusion, road decommissioning and fishery monitoring.

The Council has developed a long-term plan for the management of in-river and ocean harvest of Klamath anadromous fish. The Council provides annual advice to the Pacific Fishery Management Council (PFMC) and state and tribal regulatory agencies on necessary spawning escapements and allowable harvest levels for fall-run chinook salmon in the Klamath Basin.

Trinity River Basin Fish and Wildlife Task Force: Following completion of the Trinity River Project in 1963, fish populations in the Trinity River declined significantly. To reverse this decline, a 13-agency Trinity River Basin Fish and Wildlife Task Force was formed in 1974, and state and federal funds were budgeted to define problems, develop solutions and begin restoring the river.

Trinity River Basin Fish and Wildlife Restoration Program: In October 1984, Congress passed PL 98-541, which authorized the Trinity River Basin Fish and Wildlife Restoration Program. This act provided $57 million (in addition to the Buckhorn Mountain Debris Dam on Grass Valley Creek) to implement actions needed to restore fish and wildlife populations in the Trinity River Basin.

The Trinity County Resource Conservation District (RCD) initiated and manages the 36 square-mile Grass Valley Creek watershed project through a CRMP. Fourteen state, federal, and local agencies, including USBR and USFS, are partners with the RCD. Agency funding support has totaled more than $5 million over five years. In addition, several industrial timber companies have joined the partnership and contributed resources.

The RCD has facilitated a buyout of Champion Lumber Company's timberland by BLM, which has assumed ownership and management responsibilities. As of 1995, 10,000 acres had been treated for erosion at about 800 sites using 490,000 trees, shrubs and grass plugs, and 62 miles of roads have been reconstructed to acceptable standards or decommissioned. The project is a model of locally-led conservation involving productive partnerships with agencies and private property owners at all levels.

Watershed Management Planning

Development of a watershed management plan requires an understanding of the relationship between causes and effects throughout a watershed to comprehensively and qualitatively link watershed activities to impacts on resources. Ideally, a plan will identify historical effects of sediment, water, heat, wood and nutrient inputs and define how these are related to natural processes such as hydrology, riparian function and energy transfer (heat and hydrologic) in a watershed. Ultimately, these relationships form the basis of a watershed model which can be used as a predictive decision-making tool for fishery restoration projects. The keystone of the watershed approach is local leadership and commitment, involvement by all stakeholders, and support and guidance from state and federal governments. Through the State's participation in "For Sake of the Salmon," federal funds have been secured for grants to watershed groups to hire coordinators. Several watershed planning efforts are described below.

Eel River watershed: The Eel River watershed is located in highly erodible soils in the steep coastal mountains of the North Coast. The watershed is heavily forested and is widely managed for timber production. The watershed is lightly populated. Domestic and agricultural are the primary uses of developed water.

Many of the most dramatic changes and watershed disturbances to the Eel River have occurred within the last 50 years. Land and water development projects including logging, mining, road construction, dam construction, grazing, cultivation, residential development, urbanization and water diversions have directly or indirectly reduced or adversely altered habitat conditions for coho salmon.

Problems and issues in the watershed include:

- Excessive watershed erosion;
- degraded stream and riparian habitat;
- water diversions causing low stream flows;
- poor migration access for adults and juveniles;
- Eel and Van Duzen rivers are listed on the CWA 303(d) list of impaired streams with sedimentation identified as a pollutant affecting anadromous fish;
- concerns regarding solid waste disposal;
- concerns about dairy industry and grazing impacts;
- mercury in Lake Pillsbury (largemouth bass at concentrations approaching standards for fish flesh consumption);
- regulation of gravel extraction;
- possible impact to the river by road repairs and slides;
- timber harvesting practices;
- Potter Valley Diversion; and
- predation by introduced species such as the Sacramento pikeminnow

Efforts to address problems include:

- Formation of Eel River Watershed Improvement Group.
- Continued adherence to the North Coast Region Basin Plan which contains specific objectives and implementation programs to protect and enhance area waters, specifically federal waste discharge permits.
- Continued enforcement of policies regarding individual wastewater systems, which provides guidelines for local agency jurisdictions to prevent water degradation from septic systems.
- Continuing efforts to coordinate watershed protection efforts with local agencies and groups and appropriate state and federal organizations.

To address the issues within the Eel River Basin, the Department established a basin planner position in 1991 to work with local landowners. To date, the program has been explained to over 3,000 landowners and most of them have granted permission to survey their streams and plan restoration projects. Additionally, an ongoing series of public forums and workshops have been held to solicit ideas and concerns from the basin's landowners and managers, and other interested citizens and groups. This information, along with field assessment data, was used to develop an Eel River Action Plan.

The Eel River Action Plan provides specific actions to address problems. Fishery and watershed information was integrated with observations and concerns from citizens and basin stakeholders. This provided the assessment of present conditions, identification of current problems and recovery opportunities related to Eel River salmon and steelhead resources. The elements of this plan address salmon and steelhead problems throughout the Eel River basin. The primary goals of the action plan are: 1) halt the long-term decline in salmon and steelhead populations within the Eel River; and 2) significantly increase those populations above current levels. Dedicated efforts should improve watershed and stream conditions to a level that can be maintained for the long-term, on the basis that full watershed stewardship is adopted by landowners and resource users. Cooperative programs within the Eel River involve the RCDs in Mendocino and Humboldt counties.

The PALCO cooperative fishery program operated from 1991 through 1999 on PALCO lands in the lower mainstem Eel and Van Duzen rivers. The program was much reduced with the advent of the company's current HCP, which took over many of the fisheries program elements.

The Mendocino RCD has worked on the Tomki and Dooley watersheds, located in the upper mainstem Eel River watershed. It has assessed and prioritized five additional watershed projects. Significant erosion treatments are being applied to streambed degradation. Bioengineering practices, integrating vegetation and structural designs are being used to solve stream bank problems. Within the Tomki Creek watershed, Mendocino RCD has completed several riparian revegetation and bank stabilization projects. The Mendocino RCD has also begun similar work in the Tenmile Creek watershed.

Garcia River Watershed: Land use activities in the Garcia River watershed include timber harvesting, grazing, gravel extraction and agriculture. Significant floods also impact the geomorphic, sediment transport, and biological characteristics of the river.

Problems and issues in the watershed include:

- Garcia River is on CWA 303(d) list for impairment due to sedimentation;
- high water temperatures are an issue in some tributaries and/or sections of the Garcia River.
- the estuary has decreased in size due to sedimentation.
- gravel mining is a concern in the lower Garcia River.
- solvents, petroleum and metals have been detected in groundwater and surface water at the U.S. Air Force's Point Arena Station.

Efforts to address the problems include:

- Cleanup activities continue at Point Arena Station.
- Developing TMDL plan to reduce sedimentation and water temperatures in mainstem and tributaries and improve habitat conditions.
- Mendocino County Water Agency has developed a gravel management plan.

- Court settlement following a bentonite spill into a Garcia River tributary is being used for stream rehabilitation.
- Adopt-a-Watershed education program is active in area schools.
- Coastal Forest Lands, a timber company owning most of the North Fork Garcia River watershed, is developing a SYP which includes watershed management components.
- SWRCB and USEPA have provided a grant for a contract employee from USEPA to develop a 303(d) waste reduction strategy.
- CDF has targeted the Garcia River for pilot long-term FPR monitoring program.

The Mendocino RCD received a $100,000 grant from the California Coastal Conservancy to develop a watershed enhancement plan for the Garcia River, near Point Arena. The goal of the plan is to gather information needed to improve the resources of the river. A contract was executed to survey the watershed, collect data, and analyze existing problems. A key part of the plan is to understand and respond to the needs and visions of the landowners and the Garcia River community.

Russian River-Bodega Bay watershed:. The Russian River-Bodega Bay watershed is in erosive topography and is sensitive to land disturbance. Summer flows are often restricted to isolated areas due to numerous water diversions by agricultural and domestic users.

In the Potter Valley area north of Ukiah, irrigated cultivated agriculture and irrigated pasturing are common. Around Ukiah, irrigated orchard and vineyards are common land uses with light industrial and three large mills associated with the timber industry. The Hopland area is predominantly vineyard, with rangeland grazing in the areas away from the mainstem. South of Hopland, the Russian River flows through a small canyon, with rangeland as the primary land use, before reaching Cloverdale and more vineyards. Vineyards predominate the valley areas down to the Santa Rosa Plains. Hillside vineyard development is on the increase, replacing rangeland upslope from the mainstem Russian River. The Santa Rosa Plains, Alexander Valley, and Healdsburg geologic subunits contain large groundwater basins that supply water for municipal, domestic, and agricultural uses.

The Santa Rosa Plains contains a large concentration of confined animal operations, including almost 100 dairies. There are currently 29 active dairies in the Mark West Creek (Laguna de Santa Rosa) watershed. Conversion of rangeland pasture and orchards to vineyard has increased significantly in the last decade. The reclaimed wastewater from the City of Santa Rosa's subregional municipal waste treatment facility also has resulted in conversion of rangeland to irrigated pasture and cultivated fodder crops.

The Santa Rosa Plains area is the most populated, with six incorporated municipalities and over 200,000 residents in the area (1990 U.S. Census). Two former defense sites are located in the Santa Rosa Plains along with numerous small to large industrial sites. A number of large river terrace pit-type gravel mines are located downstream of Healdsburg.

Trends in land-use appear to be towards continued conversion of lands to vineyards (increasing onto hillsides), and continued growth of the urban areas of Ukiah, Cloverdale, Healdsburg, Windsor, Santa Rosa and Rohnert Park. Associated with growth are active construction sites and an increase in light industrial operations. A concerted effort is being made in the Santa Rosa Plains to retain the reclaimed wastewater irrigated crop and pastureland type of agriculture and maintain the viability of the dairy industry. Significant conversion of pasture to vineyards has occurred in the area.

Problems and issues in the watershed include:

- storm water runoff from agricultural, urban, industrial and construction sites;
- tertiary wastewater treatment levels are needed at all nine urban areas in this watershed, currently only three use tertiary treatment;
- high septic system failure rate at various western Sonoma County locations;
- unpermitted discharges;
- erosion from vineyards;
- confined animal facilities contribute nitrogen, phosphorus, organic matter and sediment loads to watershed;
- pesticide and fertilizer use in orchards, vineyards, turf farms and urban areas;
- mercury accumulation in fish tissue in lakes Pillsbury, Mendocino, and Sonoma are approaching California Department of Health Services (DHS) warning levels for fish consumption;
- abandoned mercury mines in Big Sulphur and Fife Creek drainages;
- modified flows out of the two federal dams impact spawning habitat and decrease stability of banks and riparian canopy;
- unimproved public (county) and private roads contribute sediment and block passage at culverts;
- the estuary is managed primarily for flood control purposes, and frequent artificial breaching reduces rearing habitat for juvenile salmonids; and
- gravel mining in excess of mainstem recruitment has destabilized most tributaries, resulting in diminished pool depth and quality.

Efforts aimed at improved coordination and ecological restoration are scattered throughout the watershed. The involvement spans a breadth of agencies and local groups from the USACE to state agencies and local groups. Some specific efforts include:

- ESA Section 7 consultation with the Sonoma County Water Agency and the USACE regarding operation of dams.
- Sotoyome RCD's watershed stewardship efforts and the Fish Friendly Farming incentive project that focus on a profit incentive program for farmers who meet environmental goals beyond regulatory ones.
- City of Santa Rosa's dairy waste management grant program.
- North Coast RWQCB's watershed planning approach for water quality (grassroots effort that includes volunteer monitoring).
- Department and USACE sponsored Russian River Watershed Council.
- Sotoyome RCDs Fish Friendly Farming program aimed at reducing vineyard impacts.

Each of these efforts is aimed at achieving specific goals, while being consistent to varying degrees with the broader goal of salmonid protection and restoration. However, there is a need to improve coordination and cooperation to avoid duplication and assure that individual actions are consistent with a broader mission. Likewise, there is a need to ensure that other watershed activities are not at cross-purposes with the restoration goals.

In addition to the above, the Department has recently released the *Draft Russian River Restoration Plan*. The goals of this plan are:

- Identify and prioritize "keystone" factors which in themselves may restore functionality to watershed systems or lifecycle patterns;
- Prioritize keystone management changes to be implemented by local, state and federal agencies and districts;
- Prioritize keystone projects to be considered for funding by local, state and federal funding organizations;
- Prioritize and encourage lower priority projects to be undertaken by private landowners that provide shorter term, but needed benefits;
- Encourage demonstration projects that demonstrate fish-friendly techniques and Best Management Practices (BMPs); and
- Engage and support an active citizenry and local government in a partnership for restoration and "stewardship" in management.

Napa River watershed: The Napa River watershed encompasses approximately 210 square miles. The river is presently intermittent in the northern reach; it then becomes perennial due to groundwater discharge. The Napa River is a significant tributary to San Francisco Bay, and is included in the 303(d) list of impaired waterbodies due to siltation, nutrients and pathogens. There are approximately 240 wineries in Napa County.

Problems and issues in the watershed include:

- Agricultural runoff;
- erosion control;
- urban runoff;
- wetlands loss;
- wastewater discharges.

In 1994, the Napa RCD and stakeholders produced the *Napa River Valley Owners Manual*, an integrated resource management plan. The Napa RCD has stewardship programs in up to seven creeks in this watershed. A sustainable viticulture group of stakeholders is producing a BMPs manual. The Napa RCD has facilitated a stakeholder group that developed BMPs for orchard heaters.

Napa County has an erosion control ordinance for both new and replanted vineyards and land grading where slope exceeds 5 percent. Strategic enforcement of this ordinance is planned. The Napa RCD, Napa County, and CDF are seeking to resolve issues related to converting forestlands to vineyards. The San Francisco Bay RWQCB is working with Napa municipalities to improve management of new development and is requiring appropriate BMPs.

San Francisco Bay watershed: San Francisco Bay has been reduced by about 40% from its original size due to sedimentation. The San Francisco Bay estuarine system marks a natural topographic separation between the northern and southern coastal mountain ranges. The watershed's waterways, wetlands and bays are at the center of the United States' fourth-largest metropolitan region, including all or major portions of Alameda, Costa Contra, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma counties.

Water quality in the San Francisco Bay system is impacted by several factors. For example, the presence of elevated concentrations of toxic pollutants in the bays, from both point and nonpoint sources, has caused them to be listed as impaired water bodies. DHS has issued health advisories on the consumption of the Bay's fish and certain waterfowl due to their elevated levels of selenium and other metals.

The San Francisco Bay Estuary Project developed the Comprehensive Conservation and Management Plan in 1993. Implementation of the Comprehensive Conservation and Management Plan's 140-plus recommended actions is underway. Actions address erosion control, vessel waste, invasive species, pollution prevention, urban runoff, watershed management planning, and the wetlands ecosystem goals project.

The CALFED Bay-Delta Program is a consortium of federal and state agencies working to restore ecological health and improve water management for beneficial uses of the San Francisco Bay and Sacramento-San Joaquin River Delta estuary.

Santa Clara Basin: The Santa Clara Basin encompasses the areas of Santa Clara County that drain into the south San Francisco Bay. The Santa Clara Valley consists of 11 sub-basins, including the Coyote Creek watershed on the east side, the Guadalupe River that drains the south-central portion of the valley, and a series of small, relatively urbanized watersheds that drain the west side. The planning area has a population of some 1.3 million and is mostly urbanized.

Problems and issues in the watershed include:

- A dense population in a small area;
- The extreme south portion of San Francisco Bay is poorly flushed, causing water quality criteria to be exceeded for certain toxic pollutants;
- Aquatic/riparian habitats are in various states of degradation;
- Several reservoirs and streams are impaired due to mercury levels.

The San Francisco Bay RWQCB initiated a watershed management effort in the Santa Clara Basin in 1996. Local agencies and environmental and community organizations are implementing a watershed management planning process. In 2001, the City of San Jose issued a *Santa Clara Basin Watershed Management Initiative and Watershed Management Plan* that addresses: habitat and water quality protection and enhancement; water rights and water supply reliability; flood management; regulatory compliance; land use; and public awareness and involvement.

Workgroups and Partnerships Programs

North Coast Watershed Assessment Program (NCWAP): In 1999, the California Resources Agency and the California Environmental Protection Agency began developing an interagency watershed assessment program for California's north coast. The purpose of the program is to develop consistent, scientifically credible information to guide landowners, agencies, watershed groups, and other stakeholders in their efforts to improve watershed and fisheries conditions.

Participating agencies include: the Department, CDF, CGS, DWR, and the North Coast RWQCB. NCWAP is designed to meet four goals:

- Develop baseline information about watershed conditions;
- Guide watershed restoration programs;
- Guide cooperative interagency, non-profit, and private sector approaches to protect the best through stewardship, easement, and other incentive programs;
- Better implement laws requiring watershed assessments such as Forest Practices, Clean Water and Porter-Cologne Acts, Lake or Streambed Alteration Agreement, and others.

The program provides a process for collecting and analyzing information to answer a set of questions designed to characterize current and past watershed conditions. It will cover approximately 6.5 million acres of private and state lands within the 12 million acre North Coast Hydrologic Region. Information will be used to guide watershed management and restoration planning, restoration and recovery planning for anadromous fisheries, and implementation of watershed protection policies and regulations.

NCWAP will provide information that small landowners can not easily obtain, such as landslide, sediment, and THP maps for all ownerships within a watershed.   These products, when used in conjunction with site specific assessments, will improve the ability to design projects that mitigate potential watershed impacts and address limiting factors to salmonid recovery.   NCWAP will also work with interested landowners to demonstrate the use of GIS tools and predictive models for project planning and cumulative effects analysis.

NCWAP will provide data sets and databases, maps and GIS data, topical reports, and an overall summary with recommendations for every basin.   Products will include photos and maps of current land use, landslide locations and risk, sediment distribution in streams, and 60 years of timber harvest history.   NCWAP will compile data on instream channel and riparian conditions, fish populations, and water quality, and develop new data as feasible.   It will analyze sediment transport and the effects of land use history on vegetation change, watershed disturbance, and instream habitat.   The Department will use this information to analyze limiting factors for salmonid protection and habitat restoration.

Coordinated Resource Management Planning (CRMP): CRMP is a problem-solving management process that allows for direct participation of those concerned with natural resource management in a given area. CRMP coordinates resource management strategies to improve resource management and minimize conflicts among land users, landowners, government agencies, and interest groups.

CRMP encourages sharing responsibilities and resources through the cooperative implementation of projects. The ultimate goal of CRMP is to protect, improve, and maintain natural resources. The objective of each CRMP effort is to develop and implement a unified program of action for resource use and management that minimizes conflict.

Resource Conservation Districts (RCDs): In 1937, Congress passed the Standard State Conservation District Law that encouraged states to form special districts to address growing problems of soil erosion and watershed management. California responded in 1938 with the addition of Division 9 to the state's Public Resources Code, which enabled the formation of Soil Conservation Districts (later renamed Resource Conservation Districts) as special districts with limited powers to levy property taxes. There are 103 RCDs in California, covering about 85% of the total area of the state, that plan and implement watershed restoration and enhancement projects throughout the state.

Cooperative county efforts: Del Norte, Siskiyou, Trinity, Humboldt, and Mendocino counties are coordinating to address the issues brought about by the listing of anadromous fish species under the ESA (known as the "The Five-County Effort"). Also, five counties (Mendocino, Sonoma, Marin, San Mateo and Santa Cruz) within the CCC Coho ESU are pursuing a similar cooperative effort. The purpose of these efforts is to provide regulatory stability for small landowners and local agencies until long-term planning and recovery efforts of the state and federal government is accomplished. The Resources Agency and NMFS has provided financial support for the groups. Working in coordination with State and federal agencies, the counties have developed and are now implementing work plans for the protection and restoration of anadromous salmonids.

The Five-County Effort has an adopted work plan that provides for a comprehensive review and coordination of county level land-use regulations and practices as they relate to anadromous salmonid fisheries habitat within coastal watersheds of the five counties. This effort: 1) establishes a Memorandum of Agreement that will provide for cooperative planning and restoration efforts among the counties; 2) assesses the adequacy of existing General Plan policies, zoning, subdivision and other land-use ordinances; 3) reviews county management practices that affect anadromous salmonid habitat in each county; 4) recommends changes to county ordinances and/or practices as necessary; 5) develops a watershed based education/training program for local agencies and decision makers that will foster better understanding between land use and maintenance practices and salmonid habitat; and 6) provides a linkage between this short-term planning effort and long-term efforts.

Monterey, Santa Cruz, San Mateo, Marin, Sonoma, and Mendocino counties have established the "Fishery Network of Central California Coastal Counties" *(*FishNet 4C). FishNet4C's goals are to facilitate effective local actions that will maintain or improve the region's water quality and riparian habitat, provide increased assistance and education for local government and the private sector, and encourage cooperation and coordination among all levels of regulatory responsibility for fishery restoration. The program seeks to accomplish these goals through a process of evaluating existing activities, recommending model programs, tracking legislation, soliciting outside funding, and increasing communications among interested agencies and the public.

The Watershed Management Council: The Watershed Management Council is a non-profit organization formed in 1986. Membership includes professionals, students, teachers, and individuals from 28 states and 3 countries whose interest is in promoting proper watershed management. Activities of the Watershed Management Council include:

- Providing a forum for the integration of knowledge from a wide array of technical disciplines;
- Periodically summarizing the state of knowledge and technologies of watershed management;
- Identifying research needs and priorities;
- Membership training;
- Encouraging appropriate policies and legislation relating to watershed management;
- Stimulating the transfer, interchange, and dissemination of current data and technology;
- Providing a forum for discussion of social and economic ramifications of watershed management;
- Networking with other organizations related to watershed management;
- Recognition of significant contributions to knowledge or management of watersheds;
- Promotion of public awareness of the importance of appropriate watershed management.

Smith River Advisory Council : The Smith River Advisory Council (SRAC) is an independent group of representatives from city, county, state, and federal agencies, fishing and environmental organizations, Smith River watershed resource users, and industry. The purpose of the SRAC is to actively promote forums that answer questions and solve problems concerning Smith River fisheries. This purpose also involves cooperatively supporting a system-wide approach towards watershed management in the Smith River basin.

The goals of the SRAC include:

- Coordinate and integrate fishery research and enhancement efforts proposed by government agencies, enhancement groups,and private industry on the Smith River.
- Pursue funding sources to facilitate research and enhancement efforts on the Smith River.
- Encourage or provide forums and materials to help educate the public about fishery/watershed issues of the Smith River Basin.
- Facilitate the development of a Smith River fishery management plan that will benefit the biological, social, and economic aspects of the Smith River Basin and Del Norte County. This includes influencing legislation and regulation changes.

Representatives to the Council include the Department, Del Norte County, USFS, USFWS, California Trout, Smith River Alliance, sport anglers, Del Norte Fishermen's Marketing Association, Lily Bulb Growers, Reservation Ranch, California Department of Parks and Recreation (CDPR), University of California Sea Grant, Humboldt State University, River Guides Association, gravel extractors, dairy farmers, Stimson Lumber Company, CALCC, Rowdy Creek Hatchery, Bar-O Boys Ranch, Redwood National Park, Rural Human Services, private consultants, River Institute, private citizens, Native American groups, and Friends of Del Norte.

Siskiyou Resource Conservation District and the Scott River Watershed Council: The Siskiyou RCD and the Scott River Watershed Council (SRWC) are two primary local entities working on resource management issues in the Scott River watershed. Together they have been developing and implementing projects and plans for the subbasin since 1992. The Siskiyou RCD was formed in 1949 and is one of five RCD's in Siskiyou County. It is governed by a five-member board consisting of local landowners. With technical assistance from the Natural Resource Conservation Service, the Siskiyou RCD develops and implements projects on private land.

In 1992, the Scott River Watershed CRMP committee was formed under the sponsorship of the Siskiyou RCD to develop cooperative solutions to anadromous fish problems in the basin. The Scott River Watershed CRMP was later changed to the SRWC. The primary focus of the SRWC's efforts is on voluntarily conserving and enhancing the natural environment. The Siskiyou RCD supports the SRWC by providing administrative assistance with contracts and grant funding.

Since 1992, over $3 million has been spent on projects that protect or enhance habitat for anadromous fish in the Scott Valley. Project types include instream structures, riparian planting and protection, fish screens, upland road inventories and road erosion reduction, water conservation, alternative stock water systems, monitoring, council coordination, planning, and education (SRWC 2001).

The Shasta River Coordinated Resource Management Planning Committee: The Shasta River CRMP was formed by the Shasta Valley Resources Conservation District in 1991. The goal of the CRMP is to identify and fix problems in the Shasta River that are reducing survival of anadromous fish. The CRMP membership is made up primarily of agricultural community and federal and state agency representatives. Administrative and contract assistance is provided by the Great Northern Corporation, a private, non-profit organization instead of the Shasta Valley Resources Conservation District.

Since 1992, over $3.3 million in projects have been completed or initiated to enhance habitat for anadromous fish in the Shasta Valley (Richard Christie, pers. comm.). Project types include:16 miles of livestock exclusion fencing, protection of riparian zones along the river, supplemental tree planting with native trees to help reduce water temperatures, off-stream water for livestock, bioengineered bank stabilization, fish screens, tailwater reuse, and improvements to irrigation diversion structures (SRCRMP 2001).

Restoration Incentive Programs

California Department of Forestry and Fire Protection's California Forest Improvement Program (CFIP): The purpose of CFIP is to encourage private and public investments in, and management of, forest lands and resources to ensure protection of all forest resources while providing for adequate future high quality timber supplies, related employment, and other economic benefits. The main emphasis is on small landowners with less than 5,000 acres of timberland. Cost-share is from 50% to 90%, depending on the type of assistance. Over one million acres are included in forest stewardship management plans. A 1986 study of the economic benefits of the CFIP program indicated that over $50 in economic activity is created for every state dollar spent for CFIP in rural areas.

Public Awareness and Support Programs

Watershed academy: Many of the state's salmon restoration programs require a high level of public awareness and support. The Department, CDF, SWRCB and the North Coast RWQCB co-sponsored a "watershed training academy" for agency staff and RPFs who conduct projects, advise landowners or approve permits. The academy was established in 1996, and 200 graduates participated in the program through 1999. The academy may be expanded to include landowners and local groups as funding becomes available. In 1997, co-sponsors included NMFS. Course content covers the technical aspects of:

- Salmonid life history and instream beneficial uses;
- watershed assessment and evaluation of cumulative effects (manuals supplied);
- recognition of potential impacts and high risk areas;
- hillslopes, roads, stream crossings, streamside zones and fish barriers;
- mitigation, protection and restoration methods; and
- monitoring theory and methods.

Department of Education's Environmental Education Grant Program (EEGP): The California Department of Education (CDE) works with the Resources Agency and Cal-EPA to promote educational opportunities relating to energy conservation, environmental protection, pollution effects, and the use of natural resources. The purpose of the EEGP is to assist kindergarten- to twelfth-grade students and teachers in achieving "environmental literacy" to understand fundamental ecological concepts, and to facilitate responsible action toward the environment.

EEGP provides four categories of comprehensive grants: mini-grants (up to $3,000), and implementation, site/facilities, and networking grants (up to $15,000). The CDE's Science and Environmental Education Unit coordinates the allocation of grant funds to schools and nonprofit agencies. Applicants must show proof of commitment through matching contributions and submit a proposal that convinces the Grant Review Committee and CDE that the project will continue to benefit the target audience after the state funds have been spent.

Inventory and Database Programs

Watershed Information Technical System (http://ceres.ca.gov/watershed/): The goal of this internet web site is to provide information and tools to support local watershed planning, restoration, monitoring, and education.

Habitat Inventory Database: The Department maintains the California Habitat Inventory Data Base. The primary purpose of performing habitat inventories is to assess the condition of a stream for potential restoration. The database converts information to maps showing where stream habitat inventories have been conducted by the Department since 1993. This type of data provides a basis for understanding the physical characteristics of instream habitat.

Other Programs

CDPR's Habitat Conservation Fund: Funding for a variety of habitat conservation projects is provided by the Habitat Conservation Fund. Eligible applicants include counties, cities, and districts. Eligible projects are those that: protect or enhance deer or mountain lion habitat, including oak woodlands; habitat for rare and endangered, threatened, and fully protected species; wildlife corridors and urban trails wetlands; aquatic habitat for spawning and rearing of anadromous salmonids and trout species; and riparian areas. The program has $2 million available annually.

State Water Resources Control Board's Proposition 204 Funds: Proposition 204 provides up to $27.5 million in loans and up to $2.5 million in grants for drainage water management units. Proposition 204 also provided $14.5 million for one-time grants to address restoration projects in watersheds tributary to the Trinity River. Eligible applicants include counties in these watersheds, joint power authorities with those counties, and, in specified cases, local public agencies.

Coastal Conservancy programs: Coastal Conservancy (Conservancy) programs that can benefit coho salmon include:

- **The Resource Enhancement Program,** which provides capital funds and technical assistance for the preservation, enhancement, and restoration of wetlands, watersheds, riparian corridors, and other wildlife habitat lands, including, where necessary, acquisition of interests in land and project design;
- **The Site Reservation Program**, which provides capital funds and technical assistance to safeguard significant coastal resource sites and responds to opportunities to acquire such sites when other agencies are unable to do so;
- **The Coastal Restoration Program**, which provides capital funds and technical assistance to ameliorate conditions that are preventing orderly development in accordance with the provisions of local coastal programs.

The Nonprofit Organizations Assistance Program: The nonprofit organization assistance program provides capital funds and technical assistance to nonprofit land conservation organizations to aid them in implementing Conservancy projects and in developing cost-effective local management of resource land and public access facilities. The Conservancy has joined in partnership endeavors with more than 100 local land trusts and other nonprofit groups.

Sustained Yield Plans for forest landowners: BOF requires landowners over 50,000 acres to develop a plan that demonstrates the continual flow of high quality forest products. The Department supplies support to CDF for technical analysis whenever the landowner wishes to incorporate protection measures for endangered species or candidates such as anadromous fish.

California Department of Forestry and Fire Protection's Forest Stewardship Program: The Forest Stewardship Program is supported by funds from the USFS's Local Assistance Program. The program provides grants to develop forest "stewardship" plans. In addition to improving forest resources and addressing fire safety, the purpose of stewardship plans is to identify resources, such as wildlife, fisheries, and threatened and endangered species for improved management. Recently, the focus of the program has changed from individual landowners to assisting the development of community-based watershed plans.

Commercial and Recreational Fishing

Federal Ocean Fisheries Management

California's ocean salmon fisheries are managed by the PFMC under authority of the Federal Magnuson-Stevens Fishery Conservation and Management Act of 1975. The Pacific Coast Salmon Plan provides the basis on which the PFMC manages the salmon harvest in fisheries occurring 3 to 200 miles offshore, from the Canada border south to Mexico.

The PFMC manages California's natural and hatchery coho salmon stocks together with Columbia River and Oregon stocks as components of the Oregon Production Index (OPI) area. The fish from these stocks are essentially intermixed in the ocean fishery, and contribute to the harvest off the southern Washington coast, as well as to that off Oregon and California. The OPI is a measure of the annual abundance of three-year-old coho salmon, and currently is the sum of: 1) ocean sport and troll fishery impacts south of Leadbetter Point, Washington; 2) Oregon and California coastal hatchery returns; 3) Columbia River in-river runs; 4) Oregon Coastal Natural (OCN) spawner escapement; and 5) Oregon coastal inside fishery impacts. Most of California production is from hatcheries, which provide a very small portion of the total hatchery production in the OPI area.

When harvest impacts are modeled and regulations are developed for the management areas south of Cape Falcon, Oregon, consideration must be given to the mandates of Amendment 13 of the Pacific Coast Salmon Plan, to recommendations of the OCN Coho Work group, and to jeopardy standards established by the NMFS for listed ESUs. The standards specify levels of incidental take that are not likely to jeopardize the continued existence of the ESU. Within the naturally-produced OPI area coho salmon stocks, NMFS has identified and set jeopardy standards for three ESUs listed as threatened: CCC Coho ESU, SONCC Coho ESU, and Oregon Coast Coho ESU (OC Coho ESU).

Key coho salmon management objectives that shaped the 2001 Federal ocean salmon regulations are:

- Prohibit retention of all coho salmon off California, for the purposes of protecting CCC coho (NMFS jeopardy standard).
- A marine exploitation rate no greater than 13% on Rogue River/Klamath River (R/K) hatchery coho salmon, used as a surrogate stock for purposes of protecting SONCC coho (NMFS jeopardy standard).
- A combined marine/freshwater exploitation rate of no greater than 15% on OCN coho, which include both OC and SONCC coho, and comprise the largest natural component of the OPI (Amendment 13 of Pacific Coast Salmon Plan).
- A combined marine/freshwater exploitation rate no greater than 8% on OCN coho (OCN Coho Work Group recommendation).

Ocean Harvest Regulations

2001 ocean regulations include time and area closures, seasonal quotas, minimum sizes, specific fishing gear restrictions, and allowable take (e.g. daily bag and possession limits). The regulations also structure the south of Cape Falcon fishery to minimize OCN coho impacts while utilizing harvestable chinook and hatchery coho salmon stocks (PFMC 2001b). Retention of coho salmon is prohibited for the commercial troll and recreational fisheries south of Cape Falcon, except for a mark-selective recreational fishery off of Oregon of up to 55,000 coho salmon originating from that state's hatcheries; these fish are distinguished by healed adipose-fin clips.

Each Pacific coast state is required to conform its fishing regulations for ocean waters under their jurisdiction (within three miles of shore) to those implemented for adjacent Federal ocean waters, or risk pre-emption of their management authority by NMFS. California's commercial and recreational ocean salmon fishing regulations are presented in Appendices E1 and E2.

Inland Sport Fishing Regulations

California's inland fishing regulations are set under authority of the Commission (FGC, Division 1, Chapter 2, Article 1) (CFGC 2002). These regulations are reviewed and revised every two years during even-numbered years. In every odd-numbered year, the Commission devotes its early August, October, November, and December meeting to recommendations for changes in the sport fishing regulations.

Current regulations (Appendix E3) continue specific protection for coho salmon instituted in 1998, which state that "silver [coho] salmon are fully protected, and may not be taken in any of the waters of the State. Incidentally hooked silver [coho] salmon must be immediately released unharmed to the waters where they are hooked". Restrictions on seasons and area closures intended for other salmonid species may also reduce incidental take of coho salmon.

Effects of Management

Under the PFMC-adopted 2001 management measures for Federal ocean waters, all of the key coho salmon management objectives are satisfied. In modeling the impacts of the regulations for non-retention and mark-selective coho salmon fisheries, mortality resulting from hook-and-release, drop-off before being boated, and non-compliance is accounted for. The resulting projected non-landed mortality for the 2001 commercial and recreational fisheries south of Cape Falcon was estimated at 27,900 and 12,900 coho salmon, respectively (PFMC 2001b). As part of these impacts, the management components of the OPI that incorporate California's north coast coho salmon, the OCN and the R/K, were projected to sustain exploitation rates of 7.4% (3,475 fish) and 3% (1,504 fish), respectively (Table 23). The rate for OCN coho is below the 8% limit recommended by the OCN Coho Work Group and the 15% under Amendment 13, and the rate for R/K hatchery coho salmon, a surrogate for the SONCC Coho ESU stock, is well below the 13% NMFS jeopardy standard.

Table 23. Projected 2001 coastwide Oregon Coast Natural and Rogue/Klamath coho salmon harvest mortality and exploitation rates (PFMC 2001b).

Fishery	Oregon Coast Natural		Rogue/Klamath	
	Mortality (#)	Expl. Rate (%)	Mortality (#)	Exp. Rate (%)
SOUTHEAST ALASKA	15	0.03	0	0.00
BRITISH COLUMBIA	2	0.00	0	0.00
PUGET SOUND/STRAITS	82	0.17	0	0.00
BUOY 10	98	0.21	63	0.13
ESTUARY/ FRESHWATER	444	0.94	---	---
NORTH OF CAPE FALCON				
Treaty Indian Troll	318	0.68	0	0.00
Recreational	334	0.71	25	0.05
Commercial Troll	229	0.49	0	0.00
SOUTH OF CAPE FALCON				
Recreational				
Cape Falcon to Humbug Mt.	453	0.97	45	0.09
Humbug Mt. to Horse Mt. (KMZ)	186	0.40	632	1.27
Fort Bragg	117	0.25	337	0.68
South of Pt. Arena	173	0.37	97	0.20
Commercial Troll				
Cape Falcon to Humbug Mt.	825	1.76	52	0.10
Humbug Mt. to Horse Mt. (KMZ)	28	0.06	103	0.21
Fort Bragg	18	0.04	69	0.14
South of Pt. Arena	153	0.33	81	0.16
TOTAL	3,475	7.4	1,504	3.03

Research and Monitoring Programs

Many of the research and monitoring programs on coho salmon in California are outlined in Appendix F. These studies involve work on population estimation and monitoring, presence distribution, life history and habitat, and genetics. The work is conducted by several methods, using a variety of sampling equipment, from direct observation to electrofishing. Many of the sampling locations collect data on more than one life stage, or use different sampling techniques for the same age class. Studies of adults comprise approximately 30% of the monitoring and research programs listed in Appendix F. Most of the work focuses on the major stream drainages north of San Francisco.

VIII. CONCLUSIONS

These conclusions regarding the status of coho salmon north of San Francisco are based on information in the preceding chapters of this report as well as the specific sources cited in this chapter. Sources include the best available scientific data on abundance and trends, distribution and metapopulation structure, and any identifiable threats to persistence. In some cases there are significant data gaps that make it difficult to arrive at precise estimates of the rate and magnitude of losses. Despite this uncertainty in some of the data, patterns and trends in many of the available indices documenting overall declines in California coho salmon populations are self-evident. These conclusions form the basis for the Department's recommendations in the following chapter of this report.

The Department did not find any evidence to contradict the conclusions of previous status reviews that coho salmon populations have suffered declines in California. Conversely, new evidence was found that supports these conclusions. The Department concludes that California coho salmon have experienced a significant decline in the past 40 to 50 years. California coho salmon populations have been individually and cumulatively depleted or extirpated and the natural linkages between them have been fragmented or severed. Coho salmon abundance in California, including hatchery stocks, could be six to 15 percent of their abundance during the 1940s, and has experienced a decline of at least 70% since the 1960s.

Changes in coho salmon distribution and abundance must be evaluated against a background of natural variation due to cyclic and changing environmental factors. Ocean conditions are known to have changed in recent years. These cyclic and non-cyclic changes have undoubtedly affected perceived and measured coho salmon distribution and abundance. However, viewed over the long-term, coho salmon populations are presently more vulnerable to adverse effects of this natural variation due to small population sizes, range restrictions, and fragmentation that has occurred since the 1940s. Natural variation is not likely to cause local extinctions unless populations are already severely depressed due to other causes.

Hatchery production has declined dramatically in recent years largely due to lack of spawners. Recent five-year averages for Warm Springs, Mad River, and Iron Gate hatcheries, and Noyo Egg Taking Station are only 11% to 44% of the average production between 1987-91. While some of this reduction can be attributed to reduced production targets, lack of spawners has been the most important natural limit to production. Only Trinity River Hatchery has maintained production at historical levels, and only Trinity River Hatchery and Iron Gate Hatchery currently produce relatively large numbers of coho salmon.

Coho salmon harvest dropped-off considerably in the late 1970s, despite a fairly stable rate of hatchery production. By 1992, ocean stocks were perceived to be so low that the commercial fishery was closed to protect them. Similarly, coho salmon retention in the ocean sport fishery ended with the 1993 season. Analysis of presence-by-brood-year, field surveys conducted from 1995 through 2001, recent abundance trend information for several streams systems along the central and north coasts, and ocean harvest data all predominantly indicate an overall declining trend throughout the state.

Southern Oregon/Northern California Coast Coho ESU

The analysis of presence-by-brood-year data indicates that coho salmon occupy only about 61% of the SONCC Coho ESU streams that were identified as historical coho salmon streams by Brown and Moyle (1991) so it does appear that there has been a fairly substantial decline in distribution within this ESU. However, our data do not support a significant decline in distribution since the late 1980s, as evidenced by the comparison of brood year presence in streams common to both the 1986 through 1991 and 1996 through 2000 periods. This analysis and the 2001 presence surveys indicate that some streams in this ESU have may have lost one or more brood-year lineages.

The 2001 presence survey data may also indicate a decline in distribution in the SONCC Coho ESU. These data show a substantial reduction in the number of historical streams occupied by coho salmon, especially for the Mattole, Eel, and Smith river systems, where coho salmon appeared to be absent from 71%, 73%, and 62% of the streams surveyed, respectively. These data should be interpreted with caution, however, because they represent only one year of surveys, and 2001 was a drought year on the north coast. Nevertheless, the inability to detect coho salmon in streams that were historically documented to have contained them and are considered by biologists to contain suitable coho salmon habitat is significant, especially to the high degree that coho salmon were not found in these surveys (59% of all streams surveyed).

Adult coho salmon counts at Benbow Dam on the South Fork Eel River showed a substantial decline in this system from the mid-1940s to the 1970s. Other trend indicators show declining or stable trends, with the only exception being coho salmon counts at Sweasey Dam on the Mad River, which shows a relatively large increase in the coho salmon population in 1962 and 1963. However, returns of adult coho salmon at Mad River Hatchery indicate a declining trend in this river in more recent years.

Considered separately, none of these lines of evidence provide conclusive evidence that coho salmon have experienced a substantial decline throughout the SONCC Coho ESU, because they are either limited in scope or are not particularly robust in detecting trends within specific watersheds. However, most of these indicators show declining trends, and in that respect, provide a high likelihood that populations have declined significantly and are continuing to decline. Some of the indicators show an upward trend in 2000 and 2001 that may ameliorate this downward trend slightly, but the overall trend is still downward in most cases, and most indicators of abundance show values that are much reduced from historical levels.

Although stocks in the SONCC Coho ESU appear to be declining and distribution within the watersheds appears to be reduced, population structure within the larger systems does not show population fragmentation as severe as that of the CCC Coho ESU. All major stream systems within this ESU still contain coho salmon populations, hence they are likely not as vulnerable to extirpation from adverse climatic or oceanic conditions or demographic effects of fragmented populations. Also, the presence-by-brood-year analysis indicates that the decline in distribution appears to have stabilized since the mid-1980s. For these reasons, the Department concludes that the SONCC Coho ESU is not presently threatened with extinction. However, because of the decline in distribution prior to the 1980s, the possibility of a severe reduction in distribution as indicated by the field surveys, and the downward trend of most abundance indicators, the Department believes that coho salmon populations in this ESU will likely become endangered in the foreseeable future in the absence of the special protection and management efforts required by CESA.

Central California Coast Coho ESU

The 2001 presence surveys in the northern portion (Mendocino County) of the CCC Coho ESU show a level of occupancy of historical streams that is similar to the SONCC Coho ESU. However, stream systems south of Mendocino County show a much greater proportion of streams in which coho salmon were not found. These surveys and other recent monitoring indicate that widespread extirpation or near-extinctions have already occurred within some larger stream systems (e.g. Gualala and Russian rivers) or over broad geographical areas (e.g. Sonoma County coast, San Francisco Bay tributaries, streams south of San Francisco). Only three streams in the Russian River system still contain coho salmon, and only one of these populations exists in appreciable numbers. Currently, there is an emergency captive breeding effort underway to keep Russian River coho salmon from becoming extinct. In the Sonoma County coastal area, coho salmon appear to be extirpated or barely persisting. Coho salmon were last observed in the Gualala River system in just two tributaries in 1995, and surveys of these streams in 1999, 2000, and 2001 failed to find coho salmon. The last year of observation of coho salmon in San Francisco Bay tributaries was in 1981. Coho salmon are now present in appreciable numbers in only three, possibly four streams south of San Francisco.

Most abundance trend indicators for streams in the CCC Coho ESU indicate a decline since the late 1980s. However, some streams of the Mendocino County coast showed an upward trend in 2000 and 2001. Time series analysis for these streams show a declining trend and predict that this trend will continue, despite the recent increases.

There is anecdotal evidence that relatively large numbers of coho salmon adults returned to some Marin County streams (e.g. Lagunitas Creek) in 2001. Lagunitas Creek and nearby tributaries still harbor coho salmon populations, and Lagunitas Creek appears to have a relatively stable, albeit small, population since the mid-1990s. However, small population sizes and the resulting isolation of this region, because of extirpation of coho salmon populations to the north and south, increases the vulnerability of these populations to extinction due to catastrophes, extreme variation in climatic and oceanic conditions, or adverse demographic effects.

Streams in the northern portion of this ESU seem to be relatively stable or are not declining as rapidly as those to the south. However, the southern portion, where widespread extinctions and near-extirpations have occurred, is a major and significant portion of the range of coho salmon in this ESU. Extant populations in this region appear to be small. Small population size along with large-scale fragmentation and collapse of range observed in data for this area indicate that metapopulation structure may be severely compromised and remaining populations may face greatly increased threats of extinction because of it. For this reason, the Department concludes that coho salmon in the CCC Coho ESU are in serious danger of extinction throughout all or a significant portion of their range.

Factors Affecting the Decline

The pattern of decline and localized extirpation of coho salmon in California mirrors that of steelhead, and to a lesser extent chinook salmon (both of which are also federally-listed species), in that the severity of the decline and number of extirpated populations increases as one moves closer to the historical southern limit of their range. Thus, the process of localized extinction seems to be moving northward and is an indication that freshwater habitat in these marginal environments is less able to support coho salmon populations than in the past.

Freshwater habitat loss and degradation has been identified as a leading factor in the decline of anadromous salmonids in California and coho salmon do not appear to be an exception to this. Timber harvest activities, especially past and present road construction, have had deleterious effects on coho salmon habitat. Diversion of water for agricultural and municipal purposes and dams that block access to former habitat have resulted in further diminishment of habitat. Water quality in historical coho salmon-bearing streams has declined substantially, as evidenced by the number of north and central coast streams that have been placed on the list of impaired water bodies pursuant to Section 303 of the CWA.

Other factors such as commercial and recreational fishing, illegal harvest, predation, changes in ocean conditions and productivity, and hatchery operations do not appear to be as significant in the decline of California coho salmon stocks. Ocean commercial and recreational harvest of coho salmon in California has been prohibited since 1993 and 1994, respectively, and inland sport harvest has been prohibited since 1998. Illegal harvest does occur, but is mostly the result of misidentification, or is opportunistic and not widespread.

Numerous studies have shown that salmonids are a minor component in the diet of marine mammals. However, when a prey population has been reduced, a very small amount of predation pressure can have a significant impact on the population, although there is no evidence that this is occurring with coho salmon in California. Predation can be significant where physical conditions lead to a concentration of adults or juveniles, or when altered ecological conditions favor an introduced predator.

Some ocean condition factors favorable to salmonids are cyclic. It appears that current productivity in the ocean is relatively high, as evidenced by large returns of chinook salmon to west coast streams in recent years, and by recent upswings in coho salmon abundance indicators in some places. Productive ocean conditions, by enhancing survival, can mask reduced productivity associated with freshwater habitat loss. When unfavorable ocean conditions occur in combination with degraded freshwater habitat conditions, productivity is greatly reduced and populations that are already fragmented and small become more vulnerable to extinction.

Hatcheries have historically been active throughout the range of coho salmon in California and have produced numbers of fish that, while relatively small in a coastwide sense, are significantly large relative to natural production in places where large hatcheries have been active. Although hatcheries may have produced some benefits to local coho salmon populations (some stocks in the CCC Coho ESU may exist only because of relatively constant input of hatchery-origin coho salmon), hatcheries have also had the opportunity to adversely affect natural California coho salmon populations. However, it is unclear exactly whether or how hatchery fish and/or hatchery operations have affected and are affecting California’s natural coho salmon populations. Hatcheries in California have dramatically reduced their production of coho salmon, limited outplanting, and stopped virtually all stock transfers in recent years. Therefore, current impacts of hatchery fish and operations on remaining natural stocks may be significantly less than in the past. Their potential to cause adverse impacts to natural stocks is severely limited by decreased production and modern management policy.

IX. RECOMMENDATIONS

The Department offers the following recommendations on the petitioned action, on management activities, and on other actions to aid in the recovery of coho salmon. Although some of these recommendations are within the authority of the Commission or Department to implement, others will depend on actions by other agencies or private parties.

Petitioned Action

The Salmon and Steelhead Recovery Coalition petitioned the Commission to list the coho salmon north of San Francisco as an Endangered Species under CESA. The Commission is guided by the guidelines promulgated under this Act in determining whether a species may be listed as endangered or threatened. Section 670.1(i) of Title 14 of the California Code of Regulations sets forth the listing criteria. Under this section, the Commission may list a species if it finds that its continued existence is in serious danger, or is threatened by any of the following factors:

- Present or threatened modification or destruction of its habitat;
- overexploitation;
- predation;
- competition;
- disease; or
- other natural occurrences or human-related activities.

Section 2062 of the FGC defines an endangered species as "....a native species or subspecies of a bird, mammal, fish, amphibian, reptile or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes....". A threatened species is defined as ".....a native species or subspecies of a bird, mammal, fish, amphibian, reptile or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required [by CESA]" (FGC Section 2067).

Based on this status review of the available scientific information, the Department concludes that coho salmon in the California portion of the Southern Oregon/Northern California Coast coho ESU (historical coho salmon streams from Punta Gorda north to the Oregon border), (Figure 3) although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by CESA. The Department concludes that the petitioned action to list this species as an endangered species is not warranted, but listing as a threatened species is warranted. The Department recommends that the Commission publish notice of its intent to amend Section 670.5 of California Code of Regulations, Title 14 to add coho salmon (*Oncorhynchus kisutch*) north of Punta Gorda to the list of threatened species.

Based on this status review of the available scientific information, the Department concludes that coho salmon in the CCC Coho ESU (historical coho salmon streams tributary to San Francisco Bay north to Punta Gorda) (Figure 3) is in serious danger of becoming extinct throughout all, or a significant portion of, its range. The Department concludes that the petitioned action to list this species as an endangered species is warranted. The Department recommends that the Commission publish notice of its intent to amend Section 670.5 of California Code of Regulations, Title 14 to add coho salmon (*Oncorhynchus kisutch*) north of and including San Francisco Bay to Punta Gorda to the list of endangered species.

Future Management

Programmatic

The Department should explore the possibility of legislation to create a CESA consultation section for state agencies to replace FGC section 2090, which has expired.

Disease Control

The reduction of stress factors, such as, but not limited to, warm water temperatures, reduced stream flows, lack of cover, lack of stream diversity, silt load, polluted water, and impeded passage, can significantly decrease the incidence of disease. The best form of disease control for wild populations is to avoid its introduction into a watershed. Minimizing handling of adults at weirs and establishing water temperature criteria for operation of research and monitoring facilities should be implemented. Fish that are rescued from a desiccating stream are stressed by one or more factors, which create a favorable environment for disease. When released into new habitat, these fish can spread diseases to the existing population in the stream. This needs to be considered when fish rescues are authorized by the Department.

Hatchery Management

Hatchery management should:

- maintain use of native, within-basin broodstock collected in appropriate numbers from throughout the natural run;

- maintain prohibitions against outplanting of coho hatchery stock in anadromous waters;

- continue to develop HGMPs that incorporate conservation measures for all coho hatcheries in California; and

- continue to evaluate the recommendations in the *Final Report on Anadromous Salmonid Fish Hatcheries in California* (CDFG/NMFS 2001) and adopt those recommendations deemed necessary and appropriate for the hatcheries within the range of coho salmon.

Forestry Activities

The Department should cooperate with the BOF to implement the “Joint Policy Statement on Pacific Salmon and Anadromous Trout” adopted by the BOF and the Commission. A combination of current timber harvest plan review in conjunction with stream assessment and broader watershed analyses would result in an effective approach to both understanding and addressing the relationship of forestry practices and coho salmon ecology, and potential regional or local differences in these relationships.

The Department should:

- provide temperature regime threshold guidelines, derived from existing literature and field studies, to CDF and the BOF for inland waters that continue to support coho salmon;

- encourage participation by all other agencies in the development of habitat conservation plans and all other landscape-scale planning efforts;

- support and participate in the development of watershed specific efforts to effectively maintain and restore coho salmon habitat by focusing on the combination of factors currently limiting the distribution and abundance of coho salmon.

General Land-use Activities

The Department should coordinate with appropriate state and federal agencies, land owners, and other interested parties to protect or enhance habitat conditions or functions. This will include coordination on development of:

- stream temperature regimes for all life-stages, especially eggs and juveniles;

- future recruitment of LWD, stream-side vegetation, and canopy cover;

- buffers for streams from upslope inputs of fine and coarse sediment;

- attenuation of existing sediment loads; and

- allowing for stream meandering and creation and cycling of streambank, side-channel, pool, and riffle habitat.

The Department should coordinate with state and local agencies and land owners on road management issues that have the potential to affect coho salmon habitat, including the consultation on permanent and temporary roads and watercourse crossings with the goal that they will be properly constructed, maintained, reconstructed, or abandoned.

Screens, Diversions, and Fish Passage

Through the Fish Passage Forum, the Department should continue to coordinate with state, local, and federal agencies and other interested parties to identify, prioritize, and remediate coho salmon passage barriers. The Department should work within the Streambed Alteration Agreement process to improve and replace existing diversions to benefit coho salmon.

Instream Flow

Flow studies to determine instream flow needs for coho salmon on the Shasta and Scott rivers are needed. For the Klamath River, the Department supports the Hardy Phase II flows to develop a flow regime in the Klamath River over five water-year types that would adequately consider California's anadromous fishery resources and allow for recovery of California coho populations.

Gravel Extraction

The Department requires gravel removal operations to be reviewed under Section 1600 et seq. of the Fish and Game Code. To deal with instream mining with statewide consistency and greater scientific rigor, the Department is currently developing guidelines to ensure compliance with this Fish and Game Code section. The NMFS Southwestern Region Policy on Instream Gravel Extraction should be used as advisory, non-regulatory guidance until the Department's draft instream mining guidelines have been finalized.

Suction Dredging

The Department requires a permit to use any vacuum or suction dredge equipment in any river. Strict adherence to the regulations and requirements pursuant to Section 5653 of the Fish and Game Code is necessary to prevent impacts to salmonids and their habitat. The Department should continue to refine and adjust the existing regulations as necessary.

Commercial and Recreational Fishing

California ocean and inland non-Indian fisheries are closed by federal and state regulations to the directed harvest of coho salmon. However, incidental mortality due to non-compliance and hook-and-release still occurs. Dockside education and enforcement in the recreational fishery has been increased in recent years, and should be continued. The moratorium on commercial and recreational harvest should also be continued.

Research and Monitoring

Coho salmon presence surveys should be continued for at least two additional years to obtain additional information on coho distribution, population fragmentation, and temporal extinctions for purposes of expanding information available for managing the species. In addition, coho salmon abundance measurements should be refined to improve the assessment of populations and the effects of habitat restoration activities on these populations.

X. RECOVERY CONSIDERATIONS

The Department's recovery objective for coho salmon is to protect and expand existing natural populations and reestablish a sufficient number of additional native populations in restored and protected habitats. This will insure their long-term survival within their native habitat and range north of and including San Francisco Bay. Recovery actions will focus on restoring, rehabilitating, and protecting habitat to ensure recovery of natural spawning populations, in accordance with State statute and Commission and Department policies.

From a management and recovery perspective, State statute and Commission policy places management emphasis and priority on natural rather than hatchery-origin stocks. For example, FGC Section 6901 states:

- Proper salmon and steelhead trout resource management requires maintaining adequate levels of natural, as compared to hatchery, spawning and rearing.

- Reliance upon hatchery production of salmon and steelhead trout in California is at or near the maximum percentage that it should occupy in the mix of natural and artificial hatchery production in the state. Hatchery production may be an appropriate means of protecting and increasing salmon and steelhead in specific situations; however, when both are feasible alternatives, preference shall be given to natural production.

- The protection of, and increase in, the naturally spawning salmon and steelhead trout of the state must be accomplished primarily through the improvement of stream habitat.

Also, the Commission policy on Cooperatively Operated Rearing Programs for Salmon and Steelhead states: "*The bulk of the state's salmon and steelhead resources shall be produced naturally. The state's goals of maintaining and increasing natural production take precedence over the goals of cooperatively operated rearing programs*." The Commission policy on salmon states that "*Salmon shall be managed to protect, restore, and maintain the populations and genetic integrity of all identifiable stocks. Naturally spawned salmon shall provide the foundation for the Department's management program*."

The Department's Salmon and Steelhead Stock Management Policy focuses on the protection of the genetic integrity of stocks through evaluation of streams and classification of their stocks according to probable genetic source and degree of integrity. Stocking programs and the role of artificial production are guided by this classification system.

In addition, monitoring the long-term trend of adult coho salmon population numbers throughout the petitioned area, as well as within sub-watersheds, is necessary. Recovery goals must ensure that the individual populations, as well as the collective metapopulation(s), are sufficiently abundant to avoid genetic risks of small population size. Therefore, these goals need to address abundance levels (adult spawning escapements), population stability criteria, population distribution, and length of time for determining sustainability. The Department will develop appropriate downlisting or delisting criteria, based on the best scientific information available, and periodically reexamine the status of coho salmon. When, in the Department's judgment, recovery goals and downlisting or delisting criteria have been met, it will make recommendations to the Commission regarding changing the status of this species.

Recovery of viable coho salmon populations in streams north of San Francisco will require vigorous efforts by the Department, other government agencies, and the private sector to reverse the present trend of coho salmon habitat debilitation. Watershed, water flow and quality, and habitat conditions must be improved to provide the necessary spawning and rearing habitat to allow the natural coho salmon population to survive, diversify, and increase to levels sufficient to withstand droughts, unfavorable climatic and oceanic conditions, and other uncontrollable natural phenomenon.

Reintroduction and expansion of naturally reproducing populations may require limited artificial propagation. These activities would be conducted under Department authority in cooperation with federal and local governments and stakeholders. Such an activity has already been implemented at Warms Springs Hatchery. Cooperative restoration efforts programs would be initiated with all county governments where viable coho salmon populations occurred historically. The CDF would necessarily be an active partner in stabilization and restoration of coho salmon habitat within wildland areas, through their authority in timberland management and wildland and rural fire control. Other appropriate federal, state, and local governmental units would be incorporated in efforts to restore and maintain stream and riparian habitats including water flow and quality. The success of the restoration efforts will largely hinge on the cooperation and participation of the local communities and landowners.

Recovery Planning

The ESA requires that recovery plans for federally-listed species be developed and implemented. Recovery plans should contain (1) objective, measurable goals for delisting; (2) a comprehensive list of the actions necessary to achieve the delisting goals; and (3) an estimate of the cost and time required to carry out those actions. In addition, NMFS Recovery Planning Guidelines suggest that recovery plans include an assessment of the factors that led to population declines and/or which are impeding recovery. Finally, it is important that the plans include a comprehensive monitoring and evaluation program for gauging the effectiveness of recovery measures and overall progress toward recovery.

NMFS has recently begun to implement a planning process to develop recovery plans for listed anadromous salmonids. Rather than developing a recovery plan for each individual species as was done in the past, NMFS will develop a single, multispecies plan for all listed anadromous salmonids inhabiting specific geographic areas, or “recovery domains”. In California, four recovery domains have been identified (listed ESUs within each domain are in parentheses):

- **Southern Oregon/Northern California Coast** (SONCC Coho).
- **North-central California Coast** (CCC Coho, Central California Coast Steelhead, Northern California Steelhead, California Coast Chinook).
- **South-central California Coast** (South-central California Steelhead, Southern California Steelhead).
- **California Central Valley** (Central Valley Steelhead, Central Valley Spring-run Chinook, Sacramento River Winter-run Chinook).

NMFS has established a Recovery Science Review Panel (Panel) to guide the recovery planning process throughout the west coast range of the listed salmonids. The Panel will: 1) review core principles and elements of the recovery planning process NMFS is developing; 2) ensure that well-accepted and consistent ecological and evolutionary principles form the basis for all recovery efforts; 3) review processes and products of all TRTs for scientific credibility and consistency; and 4) oversee a recovery plan peer review process.

A Technical Recovery Team (TRT) will be appointed by NMFS for each recovery domain. TRTs will consist of about six to nine respected scientists from inside and outside government with a mix of expertise in salmon biology, population dynamics, conservation biology, ecology, and other disciplines necessary for setting recovery standards and for measuring recovery efforts. TRT members will be appointed by NMFS based on their ability to assess factors responsible for the decline of each of the 26 salmon populations that have been identified as at risk of extinction. They will also develop recovery goals for the fish and their habitats. The TRTs will work in coordination with teams of existing scientists from state, federal, tribal, and local agencies, and in concert with ongoing conservation planning efforts in each region.

The TRTs will be asked to: 1) identify population and de-listing goals for each listed ESU within the domain; 2) characterize habitat/fish abundance relationships; 3) identify the factors for decline and limiting factors for each ESU and identify the early actions that are important for recovery; 4) identify research, evaluation, and monitoring needs; and 5) serve as science advisors to groups charged with developing measures to achieve recovery. Recovery goals must, at a minimum, restore listed ESUs to levels at which they are no longer threatened and can therefore be delisted under the ESA.

In 2001, TRT members were appointed for the Southern Oregon/Northern California Coast and the North-central California Coast domains. These two domains encompass the range of coho salmon in California. The Department plans to participate fully in the NMFS recovery planning process. To this end, Department biologists have been appointed to each of the above TRTs. Both TRTs have convened and have begun to develop delisting criteria for the listed species, including coho salmon, within each domain and will continue to meet monthly.

XI. ALTERNATIVES TO THE LISTING

The Commission has options available to it in responding to the petition to list. Several alternatives are described below.

I. Recommended Alternative

The Department of Fish and Game is recommending that the Commission list California coho salmon between Punta Gorda and the Oregon border as threatened and list the species between San Francisco and Punta Gorda as endangered.

II. Alternative Listing Scenarios

The Commission will base its decision whether to list on the Department's Status Review, other scientific reports that are submitted and any other public comments and submissions it receives. The Commission may review all of the pertinent information and conclude that listing is warranted, but at a level different than that recommended by the Department or requested by the petitioners.

The regulatory standard for the Commission's determination provides that,

> "[a] species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors:
>
> 1. Present or threatened modification or destruction of its habitat;
> 2. Overexploitation;
> 3. Predation;
> 4. Competition;
> 5. Disease; or
> 6. Other natural occurrences or human-related activities.
>   (14 CCR § 670.1(i)(1)(A))

Therefore, the Commission is required to list a species as "endangered or threatened" if one or more of the above-mentioned factors pose a serious danger or threat to the continued existence of the species. If the standard in section 670.1 is met, then the Commission will ultimately determine the level at which listing is appropriate.

FGC section 2062 defines an endangered species as one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease". FGC section 2067 defines a threatened species as a species "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]." The petitioners, the Salmon and Steelhead Recovery Coalition, assert that listing coho as endangered is warranted throughout its entire range in California.

III. Recovery Strategy Pilot Program

The Commission may elect to designate coho for recovery planning pursuant to the Recovery Strategy Pilot Program (FGC section 2105 et seq.). The objective of the Recovery Strategy Pilot Program is the development of recovery strategies with the goal that regulations or other protections for listed species will no longer be necessary. The Recovery Strategy Pilot Program authorizes the Commission to identify four species that are listed as candidate, threatened or endangered species for which recovery strategies shall be developed and implemented (FGC section 2106). The Commission may designate a candidate species for recovery planning with the concurrence of the listing petitioner (*ibid*.) or elect to designate the species for recovery planning in conjunction with the listing of the species, without the concurrence of the listing petitioner. If the Commission designates a candidate species prior to listing, with the concurrence of the petitioner, the Commission may delay a listing decision for twelve to eighteen months until a final determination is made with regard to the recovery strategy (FGC section 2114).

If the Commission were to designate coho as a species subject to the Recovery Strategy Pilot Program, the Department would assemble a recovery team consisting of department personnel, other State and federal agency personnel if appropriate, representatives of affected local governments, landowners, environmental groups and persons with scientific expertise (FGC section 2107). The team would prepare a recovery strategy within approximately 12 months of designation by the Commission (FGC section 2109). The Department may include specifications in the proposed recovery strategy regarding allowable taking of the species and policies regarding issuance of incidental take permits that are consistent with the recovery strategy (FGC section 2110). Any rulemaking proceedings that follow the Commission's consideration of the final recovery strategy would include the Department's specifications and would consider the recovery strategy, although the recovery strategy itself would not constitute a regulation (FGC section 2114).

The Commission would hold a public hearing after the Department submitted the recovery strategy for approval. The Commission would be required to approve the recovery strategy upon making findings that:

- the recovery strategy would conserve, protect, restore, and enhance the species;

- the recovery strategy and implementation schedule are capable of being carried out in a scientifically, technologically, and economically reasonable manner;

- the recovery strategy is supported by the best available scientific data; and

- the recovery strategy represents an equitable apportionment of both public and private and regulatory and nonregulatory obligations.

The Department would continue to consult with the recovery team after approval of the recovery strategy and report annually to the Commission on the status and progress of the implementation of the recovery strategy (FGC section 2113).

IV. Determination That Listing Is Not Warranted:

If the Commission determines that listing is not warranted, the California coho salmon north of San Francisco ("coho") will revert to the unlisted status under State law that it held prior to the petition filing. While projects with the potential to take coho will not be required to obtain State incidental take permits, the existing federal and State permit requirements that existed prior to the petition filing will remain in place. For example, the State will continue to negotiate Streambed Alteration Agreements and comment on Timber Harvest Plans, federal incidental take permits, applications to the State Water Resources Control Board, etc. Also, the Department of Fish and Game will continue to act as the trustee agency for the State's fish, wildlife and plant resources. In this role, the Department will review and comment on impacts to coho and recommend mitigation measures for these impacts as part of the CEQA review process.

In the absence of a listing decision by the Commission, the Department would also continue to participate in and support a variety of programs designed to benefit coho and other anadromous fish. Many of the Department's existing management efforts are detailed in Chapter VII of this Status Review, including:

- prevention of disease;
- preparation of Hatchery and Genetic Management Plans;
- continuation of working with other State Agencies to decrease impacts from timber related projects;
- implementation of the Pacific Lumber Company Habitat Conservation Plan;
- increasing the number and improve the quality of fish screens on water diversions in coho habitat;
- preparation of instream flow studies;
- participation in identifying, removing and retrofitting existing barriers to fish passage;
- working with gravel extractors to avoid, minimize, or mitigate for impacts to fisheries resources;
- continuing to restore and enhance salmon and steelhead habitat throughout the State through the Fish Restoration Grants Program;
- participation in the Coastal Watershed Restoration Program and many other federal and State conservation and restoration programs operating in the petitioned area;
- regulation of coho inland sport fishing; and
- conducting research and monitoring programs.

In addition to the Department's efforts, local governments and private parties in the petitioned area currently participate in a variety of programs designed to improve coho status and habitat. One interested party, the County of Siskiyou, has specifically requested that the Department and the Commission consider their voluntary and local regulatory efforts to protect coho and coho habitat. Siskiyou County's submissions to the Department describe their efforts currently underway to restore coho populations and habitat. The County emphasizes that local programs are voluntary and believes that a decision to list coho in Siskiyou County will be detrimental to these efforts. In essence, the County argues that participants in the voluntary programs will be dissuaded from continuing due to uncertainty over whether the cost, time and effort will ultimately expose them to prosecution for "take" and other litigation.

XII. PROTECTIONS RESULTING FROM LISTING

"...[I]t is the policy of the state to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat..." (FGC, Section 2052). If listed, coho salmon north of San Francisco will receive protection from unauthorized take under the CESA, making the conservation, protection, and enhancement of coho salmon and its habitat issues of statewide concern. Project proponents will be subject to the prohibitions on take and other proscriptions in CESA that are punishable under State law. The Department may authorize exceptions to the prohibitions in CESA under certain circumstances. However, the impacts associated with authorizing an activity that will involve take of coho salmon will be minimized and fully mitigated according to State standards.

Listing this species increases the likelihood that state and federal land and resource management agencies will allocate funds towards protection and recovery actions that benefit coho salmon north of San Francisco. With limited funding and a growing list of threatened and endangered species, priority has been and will continue to be given to species that are listed.

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APPENDIX A.

Public Notification and Solicitation of Information Relating to the Coho Salmon Status Review

APPENDIX A1- PUBLIC NOTICE

July 6, 2001
PUBLIC NOTICE

TO WHOM IT MAY CONCERN:

Pursuant to California Fish and Game Code (Fish & G. Code) section 2074.4, NOTICE IS HEREBY GIVEN that the California Fish and Game Commission (Commission) accepted for further consideration a petition to add the coho salmon, north of San Francisco, to the official State list of endangered and threatened species. The official list of endangered and threatened species is located in the California Code of Regulations, title 14, section 670.5.

Species	Proposal
Coho salmon *(Oncorhynchus kisutch)*	Endangered

NOTICE IS FURTHER GIVEN that effective April 27, 2001, the coho salmon, north of San Francisco, (coho) is a "candidate species" pursuant to Fish & G. Code section 2074.2. Also, pursuant to Fish & G. Code section 2085, coho may not be taken or possessed except as provided by Fish & G. Code section 2081, other applicable statutes, or in accordance with the terms of the Special Order Relating to Incidental Take of Coho Salmon During Candidacy Period (Special Order) pursuant to Fish & G. Code section 2084, adopted by the Commission on April 5, 2001. A copy of the Special Order is available from the Commission, 1416 Ninth St., Sacramento, CA 95814, (916) 653-4899.

The California Endangered Species Act (Fish & G. Code sections 2050 et seq.) requires that once the Commission has accepted the petition for further consideration, the California Department of Fish and Game (DFG) must notify affected and interested parties for the purpose of receiving information and comments that will aid in evaluating the petition and determining whether or not the above proposal should be adopted by the Commission. (Fish & G. Code, § 2050 et seq.) DFG will review the petition, evaluate the available information, and report back to the Commission whether the petitioned action is warranted. (Fish and G. Code § 2074.6.) DFG's recommendation must be based on the best scientific information available to DFG, and must be submitted to the Commission not later than April 26, 2002. Therefore, NOTICE IS FURTHER GIVEN, that persons with data or comments on the taxonomic status, ecology, biology, life history, management recommendations, distribution, abundance, threats, habitat that may be essential for the species, or other factors related to the status of the above species, are hereby requested to provide such data or comments to:

California Department of Fish and Game
Native Anadromous Fish and Watershed Branch
1807 13th Street, Suite 104
Sacramento, California 95814
Attn: Joe Pisciotto

Copies of the petition may be requested from the above address.

Responses received by September 15, 2001 will be considered in DFG's final report to the Commission. Pursuant to California Code of Regulations, title 14, section 670.1(h)(1), public comments and reports on this issue can still be submitted to the Fish and Game Commission after this date. Any party intending to submit a detailed scientific report for the Department or Commission's consideration should refer to section 670.1(h)(1) and 670.1(h)(2). The Department anticipates it will submit its status review to the Commission on or about April 1, 2002. If DFG concludes that the petitioned action is warranted, it will recommend that the Commission list the species as threatened or endangered. (Fish & G. Code, § 2074.6.)

If DFG concludes that the petitioned action is not warranted, it will recommend that the Commission not list the species. (Fish & G. Code, § 2074.6.) Following receipt of DFG's report, the Commission will make the report available for public review. (Fish & G. Code § 2075.)

The Department will make every effort to distribute this notice as widely as possible. These efforts will include press releases, newspaper notices, and direct mail to interested parties. Pursuant to Fish & G. Code section 2074.4, the Director of DFG has determined that ownership of the land that may provide habitat essential to the species is so widespread and fragmented that individual notice to such landowners is impractical.

Ron Rempel
Deputy Director
Habitat Conservation Division
California Dept. Fish & Game

APPENDIX A2

LIST OF INDIVIDUALS AND ORGANIZATIONS CONTACTED BY MAIL

TIM ABBOTT
CA TRADE AND COMMERCE AGENCY

BUD ABBOTT

ROBERT ABBOTT
STRATEGIC ENVIRONMENTAL

DR JOHN D ABBOTT
CIBA-GEIGY CORPORATION

JOHN ABELE
FAIRFIELD BASS REAPERS

JIM ABLE

NICHOLAS F ABOUFADEL
FIRST USA RE INC

BILL ACKERMAN
GUALALA RIV STEELHEAD PROJ

SCOTT C ACKERT

TAMI ADACHI
PACIFIC GAS & ELECTRIC

TIM ADAIR
JACOBS ENGINEERING COMPANY INC

HILLARY ADAMS

CHRIS ADAMS
WILDLIFE INVENTORY SYSTEMS

JIM ADAMS
ARCATA REDWOOD COMPANY

PETER ADAMS
NMFS

DANNY L ADAMS
INTERNATIONAL PAPER

REED ADDIS

BRENDA ADELMAN
RUSSIAN RIVER WATERSHED PROTECTION COMMITTEE

MARIN BAYLANDS ADVOCATES

IMPLEMENT SANE CORRECT AEFORESTATION

AEMC

SEBASTIAN AFRICAN

STREAMBED ALTERATION AGREEMENT
CA DEPT OF FISH & GAME

STREAMBED ALTERATION AGREEMENT
CA DEPT OF FISH & GAME, EUREKA

STREAMBED ALTERATION AGREEMENT
CA DEPT OF FISH & GAME REG 1, REDDING

ANDREW C AGUILAR

SHANE ALBERS
HABERSTOCK CONSTRUCTION

M ALBERT

DOUG ALBIN
DEPT OF FISH AND GAME

TESS ALBIN-SMITH
FORESTRY & FIRE PROT

BOB ALDRICH

MAHLON ALDRIDGE
ECOLOGY ACTION
LARRY ALEXANDER
NO CA ECOSYSTEM TRAINING CENTER

PETE ALEXANDER
EAST BAY REG PARK DIST

ED ALLEN

STAN ALLEN
PACIFIC STATES MARINE FISHERIES COMMISSION

MICK ALLEN
LOUISIANA-PACIFIC CORP

EMILY ALMA
STREAMINDERS

ASSEMBLYWOMAN ELAINE ALQUIST
STATE CAPITOL

FRANK ALVAREZ

ANTHONY AMBROSE

JAY AMIN
INTERNATIONAL PAPER

JENNIE AMISON
SAN DIEGO ST UNIV FOUND

MRS B AMOROSO

NICK ANASTE
NAPA VALLEY COLLEGE

BOB ANDERSON
UNITED WINEGROWERS FOR SONOMA COUNTY

SHANNAH ANDERSON
AQUATIC OUTREACH INSTITUTE

CRAIG ANDERSON
LAND PARTNERS THROUGH STEWARDSHIP (LANDPATHS)

KEITH ANDERSON
SANTA CLARA CO STREAMS FOR TOMORROW

BOB ANDERSON
NORTHCOAST SALMON HABITAT REST GROUP

DAVID ANDERSON
REDWOOD NATL PARK

BERT J ANDERSON

DAVID ANDERSON
EUREKA TIMES STANDARD

KEN ANDERSON
CALIFORNIA DEPARTMENT OF FISH AND GAME

MARK ANDERSON
STATESIDE ASSOCIATES

ROSS ANDRESS

GREGORY ANDREW
MARIN MUNICIPAL WATER DIST

BETTY ANDREWS
PHILIP WILLIAMS & ASSOC

ORO MADRE BASS ANGLERS

ANJANETTE
NORTHERN CALIF WATER ASSN

DAVID ARANDA
STALLION SPRING COMM SVCS DIST
ANDREA ARENOVSKI
QUESTA ENGINEERING CORP

MARCIA ARMSTRONG
SISKIYOU COUNTY FARM BUREAU

RADHA ARMSTRONG

BILL ARNOLD
INTER-FLUVE INC

ASSEMBLYWOMAN DION ARONER
STATE CAPITOL

MARCIA ARRANT
CALIFORNIA DEPT OF TRANSPORTATION

RAYMOND ARTIST
BARD RCD

TIM ASH
CAL TRANS

EVELYN E ASHLEY

RIECHERS SPENCE & ASSOC

MEADOWBROOK CONSERVATION ASSOC

PIERCY WATERSHED ASSOC

SHASTA CASCADE WONDERLAND ASSOC

TOM HESSELDENZ & ASSOC

SAN LUIS OBISPO SPORTSMENS ASSOC

CARLENZOLI AND ASSOCIATES

KEVIN WOLF & ASSOCIATES

WALLACE-KUHL & ASSOCIATES

URIBE & ASSOCIATES

HARDING LAWSON ASSOCIATES

BSK & ASSOCIATES

KLEINFELDER & ASSOCIATES

WILDAN ASSOCIATES

NASH RANCH ROAD ASSOCIATION

LOYOLA LODGE ASSOCIATION

GREENWOOD WATERSHED ASSOCIATION

PAMELA ATKINS
CONERSTONE STUDIOS INC

BARBARA BARRETT ATTORNEY

RENE ATWATER
DAMES & MOORE

ERIC AUSTENSEN
SURFRIDER FOUND SONOMA CO CHAP

PAUL AVERY

BRANDON AXELL
HOOT OWL CREEK VINEYARDS

ED AYERS
TURLOCK SPORTSMENS CLUB

JOHN AZEVEDA
US ARMY CORPS OF ENGINEERS

RHONDA AZEVEDO

AL BABICH
SHELDON BACHUS
CALTROUT

CARTER BEHNKE OGLESBY & BACIK

JOHN BACKSTROM
SANTA CRUZ CO BD OF SUPVSRS

BONNIE BACON

BOB BADARACCO
DEPT OF GEN SVCS SLO COUNTY

BARBARA BAER

ART BAGGETT
SWRCB EXECUTIVE OFFICE

KRISTIN BAIL
BUREAU OF LAND MANAGEMENT

LAURA BAILEY
YOLO CO SUPT OF SCHOOLS

LINDA BAILEY

GARY BAILEY
RECLAMATION DISTRICT 1004

RICHARD BAILEY
LAKE MERRITT INST

CATHY BAILEY

STEVEN MC BAIN
LA DEPT OF WATER & POWER

ROBERT BAIOCCHI, CA SPORTFISHING PROTECTION ALLIANCE

A BAIRD
AM BAIRD ENGINEERING

TRAVIS BAKER

COLLEEN BAKER
SISKIYOU CO BD OF SUPERVISORS

TERRY BAKER
AKER ENVIRONMENTAL

JODI BALCOM
EDAW INC

TOM BALL
ETNA HIGH SCHOOL

BETTY BALL
MENDOCINO ENVIRONMENTAL CENTER

JAN BALL
FT JONES ELEMENTARY SCHOOL

THOMAS E BALLARD
APEX ENVIORTECH INC

JOHN BALLESTIN
SHASTA RIVER WATER ASSN

HISAM BAQAI
RWQCB LAHONTAN REGION

ALAN BARACCO
DEPT OF FISH AND GAME

TERI JO BARBER
RIDGE TO RIVER

TERI JO BARBER
BIOENGINEERING INSTITUTE

TERRY BARBER, SISKIYOU COUNTY HEALTH DEPARTMENT

CAROLYN BARBULESCO
RUSSIAN RIVER BULLETIN

LARRY BARCLAY
SALMON TROLLERS MARKETING ASSOC INC

LARRY BARCLAY, SALMON RESTORATION ASSOC OF CA INC

LOIS C BARCLAY

DAVID BARKER
RWQCB SAN DIEGO REGION

RON BARKSDALE
CLOVIS BASS CLUB

DARRYL L BARNES, DIRECTOR
CITY OF UKIAH PUBLIC UTILITIES

DEBORAH BARNES
CAL/EPA GENERAL COUNSEL

STEVE BARNETT
PTI ENVIRONMENTAL SERVICES

GLORIA BARNWELL

MARY L BARR
PACIFIC GAS & ELECTRIC

MEADOW BARR

TRACY BARREAU
STATE HEALTH

PHIL BARTHOLOMEW
DEPT OF FISH AND GAME

BOB BARTHOLOMEW
SHASTA VALLEY RCD

MARK H BARTHOLOMEW
US ARMY CORPS OF ENGINEERS

REDDING BASSERS

GREGG BATES
DRY CREEK CONSERVANCY

KEN BATES
CLOUDBURST FISHING COMPANY

DON BAUDERS
DELTA BASSMASTERS

JASON BAUER - ALG

BILL BAXTER
FORESTRY & FIRE PROT

THE HUMBOLDT BEACON

JIMMIE-FAY BEAL

ALAN BEAVIN

WILLIAM BECHUM
CALIFORNIA COASTAL COMMISSION

DIANE BECK

NICOLE G BECK
SWANSON HYDROLOGY

TOM BECKER
THE HARLAND LAW FIRM

SUE BECKER, USFS MODOC
NATIONAL FOREST SERVICE

LANA BECKETT
ENVIRONMENTAL AFFAIRS GROUP

STEVEN BECKLEY
CALIFORNIA FERTILIZER ASSOCIATION

DAVID S BECKMAN, NATURAL
RESOURCES DEFENSE COUNCIL

JOHN BEEMAN

JOHN BELL, CA INTEGRATED
WASTE MANAGEMENT BOARD

CRAIG BELL
MENDOCINO WATERSHED SERVICE

CRAIG BELL
GARCIA RIVER WTRSHD ADVISORY GRP

CRAIG BELL
SRF/NCARG/MCF&GC

CAROLYN BELL

ELENA BELSKY

AL BELTRAMI
MENDOCINO COUNTY EMPLOYERS
COUNCIL

BILL BEMIS
USFS HAPPY CAMP ROAD

JIM BENEDICT
SANTA MONICA MTNS NATL REC AREA

CAROL BENFELL
PRESS DEMOCRAT

NATHAN BENJAMIN
NORTHCOAST ENVIRONMENTAL CENTER

ERIKA BENNETT
MICHAEL BRANDMAN ASSOCIATES

ERIKA BENNETT
MICHAEL BRANDMAN ASSOC

ROB BENSON
DEPT OF FISH AND GAME

RANDAL BENTHIN
DEPT OF FISH AND GAME

JACK BENTLEY

VILMOS AND MARTA BERES

DARRIN BERGEN

TIM BERGER
VERSAR INC

MARK L BERGSTROM
CALIFORNIA TROUT

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JEREMIAH SIEM

ILAN SILBERSTEIN

REBECCA SILVA, GEOCON

CHRIS SILVA, CLEMENT
FITZPATRICK & KENWORTHY

CITIZENS ADVOC FOR PRES OF ST
VINCENT/SILVEIRA

JACK SILVER
NCRW

MARK SILVERSTEIN
ELKHORN SLOUGH

ASSEMBLYMAN JOE SIMITIAN
STATE CAPITOL

DOUG SIMMONDS

BOB SIMMONS
MENDO BASSERS BASS CLUB

PAULINE SIMON
SFSU OFF OF RES & SPONS PROJ

KAYDEE SIMON
LEGACY-THE LANDSCAPE CONNECTION

DONALD S SIMON
ATTORNEY-AT-LAW

SABRINA SIMPSON
STILLWATER SCIENCES

DAVID SIMPSON, MILL CREEK
WATERSHED CONSERVANCY INC

Y J SIMPSON

HAROLD SINGER
RWQCB LAHONTAN REGION

GLENN SINGLEY
LA DEPT OF WATER & POWER

RICHARD C SLADE
RICHARD C SLADE & ASSOCIATES

ANNE SLATTERY
NO COAST CHALLENGE NETWORK

SCOTT SLAYTON

GEORGE SLIGHT
S&S CONSTRUCTION

DENNIS SLOTA
MENDOCINO CO WATER AGY

LYNN SMALL, CITY OF SANTA ROSA
LAGUNA TREATMENT PLANT

KEVIN SMEAD
TETSON ENGINEERS INC

MARK G SMELSER
WILLIAM COTTON & ASSOC

DAVID SMERNOFF
NASA - AMES RESEARCH CTR

ROBIN SMITH
MINARETS/MARIPOSA RANGER DISTRICT

DECKER W SMITH

RON SMITH
NATIONAL PARK SERVICE
POINT REYES NATIONAL SEASHORE

JERRY SMITH
SAN JOSE STATE UNIVERSITY

RICHARD SMITH
WEST LAKE RCD

STEVEN SMITH

BERN SMITH
TRUST FOR PUBLIC LANDS

SUPERVISOR TIM SMITH, SONOMA
COUNTYBOARD OF SUPERVISORS

MATT SMITH
NORTH COAST FISHERIES

F SMITH
RICHMOND ROD AND GUN CLUB

TREVOR SMITH, ROBERT BEIN
WILLIAM FROST & ASSOCIATES

KATHLEEN SMITH

DEBBIE SMITH
RWQCB LOS ANGELES REGION

PEGGY SMITH

CHRIS SMITH, ACADEMY
ENVIRONMENTAL CONSULTANTS

JOHN SMOOT

HOPE SMYTHE
RWQCB SANTA ANA REGION

DAVE SNETSINGER

CHRISTOPHER SNIPES
NATIONAL MARINE FISHERIES SERVICE

BOB SNYDER
DEPT OF FISH AND GAME (5)

MARK SNYDER
SAN MATEO CO MEMORIAL PARK

JANA SOKALE, PARKS DIV
CITY OF MOUNTAIN VIEW

PATRICIA M SOLEM

DAVE SOLEM
KLAMATH IRRIGATION DISTRICT

WD BILL SOLINSKY

FRANK AND DEAN SLOLINSKY

BOB SOLOTAR
LEVINE FRICKE

TRACY SOLUM

SARI SOMMARSTROM

SARI SOMMARSTROM

VIC SOOHODOLSKY

TONY SORACE

JESS SOUZA
WESTERN SHASTA RCD

JEFF SOUZA
AGRIBUSINESS INSTITUTE

RD SOWERS
TABER CONSULTANTS

TRUDY RILLING SCI ED SP
SISKIYOU CO OFFICE OF EDUCATION

JODY SPARKS
TOXICS ASSESSMENT GROUP

JEAN SPATH
RWQCB - REG 1

DAVE SPATH, CA DOHS OFFICE
DRINKING WATER

SPAWN

JIM SPEAR
NAT RES CONS SERVICE

SENATOR JACKIE SPEIER
STATE CAPITOL RM 2032

RYAN SPENCER
VIRGINIA STROM-MARTIN'S OFFICE

DEANNA SPOONER
PACIFIC RIVERS COUNCIL

ORGANIZED SPORTSMEN

DONA SPRING

HENRY C BAKER SR

ROXANNE STACHON

BRENDA STADNIK

GLEN STAILEY
VISALIA BASS CLUB

JERRY STALEY
DEPT OF FISH AND GAME (5)

RICHARD C STALLMAN

STACEY STANISH

BRIAN B STARK
LAND CONS OF SAN LUIS OBISPO CO

HONORABLE FORTNEY PETE STARK

DIANA STEELE, TOWN OF
WINDSOR PUBLIC WORKS DEPT

DOUG STEELMAN
VISALIA SPORTSMENS ASSOC

JOHN STEERE
COASTAL CONSERVANCY

SCOTT STEEVER
LANAHAN & REILLEY LLP

SCOT STEGEMAN

RICHARD STEIN
HUMBOLDT CO DEPT OF PUB WKS

PARK STEINER
STEINER CONSULTING

TODD STEINER, TURTLE ISLAND
RESTORATION NETWORK

W PARK STEINER
STEINER ENVIRONMENTAL CONSULTING

TED STEINHARDT
FORT BRAGG CITY OF

RANDY STEMLER
REDWOOD COMMUNITY ACTION AGENCY

JANINE STENBACK
RESOURCES AGENCY

ANNE STEPHENS
BIDWELL JR HIGH SCIENCE DEPT

TOM STEPHENS
STEPHENS TECHNICAL SERVICE

BEN STEPLETON, SANTA CRUZ COUNTY HEALTH DEPARTMENT
GUS STEPPEN
TETRA TECH

CHERYL STEVENS

JENNIFER STEVENSON

LYNN STEVENSON, US ARMY CORPS OF ENGINEERS SACRAMENTO DIST

MARTY STEVENSON
KINNETIC LABORATORIES INC

WANDA STEWART
POWER PERSONNEL

LEONARD STEWART

LORRAINE STEWART
KAHL ASSOCIATES

JESSE STOCKHAM

TOM STOKELY, TRINITY COUNTY PLANNING DEPARTMENT

TOM STOKELY

J STONE

DONNA STONEMAN
STONEMAN FORESTRY SERVICES

LARRY STORNETTA

PHIL STRAND
MARIPOSA/MINARETS RD

KAY STRICKLAND

ASSEMBLYMEMBER STROM-MARTIN
ASSEMBLY CALIF LEGISLATURE

ASSEMBLYWOMAN VIRGINIA STROM-MARTIN
CAPITOL OFFICE

CARL STROMBECK

F ROBERT STUDDERT

PAUL A STUDEMISTER
THE BENTLEY COMPANY

JEFF STUMP
COASTAL COMMISSION

BILL STURGEON

GENE SUEMNICHT
KLEIFELDER INC

PATRICIA SULLIVAN
PACIFIC GAS & ELECTRIC

KEVIN SULLIVAN
GROUNDWATER TECHNOLOGY INC

JOHN AND CHERYL SUNDBERG

ERIC SUNSWHEAT

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DEPT OF PARKS & REC BAY AREA DIST

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SHASTA-TRINITY NATIONAL FOREST

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SISKIYOU COUNTY BOARD OF SUPERVISORS

SAN BENITO CO BD OF SUPERVISORS

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SANTA BARBARA CO BD OF SUPERVISORS

CONTRA COSTA CO BD OF SUPERVISORS
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LOS ANGELES CO BD OF SUPERVISORS

MENDOCINO CO BD OF SUPERVISORS

SONOMA CO BD OF SUPERVISORS

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ALAMEDA CO BD OF SUPERVISORS

VENTURA CO BD OF SUPERVISORS

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MENDOCINO REDWOOD CO

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C/O MENDOCINO REDWOOD

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TONY SVEJAR
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FRED SWEEZER

BOB SWIFT
SONOMA CO ENVIR HEALTH DEPT

ZENO SWIJTINK, ATASCADERO CREEK AND GREEN VALLEY CREEK WATERSHED

LEANDRA SWINT
SO SONOMA CO RCD

DR ZENO G SWITJINK,
ATASCADERO & GREEN VALLEY CREEKS WATERSHED COUNCIL

BILL TAGGART
TRINITY CO DOT

LOUANN TALBERT

BRIAN TALBERT

MOLLY TALLMON
MICHELE TARKINGTON, KAISER FOUNDATION HEALTH PLAN INC

THOMAS TATE

KEN TATE
UC DAVIS COOPERTIVE EXT

MARGARET TAUZER, NMFS

ROSS TAYLOR
ROSS TAYLOR & ASSOC

BRUCE TAYLOR
LAKE MERRITT INSTITUTE

TOM TAYLOR
TRIHEY & ASSOC

WALNUT CREEK CA 94596-3807
ROSS TAYLOR

LYN TAYLOR
ECOLOGY CENTER

VINCE TAYLOR

COTTONWOOD BASS TEAM

ANNE TEAMES

STEPHANIE TEBBUTT
LAND AND PLACE

EVAX TECHNOLOGIES

AQUA TERRA TECHNOLOGIES

JULIE TELL

SYD TEMPLE
QUESTA ENGINEERING

SUE TERENCE, BUTLER CREEK

MICHAEL THABAULT, NMFS

DON THIBODEAU

RICK THOMAS, LEGACY/LDP

ROY THOMAS
CARMEL RIVER STEELHEAD ASSN

BILL THOMAS, MARINE BIOCHEMISTS OF CALIFORNIA INC

RICHARD D THOMAS

MICHAEL THOMAS
RWQCB CENTRAL COAST REGION

CONGRESSMEN THOMPSON

ANNETTE THOMPSON, GOLDEN WEST WOMEN FLY FISHERS FOUND

JIM THOMPSON
DEPT OF FISH AND GAME

HONORABLE MIKE THOMPSON

GLENN THOMPSON
BLAKELEY ENVIRONMENTAL

ASSEMBLYWOMAN HELEN THOMSON
STATE CAPITOL

BRYAN THURMOND
MOAT CREEK MANAGING AGENCY

EMILY TIBBOTT
THE NATURE CONSERVANCY

LESLIE TIFF
JEFFERSON HIGH SCHOOL

BRIAN TILLEMANS
LADWP

TIMES-STANDARD

ROBERT TIMM
HOPLAND FIELD STN DIV OF AG

JIM TIMMONS

DAVE TINKER
CORNING HIGH SCHOOL

JIM TISCHLER
REDWOOD EMPIRE TROUT UNLIMITED

STEPHANY TOM
CALIFORNIA DEPT OF FISH AND GAME

SAM TOPLISS

SENATOR TOM TORLAKSON
STATE CAPITOL RM 2068

JAMES P TOUCHSTONE

DUANE TOUTJIAN

MRS P TOUTOLMIN

PETE TOVIA
CAMP DRESSER & MCKEE INC

PETER TOWNLEY
SHASTA VALLEY RCD

BILL TOWNSEND
UKIAH ROD AND GUN CLUB

BILL TOWNSEND

ROB TOWNSEND
WOODMAN CREEK ASSOC

PAM TOWNSEND, ENDOCINO COUNTY PLANNING AND BUILDING DEPT

STEVE TRAFTON
TROUT UNLIMITED

CALIFORNIA DEPARTMENT OF TRANSPORTATION

BRIAN TRAUTWEIN
ENVIRONMENTAL DEFENSE CENTER

DELL TREDINNICK
CITY OF SANTA ROSA UTILITIES DEPT

TIM TREICHELT, GEORGIA-PACIFIC CORPORATION - GOV AFFAIRS

DIANNE TREICHLER
BETH TREMAIN
MONTGOMERY/WATSON

THOMAS M TRENT

E WOODY TRIHEY
TRIHEY & ASSOC

MICHAEL TRIMNELL

PACIFIC FOREST TRUST

PACIFIC FOREST TRUST

PAUL TSCHIRKY
C/O BENNIE TSCHIRKY

ROBERT TUCKMAN
HOLME ROBERTS & OWENS

ED TUNHEIM

JOHN TURNER
DEPT OF FISH AND GAME

MICHAEL TURNICK

DON TUTTLE
HUMBOLDT CO DPW

ELINOR G TWOHY

TOM TYLER
FRIENDS OF THE SAN LEANDRO CR

BLAKE & JILL TYRRELL

MIKE UENGUREANU
ROAYSPAR CONSTRUCTION CO

S UGANDA

L ROBERT ULIBARRI
VISIONS ENTERPRISES

MIKE UMBRELLO
ELEM INDIAN COLONY

DOCUMENTS UNIT
COSTA COUNTY LIBRARY

BASIN PLANNING UNIT
SWRCB

RAY UTTERBACK

THOMAS R VADON

LINDA VANCE, RANGELAND
WATERSHED PROG, DEPT OF
AGRONOMY/RANGE SCI

CHERYL VANDEVEER

DAVID VANICEK
CSU SACRAMENTO

SENATOR JON VASCONCELLOS
STATE CAPITOL

PATRICK VAUGHAN
CA DEPT. OF PARKS & RECREATION

HARRY VAUGHN, PCFFA
EEL RIVER SALMON RESTOR PROJ

KIRK VEALE
VEALE INVESTMENTS

ALEX VEJAR
DEPT OF FISH AND GAME

MARY VERKE

VICKI VERLEY, USDI FISH &
WILDLIFE SERVICE - TULELAKE

JULIE VERRAN
INDEPENDENT COAST OBSERVER

ANDREW VESSELINOVITCH
TRUST FOR PUBLIC LANDS

MARK VEST, CA DEPT OF
TOXIC SUBSTANCES CONTROL

VICTOR
SONOMA COUNTY WATER AGENCY

RENEE VICTORIA, INFORMATION
CENTER FOR THE ENVIRONMENT

RWQCB LAHONTAN REGION
VICTORVILLE

PATTY VIDA, DOWNEY BRAND
SEYMOUR & ROHWER

JUDITH VIDAVER
FRIENDS OF TEN MILE

JUDY VIDAVER
SIERRA CLUB REDWOOD CHAPTER

TIM VIELS
NATIONAL RESOURCES CONSERVATION
SERVICE

JULIA VIERA
FRIENDS OF ISLAIS CREEK

JOSHUA VIERS, INFORMATION
CENTER FOR THE ENVIRONMENT
DAVIS

MICHELLE VIKUPITZ
LARRY WALKER ASSOCIATES INC

NICK VILLA
DEPT OF FISH AND GAME (5)

TONY VILLA
CLOVERDALE CITY OF

JIM VILLEGAS
MODOC NATL FOREST DOUBLEHEAD RD

JIM VILLEPONTEAUX
SALMON RIVER REST COUNCIL

JOAN VILMS

JOAN VILMS
FRIENDS OF THE RUSSIAN RIVER

MANNY VINCENT
TULARE BASTARDS SPORTSMENS CLUB

UNIVERSITY OF VIRGINIA
LAW LIBRARY

FRAN VITULLI

SWRCB OLPA 4TH FLOOR

MARK VOGEL
ROOKS & VOGEL

STEPHEN C VOLKER
SIERRA CLUB LEGAL DEFENSE FUND

JANE VORPAGEL
CA DEPT OF FISH & GAME

ALEX VOSHER

SCOTT VOURI
PROTECT OUR WATER RESOURCES

TRUEMAN VROMAN
VROMAN ENGINEERING

SONJA WADMAN, FRIENDS OF FIVE
CREEKS/URBAN CR COUNCIL

BRIAN WAGGONER
MENDOCINO COAST ENV CENTER
TERRY WAGNER

CYNDIE WALCK
DEPT OF PARKS & REC SIERRA DIST

JIM WALDVOGEL
SMITH RIVER ADVISORY COUNCIL

JIM WALDVOGEL
SEA GRANT ADVISOR

LISA WALKER

TED WALKER
SONOMA CO ENVIR HEALTH DEPT

HAL WALKER
IT CORP

SHAEM WALKER-ROSE
SF TRINITY RIVER LAND CONS

WENDY WALL
SALMON RESTORATION ASSOC

KEVIN WALSH

VIRGINIE H WALSH

RICK WANTUCK
NMFS

DAN WARD
CALIFORNIA TROUT

CASIDY WARD

KIM WARD

CLAUDE WARDEN
DIABLO VALLEY FLY FISHERMAN

RON WARNER, CA DEPARTMENT
OF FISH AND GAME

GARY WARNER
KIDDER CREEK OUTDOOR SCHOOL

PHIL WARNER
DEPT OF FISH AND GAME (5)

LINDA WARREN
ROBERT WARREN CONSTRUCTION

ROBERT WARREN

LONNIE WASS, RWQCB
CENTRAL VALLEY REGION FRESNO

BEV WASSON
REGIONAL WATER BOARD MEMBER

RAY VAN DE WATER, REDWOOD COAST
LANDS CONSERVANCY

LAWYERS FOR CLEAN WATER

GEOFFREY W WATKIN
JACOBS ENGINEERING GROUP INC

GEOFFREY W WATKIN
JACOBS ENGINEERING GROUP INC

ROD WATKINS
BIG BEAR COMM SVCS DIST

JOHN WATKINS

STANISLAUS FLY FISHERMEN INC

DAN WATSON
CITY OF SAN JOSE

JARVIS WATSON
METCALF & EDDY

MECA WAWONA
GREENFIELD RANCH ASSN

MECA WAWONA

HAGANS / WEAVER
PACIFIC WATERSHED ASSOC

ART WEBER

BUTCH WECKERLY
HOPLAND FIELD STN DIV OF
AGRICULTURE

LARRY WEEK
DEPT OF FISH AND GAME (5)

LARRY WEEK
CALIF DEPT OF FISH & GAME

RIXANNE WEHREN
COASTAL LAND TRUST

RIXANNE WEHREN
COASTAL LAND TRUST

RIXANNE WEHREN
COASTAL LAND TRUST

DON WEIDLEIN
DEPT OF FISH AND GAME (5)

SHUTE MIHALY & WEINBERGER

ROBERT WEIR

MIKE WEISE

LARRY WEISE
ENTRIX INC

DEREK WELLER
LANAHAN & REILLEY LLP

KEN WELLS, SONOMA COUNTY
DEPARTMENT OF PUBLIC WORKS

STEVE WERNER, CALIFORNIA
DEPARTMENT OF TRANSPORTATION

TOM WESELOH

JACK WEST
USFS KLAMATH NATL FOREST

JOHN WEST

DOUG WEST
UNITED WATER DIST

BOB WEST

INTERMOUNTAIN WEST

MR & MRS PHILIP WESTDAHL

RICHARD WESTON
HIGHLANDS ACRES RANCH

JOE CECH DEPT WFCB
UC DAVIS

JOHN J WHEELING

MARK WHEETHAM
COASTAL CONSERVANCY

MARK E WHEETLEY
CA COASTAL CONSERVANCY

MARK E WHEETLEY
CALIFORNIA COASTAL CONSERVANCY

JIM WHELAN
DEPT OF FISH AND GAME

THOMAS L WHITCHURCH
CIVIL ENGINEER

MORROW WHITCOMB
MONTEREY BAY SALMON AND TROUT PROJ

SANDY WHITE

DENNIS WHITE

MIKE WHITE
CONSERVATION BIOLOGY INSTITUTE

SEAN WHITE
SONOMA CO WATER AGENCY

JOE WHITE

MARIE WHITE

MIKE WHITE
ERC ENVIRONMENT

JOHN WHITE

VICKI WHITING
ADOPT A WATERSHED

LAYNE WHITLEY
WATERSHED COORDINATOR

CHUCK WHITLOCK

WAYNE WHITLOCK
PILLSBURY MADISON & SUTRO

BOB WHITNEY

ARNOLD WHITRIDGE
TRINITY CO PLANNING

DEREK WHITWORTH
CA DEPT OF TOXIC SUBSTANCES CONTROL

SUSAN WICKHAM
QST ENVIORNMENTAL

RUSS WICKWIRE
DEPT OF FISH AND GAME

TONY WIEGNER

ASSEMBLYWOMAN PATRICIA WIGGINS
STATE CAPITOL

BLM DEPT. OF WILDLIFE

BOB WILKINSON

ROBERT WILL
LITTLE NORTH FORK RANCH

BOB WILL
ROWDY CREEK FISH HATCHERY

JEFF WILLETT
CAMP DRESSER & MCKEE INC

RICHARD WILLIAMS
DRS MARINE

KERRY WILLIAMS
SOTOYOME RCD

SUSAN WILLIAMS
EAST BAY REGIONAL PARK DIST

LAYMON R WILLIAMS

JOHN WILLIAMS

TERRY WILLIAMS, PACIFIC GAS &
ELECTRIC
HUM BAY POWER PLANT

JOHN WILLIAMS
THPOINT PARKWAY

DARRELL WILLIAMS
JH BAXTER & COMPANY

BILL WILLIAMSON
SANTA CRUZ CO PUB WORKS DEPT

MIKE WILLIAMSON
SALMON RESTOR ASSN OF CA

GEORGE WILLIAMSON
PLANWEST

SARA WILLIS
SAN JOSE STATE UNIV FOUNDATION

TWILA WILLIS-HUNTER
SANTA MONICA BAY RESTORATION PROJ

BURCE WILMES
SYAR INDUSTRIES

CHARLES WILSON

CARREN WILSON
SCOTTS CREEK WATERSHED COUNCIL

CRAIG WILSON
SWRCB OFFICE OF THE CHIEF COUNSEL

BEVERLY WILSON
TRINITY RIVER LUMBER COMPANY

TED WINFIELD
ENTRIX INC

MICHAEL WINN
PATTERSON ACADEMY

RICHARD E WINNIE

MARTY WINSTON, LAKE COUNTY
ENVIRONMENTAL HEALTH
DEPARTMENT

FARRELL WINTER

ALAN & SUSAN WINTERMEYER

ROANNE WITHERS
MENDOCINO COASTWATCH

JAKE WITTWER
ORLEANS ROD AND GUN CLUB

ALAMEDA CO PUB WKS

PATRICIA WOLF
DEPT OF FISH AND GAME

DEAN WOLFE
BECHTEL ENVIRONMENTAL INC

GEORGE WOLFF

DAVID WOLFF
EIP ASSOCIATES

LESLIE WOLFF
NATIONAL MARINE FISHERIES SERVICE

WAYNE R WOLSKI
BELDEN ABBEY WEITZENBERG & KELLY

JOHN WONDELLECK
CAMP DRESSER & MCKEE

DARRELL M WONG
DEPT OF FISH AND GAME REG 5

HAL WOOD
RUSSIAN RIVER UTILITY WATER
SYSTEM

TALMADGE WOOD

ROBERT E WOODCOCK

JAN WOODRUFF
DOCUMENT RESEARCH

KEITH WOODS
NORTH COAST BUILDERS EXCHANGE

LYNN WOOLSEY
US CONGRESS HOUSE OF
REPRESENTATIVES

HONORABLE LYNN WOOLSEY

J WORRELL

JAMES L WORTHEN

PETER WRIGHT
ETNA ELEMENTARY SCHOOL

KRISTI WRIGLEY
ELK RIVER WATERSHED CONSERVANCY

KRISTI WRIGLEY

LILIANA CHRISTOPHE WTR-4
US EPA REGION IX WATER
MANAGEMENT DIV

BOB WUNNER
TWIN PARKS LUMBER CO

PHIL WYELS
SWRCB OFFICE OF THE CHIEF COUNSEL

KAREN WYETH

FRIENDS OF THE NAPA RIVER

CHERYL WYSOCKI

MIKA YAMAMOTO
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BRELJE & RACE CONSULTING

TOM YARISH
FRIENDS OF THE ESTERO

LINDA YATES

JT YEAN
FUSCOE ENGINEERING

SIG YEARLING

RICHARD L YODER

PAULA YOON
FISHERIES FOCUS

PAULA YOON
HUMBOLDT FISH MARKETING
ASSOCIATION

GLENN YOSHIOKA

JEFF YOUNG

ERICA YOUNG

TOBIAS YOUNG

DEBORAH YOUNKIN
MARINWOOD COMM SVCS DIST

GEORGE YPSILANTIS
MERG

BRUCE YUHASZ
FORESTRY & FIRE PROT

THE ZAHAROFFS

ELLIOT ZAIS, OREGON
DEPARTMENT OF ENVIROMENTAL
QUALITY

DAVE ZAPPONI
KLAMATH WATER USERS ASSOCIATION

DEENA ZARLIN
MENDOCINO UNIFIED SCHOOL DIST

ROBERT ZATKIN

PAUL ZEDONIS
USDI FISH AND WILDLIFE SERVICE

STEVE ZEMBSCH
WATERSHED SCIENCE

DAVID ZINNIEL
ZINCO CO

ROSE ZOIA
BRANDT-HAWLEY & ZOIA

SETH ZUCKERMAN

LINDA ZUKOWSKI

JOSEPH ZUSTAK
USFS

ROGER ZWANZIGER
SISKIYOU COUNTY BOARD OF
SUPERVISORS

FISH/ HYDROLOGY, (2), SIX RIVERS
NATL FOREST LWR TRINITY RD (5)

CAROL BORDIN (2)
LAKE CO DEPT OF PUB WRKS
FLOOD & LAKES MGMT DIV

ALISTAIR BLEIFUSS (5)

MR PETE PHILLIPS (A-43)
CALIF DEPARTMENT OF FISH AND GAME

DEPARTMENT OF FISH AND GAME-
REGION 1

WARREN A SMITH 251/10
OPTICAL COATING LABORATORY INC

STEVE JONES 1516-38
FORESTRY & FIRE PROT (10)

HOWARD E WHITNEY #HG 193
REMEDIATION TESTING AND DESIGN

CHAR KEMPERS 2USN
HEWLETT-PACKARD COMPANY

ULTRAPOWER 3

HUNTER AND FISHERMENS
BETTERMENT A

APPENDIX A3

Newspapers that Published the Public Notice

NEWSPAPERS THAT PUBLISHED THE COHO SALMON NORTH OF SAN FRANCISCO LEGAL NOTICE

Publication	Date Published
The San Jose Mercury News	**August 16, 2001**
The Press Democrat	**August 15, 2001**
The Times-Standard	**August 14, 2001**
The Siskiyou Daily News	**August 15, 2001**

APPENDIX A4

Press Release

July 24, 2001
NEWS RELEASE FOR IMMEDIATE RELEASE 01:061

Contact: Dennis McEwan, Environmental Specialist, (916) 327-8850
Joe Pisciotto, Associate Biologist, (916) 324-6902

DFG to Review North State Coho Salmon for CESA Listing

The California Department of Fish and Game (DFG) announced it will commence a status review of the coho salmon that inhabit coastal streams from San Francisco Bay north to the Oregon border to determine whether to recommend the popular commercial and sport angling fish for listing as endangered under the California Endangered Species Act (CESA). The year-long status review will solicit biological information and public comment from a variety of sources to help develop the basis for DFG's conclusions.

The review process began in April when the California Fish and Game Commission (Commission) accepted for consideration a petition from the public to list the north state coho salmon, also known as silver salmon, as endangered. Once the Commission accepted the petition for consideration, coho salmon became a candidate species under the provisions of CESA and DFG was required to undertake the status review. DFG has until April 2002 to present its report and its recommendations to the Commission, which will then make the decision to list the fish or not, and at which category, threatened or endangered.

This week, DFG mailed public notices that announced to various constituents and interested parties that the status review has begun. The notice also contains a solicitation for information and comments that will assist in the review. Responses must be received by August 31, 2001 to be considered in the final report to the Commission.

Information and comments should be sent to:

California Department of Fish and Game
Native Anadromous Fish and Watershed Branch
1807 13th Street, Suite 104
Sacramento, CA 95814
Attention: Coho Status Review

Coho salmon were once a popular commercial and sport angling fish in California. They are found in coastal streams from the Oregon border south to Santa Cruz County. The decline of California populations of coho salmon in recent years has resulted in severe restrictions on commercial and recreational fishing. In 1995, the Commission listed coho salmon that inhabit streams south of San Francisco as state-listed endangered. All California populations of coho salmon are listed as threatened under the federal Endangered Species Act.

[Copy of the Public Notice attached]

APPENDIX A5
Letter to Scientific Collecting Permit Holders Soliciting Information

September 24, 2001

Dear Scientific Collector:

You are being contacted to request your assistance. The California Fish and Game Commission is considering listing coho salmon in California under the California Endangered Species Act. The decision reached will be based in large part on recommendations made to the Fish and Game Commission by the Department of Fish and Game. In order to make these recommendations, we need as much information as we can obtain, from all available sources, on coho salmon. The information you provide will help us to make the best possible recommendations to the Fish and Game Commission with respect to protection of coho salmon.

Our records indicate that your collecting activities may take place or have taken place in inland waters where anadromous salmonids occur. Because of this, and pursuant to terms of your Scientific Collecting Permit, we are requesting that you provide the Department of Fish and Game information regarding collections you have made. Specifically, we request any and all information that you have collected pertinent to coho salmon inhabiting inland waters north of, and including, San Francisco Bay and tributaries. This includes observations that may have been made during collecting activities where coho salmon were not the object of your collecting efforts.

If you have collected information pertinent to coho salmon north of the Golden Gate, please provide this information to us no later than October 15, 2001. The information should be sent to:

Mr. Joseph Pisciotto
Native Anadromous Fish and Watershed Branch
1807 13th Street, Suite 104
Sacramento, California 95814
phone (916) 324-6902
e-mail jpisciotto@dfg.ca.gov

If you have questions regarding this request, please contact Mr. Harvey Reading at (916) 654-6505.

Thank you for your assistance and cooperation in this matter. We look forward to our continuing partnership with scientific collectors in California.

Sincerely,

Larry Week, Chief
Native Anadromous Fish and Watershed Branch

APPENDIX A6
Scientific Collecting Permit Holders Contacted for Coho Salmon Data

1999 PERMITS

Anthony J. Keith	Anna M. Roche	Alan Young
Brent B. Bridges	Bradley Cavallo	Brian Cypher
Bonnie Grey	Bruce G. Halstead	Bryan Kawakami
Bradley Straatman	Bradley E. Valentine	Barbara K. Whitmore
Brian D.C. Williams	Bryan J. Young	Colin W. Anderson
Charles D. Chamberlain	Christine M. Champe	Chris W. Conard
Carey E. Cooper	Craig A. Fleming	Christopher S. Gaither
Christine K. Gemperle	Christopher Hooton	Chris F. Howard
Charles Liston	Christopher M. Peregrin	Casey L. Ralston
Craig P. Seltenrich	Curtis E. Steitz	Camm Churchill Swift
Curt Uptain	Christine L. Van Horn Job	Christa L. Zwieg
Donald W. Alley	David R. Casper, D.V.M.	Donald W. Faris
David D. Fuller	Donald Gallardo	Darcy Gordon
Dennis P. Halligan	Don Harding	David E. Hinton
Daniel W. Lantz	David R. Longanecker	David J. Manning
David L. Mayer	Dee R. McClanahan	Deborah R. McEwan
Diane S. Moore	David S. Nieman	Dirk Pedersen
Douglas C. Rischbieter	David D. Salsbery	David A. Vogel
David Wrobel	David Zajanc	Ethan Bell
Elaine Esteban	Ellen Fermanis	Erik R. Helgoth
Eliza M. Sater	Erin L. Sauls	Edward Seidel
Erik A. Tynes	Edward D. Weber	Fred V. Feyrer
Frank Ligion	Fletcher Nelson	Fraser R. Sime
Glen Tod Allison	Gerald L. Boles	Gretchen C. Coffman
Gary Gillingham	Gary L. Hendrickson	Geoff J. Malloway
Gilbert Van Dykhuizen	Howard L. Brown	Harriet L. Rooks
Josh L. Brown	Joe M. Croteau	Janis Duncan-Vaughn
Joaquin B. Feliciano	Jacques Finlay	Jeff Green
J. Mark Jenkins	Jason E. Kindopp	Jeffrey F. Kozlowski
Jennifer L. Lamb	John S. Lang	Joan C. Lindberg
Jason T. May	Jeff S. McLain	John Moran
Jess M. Newton	John A. Nogué	John B. O'Sullivan
James C. Roth	Jose D. Setka	Johnevan M. Shay
Jerry J. Smith	Jonathan E. Stead	Jonathan P. Toal
Joseph Welsh	Keith N. Barnard	Kurtis Brown
Kevin J. Cassady	Kenneth M. DiVittorio	Ken Kronschabl
Keith R. Marine	Kori A. Murphy	Kristofor D. Sundeen
Lenny F. Grimaldo	Lloyd J. Hess	Leslie C. Millett
Lisa R. Porcella	Laura E. Riege	Lori Wichman
Mary R. Arkoosh	Mary E. Boland	Mark D. Bowen
Micah Brosnan	Martin J. Canning	Matthew M. Carpenter
Michael J. Connell	Mark F. Dedon	Mark Ferguson
Mark E. Freitas	Michael E. Fry	Mark R. Jennings
Mark S. Nelson	S. Mark Nelson	Matthew L. Nobriga
Miguel Moreno Olivera	Mark M. Pierce	Michael Robinson
Mark R. Stromberg	Megan A. Sheely	Michelle C. Tattersall
Nathan A. Farnau	Paul D. Cadrett	P. Huckobey
Paul F. Kubicek	Perry J. LeBeouf	Patrick A. Monk
Paul J. Randall	Patricia J. Tartarian	Peter Tomsovic
Peter C. Wainwright	Robert Aramayo	Richard F. Brocksmith
Richard H. Burmester	Richard R. Corwin	Ronald L. Critchlow
Richard E. Crowe	Rodney O. Engle	Reginald Gary
Ralph E. Geary	Ruth-Anne Goodfield	Roger D. Jones
Ryon S. Kurth	Robert A. Leidy	Ryan T. Martin
Robert Edward Miller	Rodney J. Nakamoto	Robert E. Schroeter
Ramona O. Swenson	Ross N. Taylor	Richard V. Thall
Rakhal Turcotte	Randy M. Turner	Scott Adams
Sandy M. Borthwick	Stephen R. Boyd	Steve Brorsen
Shannon L. Brown	Stacy A. Burnett	Sean A. Carlson
Scott Cressey	Sally M. de Becker	Stephen A. Gough
Scott Greenwald	Stephen R. Horner	Spencer Johnson
Steven H. Kirihara	Steven F. Lee	Stacy K. Li
Stewart P. McMorrow	Scott E. McReynolds	Stuart W. Moock
Stanton D. Moore	Shawn V. Petrash	Scott Reid
Stuart K. Running	Stuart K. Running	Scott M. Siegfried
Stephanie R. Theis	Steven P. Tussing	Sean K. White
Sally Wuttken	Terri L. Gaines	Timothy R. Hayden

Thomas R. Lambert
Timothy P. Smith
Todd Steiner
Timothy J. Vieira
Warren Case
Warren J. Shaul
Juddson D. Sechrist
Teresa MacColl
Thomas A. Shaw
Thomas K. Studley
Victoria K. Poulton
William C. Harrell
Wayne M. Swaney
Tim Salamunovich
Ted R. Sommer
Tanya C. Veldhuizen
Wendy N. Batham
Warren T. Nichols
Zoltan Matica

2000 PERMITS

Angie Bourandas
Albert K. Dunlap
Aaron M. Nadig
Amos Pole
Allen H. Tanner, Jr.
Andrew Whitehead
Bobby Brown
Brian D. Michaels
Benjamin O. Ransom
Colin W. Anderson
Charles H. Hanson
Carl J. Page
Chrissy L. Sonke
David F. Arwood, II
Daniel M. Corcoran
Darrell D. Hostler
Douglas B. Parkinson
David Zajanc
Elizabeth A. Gilliam
Edward D. Weber
Gregory M. Andrew
Geoffrey J. Malloway
Gerald A. Sanchez
Glen D. Wightman
Harry W. Vaughn
John L. Biggin
John R. Dvorsky
Jack D. Herr
James R. Kilgore
Jerry D. Roe
Kyle E. Brakensiek
Keith E. Whitener
Trevor M. Lucas
Lori Wichman
Mark T. Fiorini
Michael D. Layton
Mike Marshall
Maureen F. Roche
Mark H. Walter
Paul E. Maslin
Richard A. Bush
Robert C. Fuller
Rick A. Moncrief
Rebecca M. Quiñones
Robert E. Schroeter
Sean R. Avent
Sarah Giovannanetti
Seth J. Ricker
Troy V. Branham
Trevor M. Lucas
Weldon E. Jones
Angela J. Petitt
Alison R. Brown
Anstey A. Hinkson
Alan D. Olson
Alice A. Rich
Aileen D. Theile
Andrea F. Zuur
Benjamin A. Camarena
Brenda J. Olson
Bethany A. Reisberger
Colum P. Coyne
Clyde Matilton, Jr.
Cassandra A. Roberts
Cindy A. Walker
Daniel Ashe
Doug Demko
Dana R. McCanne
Debra J. Parthree
Eddie T. Bullock
Eric J. Loudenslager
Erich M. Yokel
Greg R. Bates
Gavin O'Leary
Greg Silver
Hank C. Alameda, Jr.
Ingo H. Gaida
Joseph J. Cech, Jr.
Joaquin B. Feliciano
Joshua A. Israel
Jeffrey F. Kozlowski
Joshua P. Seney
Karen A. Gehrts
Kip K. Young
L. Morgan
Michael R. Carbiener
Mary L. Harrison
Michael P. Limm
Melissa L. Niederreiter
Michael D. Sparkman
Natalia J. Boettcher
Pamela Ryan
Ryan M. Cuthbert
Robert W. Holmes
Richard L. Myers, II
Ron R. Reed
Randy M. Turner
Sam Cuenca
Steve M. Hasslinger
Sean S. Runyon
Timothy R. Carpenter
Tim Walcott
Patrick A. Curry
Aaron M. Nadig
Alexander I. Culley
Aric R. Lester
Andrea N. Phillips
Anthony Scheiff
Annette M. Thompson
Bradd L. Bridges
Ben B. Griffith
Bruce F. Oppenheim
Brent E. Spencer
Cathy C. Culver
Cindy M. Messer
Carrie S. Culver
Christian E. Zimmerman
Donald S. Baldwin
Danielle J. Gainok
Dennis Michniuk
Dennis Therry
Emmanuel G. Da Costa
Ethan Pole
Frederick R. Rogers
Grace A. Brookman
G. Peterson
Greg Suba
Henry J. Calanchini
Jesse T. Anderson
Jim L. Craig
John B. Hamilton
Jason Jones
Joy M. McCandless
Jason L. White
Karen L. Larsen
Lisa A. Beaumont
Lori B. Webber
Michael H. Fawcett
Michael J. Justice
Mark Magneson
Matthew L. Nobriga
Mitchell A. Stolfus
Patricia K. Magnuson
W. Park Steiner
Russell Fairey
Roy P. Jones
Royden Nakamura
Rachael K. Roditti
Ray J. von Flue
Scott A. Fullerton
Silas S.O. Hung
Scott J. Volan
Tiffany R. Hernandez
Valary K. Bloom
Samantha L. Ficksman

2001 PERMITS

Alison M. Bell
Alan T. Monji
Anthony P. Spina
B. Bonner
Bryan T. Drew
Brook K. Pattison
Andrew M. Bundschult
Anthony J. Scheiff
Anita J. Thompson
Bradley Cavallo
Benjamen M. Kennedy
C. Brown
Andrea K. Gingerich
Alicia M. Seesholtz
Andrew Whitehead
Beverly M. Chaney
Bert W. Mulchaey
C. Eggleston

C. Gaither	Charles S. McCandlish	C. Miller
Craig Reece	Corrie Veenstra	David D. Fuller
Donna M. Maniscalco	Douglas M. Mooneyhan	Derek W. Ogden
Dirk T. Pedersen	Douglas C. Rischbieter	David D. Salsbery
Dagmar Ruth Sundermeyer	David W. Wright	Elaine Atherton-Nelson
Ethan Bell	Erika C. Caceres	Elaine M. Esteban
Eric J. Gonzales	Erin P. Triolo	Edward D. Weber
Francesca C. Demgen	G. Allison	Greg H. Goldsmith
George J. Guillen	Garth Hodgson	Geoff M. Hoetker
Geoff L. Rogers	Gary M. Santolo	Greg Silver
Heather R. Larson	Heidi L. Peure	Harriet L. Rooks
Hartwell Welsh, Jr.	Jill E. Andersen	Jerry A. Boberg
Josh Boyce	James M. Carlson	James M. Carlson
Joseph A. Collins	Jessica Doremus	Jeff Duda
Julie J. Eliason	John Emlen	Joaquin B. Feliciano
Jay D. Glase	Jeff M. Hagar	John D. Hopkirk
John E. Howard	John T. Kelly	Jason E. Kindopp
John S. Lang	Jakob Leube	Jim R. Long
Jessica R. Martini-Lamb	Jason T. May	Jeff McLain
J. Newton	Jacob A. Nicholas	Jeff K. Parr
Jeff M. Reid	Julia Remmenga	Jane C. Sartori
Jose D. Setka	Johnevan M. Shay	Jason L. Shillam
J. Smith	John S. Southwick	J. Williamson
K. Brown	Kenneth E. Fetcho	Kimberly A. Gillespie
Karen Kentfield	Kindra E. Loomis	K. Niemela
Katherine L. Seefloth	Kandi M. Vargas	Louis A. Courtois
Lauren D. Dusek	L. McLaughlin	Lori B. Webber
Lori M. Wichman	Mary R. Arkoosh	M. Brown
Martin J. Canning	M. Currier	Michael L. Dietl
Michelle M. Foye	Mary E. Greaves	Monica D. Hiner
Michele K. Lukkarila	Maureen R. McGee	Michael J. McSweeney
Michael Moon	Maren K. Siavage	Melissa A. Turner
Margaret A. Wilzbach	Nathaniel S. Dachtler	Noel Davis
Paul C. Albro	Paul M. Bratovich	Paul Cadrett
P. Gaines	Philip R. Huckobey	Patrick L. McNeil
P. Parker	Paul R. Weissich, Jr.	Ronald C. Benkert
Robert E. Blizard	Richard H. Burmester	Richard R. Corwin
Robin E. Dakin	Rodney O. Engle	Robert L. Grasso
Roger D. Hartwell	Robert W. Holmes	Robert M. Hughes
Ryon S. Kurth	Robert A. Leidy	Richard Stewart
Ross N. Taylor	Sarah S. Beesley	Sandy M. Borthwick
Shawn D. Chase	Severiano C. Del Real	Scott B. Engblom
Sharon L. Frazey	S. Giovannetti	Sharon H. Kramer
Stacy L. Johnson	Steven Kramer	Scott E. McReynolds
Scott Monday	Stewart B. Reid	Sylvia M. Rutter
Scott Searle	Scott M. Werner	Steven C. Zeug
Timothy L. Hamaker	Trevor A. Kennedy	Tom Kisanuki
Timothy Maloney	Thomas A. Shaw	Tamara G. Swingle
Timothy J. Vieira	Veronica A. Pedro	Victor R. Sundberg
William A. Bennett	Walter G. Duffy	William Gray
William C. Harrell	W. McKinney	Wayne D. Padley
W. Poytress	Zoe B. Knesl	

APPENDIX B.

Peer Review

APPENDIX B1

LIST OF EXPERTS SOLICITED FOR PEER REVIEW

Name	Title/Organization
Walt Duffy, Ph.D.	Unit Leader, Fish and Wildlife Cooperative Unit, Arcata
Michael Healey, Ph.D.	Westwater Research Center; Professor, Dept. of Oceanography, University of British Columbia
Peter Moyle, Ph.D.	Professor, Dept. of Wildlife, Fish , and Conservation Biology, University of California, Davis
Gordon Reeves, Ph.D.	U.S. Forest Service, Pacific Northwest Research Station, Corvalis, Oregon
Terry Roelofs, Ph.D.	Professor, Dept. of Fisheries, Humboldt State University
William Trush, Ph.D.	Director, Institute of River Ecosystems; Adjunct Professor, Dept. of Fisheries, Humboldt State University
Hiram Li, Ph.D.	Professor, Dept. of Fisheries, Oregon State University.
Staff	National Marine Fisheries Service, Southwest Region Fisheries Science Center, Santa Cruz.

APPENDIX B2

Peer Review Comments Received

note: some of the comments below have been incorporated into the Status Review Report.

<u>National Marine Fisheries Service, Southwest Region Fisheries Science Center</u>

April 17, 2002

Dennis McEwan
California Department of Fish and Game
1807 13th Street, Suite 104
Sacramento, CA 95814

Re: NMFS SWFSC Comments on California State *Status Review of California Coho Salmon*

Dear Mr. McEwan:

Below, please find comments made by staff of the NMFS Southwest Fisheries Science Center (SWFSC) regarding the draft document "*Status Review of California Coho Salmon (Oncorhynchus kisutch*)" prepared by the California Department of Fish and Game (CDFG). Scientists participating in this review included Dr. Brian Spence, Dr. Peter Adams, Dr. Eric Bjorkstedt, Dr. Carlos Garza, and Thomas Williams from the Science Center, and Dr. George Boehlert from NMFS Pacific Fisheries Environmental Laboratory, who reviewed the section in Chapter VI on oceanic conditions. We appreciate the opportunity to participate in this review and hope that you will find the comments useful in preparing your final report.

Overall, NMFS SWFSC reviewers found the report to constitute a reasonably thorough review of the status of coho salmon in California. It is clear that CDFG went to considerable effort in compiling recent and historical information on the distribution and abundance of coho salmon in the state, and CDFG is to be commended for the extensive sampling effort it undertook in summer of 2001 to collect up-to-date information on the distribution of coho salmon. We know of no additional major available data sources that would appreciably alter any of the conclusions reached in the document regarding the status of coho salmon. Furthermore, we agree with the major conclusions of the report: that coho salmon in the Central California Coast ESU (north of San Francisco Bay) are currently in danger of extinction, and that coho salmon in the California portion of the Southern-Oregon Northern California Coast ESU are likely to become endangered within the foreseeable future.

There is one area in which conclusions of CDFG are inconsistent with those reached in the NMFS (2001) status review of coho salmon; this discrepancy relates to whether there is evidence that reductions in the distribution and abundance of salmon in the Southern Oregon-Northern California Coast ESU have continued into the 1990s or whether the losses occurred prior to the mid-1980s. This discrepancy (elaborated below) results from differences in analytical approaches, specifically, with respect to the temporal frames within which presence-absence data are aggregated. Fundamentally, these differences do not affect the ultimate assessments of extinction risk. However, accepting the NMFS analysis would strengthen the CDFG conclusions that SONC coho salmon are threatened with extinction.

Aside from this, most of our remaining comments are directed toward improving the thoroughness, accuracy, and readability of the report. In the attached pages are chapter-by-chapter comments for chapters I though VI, and VIII through XI. The numbers correspond to numbers in the margins of the hard-copy text, which will be sent to you via express mail tomorrow. There are additional comments of a relatively minor nature written directly on the manuscript.

Again, we hope these comments are helpful in revising this important document. Please do not hesitate to contact me if you have any questions or need any clarification regarding any of the comments contained herein.

Sincerely,

Brian C. Spence, Ph.D.
NMFS Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, CA 95060

Chapter I. Executive Summary

1. Pg. 1. Since the 1940 estimate cited on pg. 65 is a range (250,000 to 500,000) then the percentage should also be a range (6-12%). It would not hurt to also mention the estimated numbers for each of the time periods discussed.

2. Pg 2. Also, although this is an executive summary, you still need to provide sufficient information on methods so that these results can be interpreted appropriately. The reader has, at this point, no knowledge of what the "analysis by brood year" entailed, or what baseline (i.e., Brown and Moyle) was used to make this comparison. Without that information, these four paragraphs are difficult to understand.

   Also, the 61% number does not jive with the number listed for 1995-2000 brood years cited in Table 5, pg. 54, which is 50%.

   The statement that "*there does not appear to have been a significant decline in distribution between the late 1980s and the present*" disagrees with analysis of presence-absence data with annual resolution that indicates a decline in detectability in northern California (NMFS 2001). Based on this analysis, we reached a different conclusion: that the California portion of the SONC is not stable through the 1989-2000 period. Some attempt to reconcile these different conclusions is warranted. See comments on Chapter V for further elaboration including discussion of potential biases associated with the CDFG analysis.

   Additional confusion results from the statement that "*The 2001 presence survey data* ***also*** [emphasis added] *show a decline in reported distribution in this ESU,*" which seems to contradict the aforementioned conclusion. Again, it is not clear what the benchmark or reference point is.

Chapter II. Introduction

1. Pages 5-7. Section generally looks good. Only minor clarification needed (see marginal comments).

2. Pg. 7. It is worth noting that the conclusion of the BRT that the CCC ESU is in danger of extinction is not reflected in the listing decision, which gave CCC coho "threatened" federal status.

Chapter III. Biology.

1 Pg. 10. Snyder (1912) does not list the Pajaro River as a historical coho stream. Also, although there are recent reports of adult coho occurring in Aptos Creek, Waddell Creek appear to be the southern-most stream containing persistent populations at this time.

2 Pg. 13. In general, the section on taxonomy and systematics looks good, with the exception noted below.

3 Page 15. It is not sufficiently clear in Table 2 that almost all of the California population samples in the Weitkamp et al. 1995 document are not new data, but only data from the other cited sources.

4 Page 22. Need citations to support summer and winter habitat requirements of coho salmon. Should also probably include some discussion of the fact that current models of rearing capacity being used in Oregon (Nickelson and Lawson), which place great emphasis on winter rearing habitat, may not be "exportable" to California, where summer low flows and summer temperatures may be important population regulation mechanisms.

Chapter IV. Habitat Necessary for Survival

1. Page 25. Many sections in this chapter need greater acknowledgement of sources. Some, but not all, of these are noted in the margins.

2. Page 26. Discussion of effects of temperature on embryos and alevins should include more than "optimal" and "lethal" temperatures. Because of the tight coupling of temperature and developmental processes, changes in thermal regime, even when well within the physiological tolerable range for the species, can have significant effects on development time (and hence emergence timing), as well as on the size of emerging fry.
3. Page 26. Low DO can also affect size and condition of emerging fry.

4. Page 28. This sections needs discussion of importance of linkages between sediment inputs, substrate quality, and potential effects on salmonids. Food production and cover in the form of substrate interstices are important aspects of habitat that are adversely affected by high sediment loads. These are probably bigger issues than turbidity in most cases.

5. Page 28. Spence (1995; cited in preceding paragraph) also found that the probability that coho smolts will migrate downstream increases with rapid increases in temperature.

6. Page 29-32. Be careful here with the discussion of "optimal" conditions. Most studies define optimal conditions on the basis of physiological responses or efficiencies under laboratory conditions. If one believes that coho salmon populations become locally adapted to the particular suite of environmental conditions in their natal stream, then "ecologically optimal" conditions may fall outside of the narrow range deemed "physiologically optimal." Most important of these potential influences is the alteration in timing of life-history events. There is evidence, for example, that development time of embryos varies among populations, the assumption being that natural selection has operated to ensure emergence occurs at a favorable time. Similarly, smolt outmigration timing (and age at smolting, if you move farther north) has presumably evolved to ensure ocean entry at appropriate times. Consequently, small changes in temperature can disrupt the natural synchrony of biological cycles. Thus, in table 4, just as you indicated that the appropriate flow regime is specific to a watershed, so too is temperature regime.

Chapter V.

1a. Pages 35-36. The treatment of population structure is a bit superficial and could go a bit deeper into the primary literature, much but not all of which is cited in McElhany et al. (2000). That said, given that there is no attempt to link the data to these concepts in a quantitative way, an in-depth review is not really required. Are there reviews in the literature that might serve as a broader set of references than what appears to be sole reliance on McElhany et al. (2000) for context? A focus on hierarchical structuring in salmonid populations and ESUs will likely prove more useful in placing the available data in context than will invoking metapopulation theory.

1. Page 36. Should also mention that, over longer periods, the relationship between source and sink populations may change (i.e., sources may become sinks and vice versa). Thus, protecting only "current" source populations may be inadequate to ensure long-term persistence.

2. Page 36. If you are going to suggest that hatchery and wild populations may function as sources and sinks, respectively, then you need to point out that 1) the reverse may also be true…wild "source" populations can be mined for broodstock. (Despite the release of thousands of smolts notwithstanding, survival through the entire life cycle may be inadequate to replace the wild fish taken from the population [see e.g., Currens 1995]); and 2) genetic effects resulting from hatchery-wild matings may change the relative productivity of wild populations, such that wild sink populations become even less productive through time (an important consideration given that millions of hatchery juveniles have been pumped into streams over the last 20-30 years).

3. Page 36. Connections over time are also potential important for local population persistence. Gene flow between brood lineages in the same location may be limited, barring sufficient numbers of jacks or 2+ smolts in a population.

4. Page 36. A brief explanation needs to be offered as to why the status of salmon is being considered separately for the two ESUs. In that regard, the relationship between the populations from S. F. Bay to Punta Gorda and those south of S. F. Bay needs to be addressed. What are the implications of stocks south of S. F. Bay for ESUs, risk analyses, application of Brown and Moyle data, etc.?

5. Page 36. Need to note the distinction between population viability and ESU viability. With respect to the specific ESUs in question, it appears likely that there will be multiple independent populations within each ESU, and that ESU viability will require ensuring that a number of independent populations will need to be viable for the ESU to be considered at negligible risk of extinction.

6. Page 37. Mention of the Higgins et al. 1992 review for the Humboldt Chapter of AFS would seem warranted.

6b. Page 37. A comment on the assembly and analysis of data in the "Presence by Brood Year Investigation" section: the practice of assigning presence to a mainstem based on presence in a tributary potentially introduces a bias in identifying patterns and trends in presence-absence because the reverse mapping (mainstem implies tributary) is not applied—admittedly it cannot be applied. If the data are treated at an aggregate level with mainstems (and associated tributaries) as the unit, this may no longer be a concern; however, it is not clear whether this (necessary) rule was applied. Also, more information is needed on the application of the statistical tests to these data on p.53—perhaps provide the actual tables analyzed? Application of chi-square tests to proportion data is not recommended, and it isn't clear whether this was done here.

7. Page 38. The narrative describing historical and current distributions (pages 38 through 52) needs significant reworking to 1) clarify the primary intent of the section, 2) provide succinct definitions of what CDFG considers "historical" and "current," 3) provide greater consistency (geographically speaking) in level of detail, and 4) simplify the presentation.

Intent. It is unclear to the reader whether the overall purpose of this section is to 1) comprehensively review all available data on historical and current distributions, or 2) provide a direct comparison to Brown and Moyle (1991). This confusion stems, in part, from the fact that both the level of detail and the attempts to compare current to historical distributions (and to use Brown and Moyle as the basis for comparison) differ among watersheds. You need to decide whether the goal of this section is to provide a comprehensive view (defining your own rules and ignoring, for the moment, the Brown and Moyle list), or whether you want this to focus on a direct comparison between Brown and Moyle. Because the "Presence by Brood Year" analysis provides a relatively direct comparison to Brown and Moyle, we would favor the comprehensive approach in the narratives (though see comments on simplification below).

Definitions. To help clarify the intent of the section, begin with a clear statement of what CDFG considers to be "historical" and "current" occurrence. For all watersheds in Del Norte County, it appeared that you were treating any observation prior to brood year 1995 as "historical" and any subsequent observation (brood years 1995 through 2000) as "current." For the Klamath, however, that structure broke down, and the narrative consisted of descriptions of various surveys, some of which yielded opposite results within the last 6 years (e.g., Kier indicating "presence" in the E. Fk. N. Fk. Trinity River in their 1999 report but CDFG indicating "absence" in 2001). The overall picture becomes murky with the details of specific surveys. Further, streams are omitted from the list of "historical" streams but then are cited later as "historical" in the description of current distributions (Bluff and Slate Creeks are two examples on pg 42; there are others as well).

We recommend adopting some simple rules (i.e., current means any time during the last two brood lineage cycles, for example), making those rules very explicit, and then summarizing the information according to those rules. The details of individual surveys are best left to an appendix list. What would also be helpful in the narrative would be greater emphasis on putting the results into a larger context. For example, at the conclusion of the Smith River section, you note that there have been few recent observations of coho salmon in two major subbasins (South and Middle Forks); this is an important observation given that the Smith River is often considered to be a "stronghold" for salmonids. In other sections, the summaries list streams without much geographic reference or simply summarize that fraction of streams for which recent coho salmon observations have been made; thus whether apparent reductions in distribution are widely scattered versus concentrated in a few subwatersheds is not evident.

Level of detail. As noted above, there is significant disparity between the level of detail presented for the various watersheds or geographic regions. For example, the discussion of historical and current distributions in the Smith River is very detailed, naming virtually every major and minor tributary for which there exists some record of coho salmon occurrence. In contrast, for the sections covering Mendocino and Sonoma County watersheds, the information presented is of a summary nature, e.g., "*Recent status reviews place the number of streams historically containing coho salmon in the Ten Mile River watershed at between eight and 18*"); few specific tributaries are mentioned by name as either historical or current coho salmon streams. Because of this, it is difficult to get any sort of spatial picture from the data provided.

Simplification. Having said the above, we also wonder if presentation of this information couldn't be substantially simplified with the use of tables. While the narrative approach does parallel the effort of Brown and Moyle, tables that list tributaries according to subwatersheds (along with presence/absence data) would provide an easy way to present the data in their entirety. The narrative could then focus on summarizing what the tables say, comparisons with Brown and Moyle, and overall spatial patterns, rather than get bogged down in lists of stream names, most of which will have little meaning for many readers.

8. Page 38. The use of the term "cohort" at various places in the document adds the potential for confusion—it is sometimes unclear if, say, the 1996 "cohort" is intended to mean the 1995 brood year or the 1996 brood year. Sticking to "brood year" reduces this ambiguity (though be sure to address the fact that spawning runs may span two calendar years, in which case adopting a convention of referring to 1995/1996 spawners as representing the 1995 brood year is warranted).

9. Page 40. Given that this section is focused on distributions, it might be more logical to put information on historical *abundance* in the subsequent section.

10. Page 40. There are a significant number of streams in the Klamath-Trinity system that were identified as historical coho salmon streams that are not mentioned in the narrative as such (see list in NMFS 2001a). NMFS pulled some of these data from Brownell et al. (1999), which in turn cited various USFS districts or other sources. Since Brownell et al. (1999) is listed as a primary source for historic and current information, what was the basis for excluding these streams from the narrative? If, in fact, you've done additional research that suggests these observations are either in error or impossible to confirm, then this would be important information to include in the document (perhaps as an appendix), since the work of Brownell et al. (1999) is often cited as a definitive source.

11. Page 54. Does CDFG intend to fill in Table 5? The data necessary to create such a table are available in appendices to NMFS 2001a combined with the CDFG 2001 surveys.

12. Page 53. Conclusions reached in this section regarding trends in the probability of detection of SONC coho differ from those of NMFS (2001) and subsequent analyses we have performed. Our analyses, which retain the annual resolution of the data, suggest that in the California portion of the SONC, the probability of detecting coho salmon is indeed declining over the period 1989-2000, whereas CDFG concludes that the declines between 1986-1991 and 1995-2000 are insignificant.

    Analysis of presence-absence data pooled over brood-year-lineages is biased towards reporting presence—the loss of a brood-year-lineage in a basin cannot be captured by the aggregated data (i.e., one detected presence over a six-year period is considered equivalent to six detections over a six-year period when data are aggregated). The CDFG data for 2001 presented in this report, which indicate substantially lower detection percentages than estimated from the aggregated data, suggests that brood lineages may, in fact, be disappearing.

Note also that a second potential source of bias may be introduced if sampling effort (i.e., frequency with which a stream is visited during the six-year period) differs between the two sampling periods. There is some suggestion in the CCC ESU data that the probability of detection is increasing over time, but this is strongly confounded with temporal trends of increasing sampling effort over time. In analyses that incorporate weights based on sampling effort, the indication of increased detection in the south parallels the increase in sampling effort. However, a substantial change in sampling effort is not apparent in the north, which suggests that the apparent decline is less likely to represent an artifact of sampling in the data.

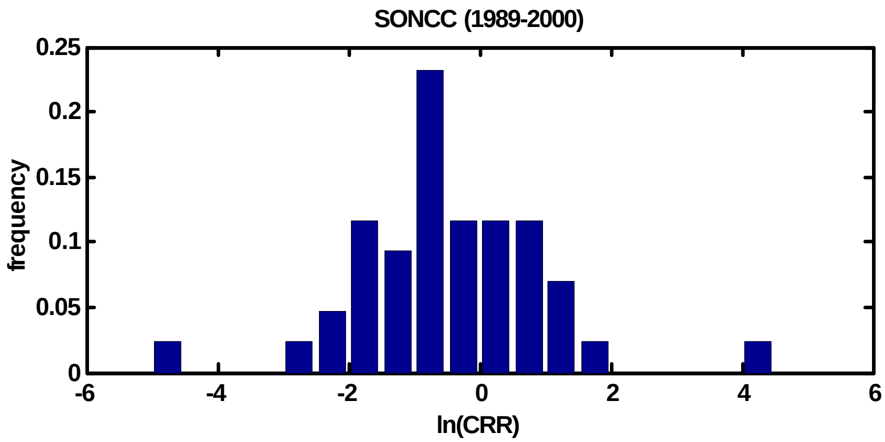
To summarize, our most recent analyses suggest the following conclusions:

- coho presence (detectability) is declining in the north
- coho presence (detectability) is lower in the south than in the north
- trends in coho presence (detectability) are unclear in the south—apparent trends are confounded by substantial changes in sampling effort over the period 1989-2000.

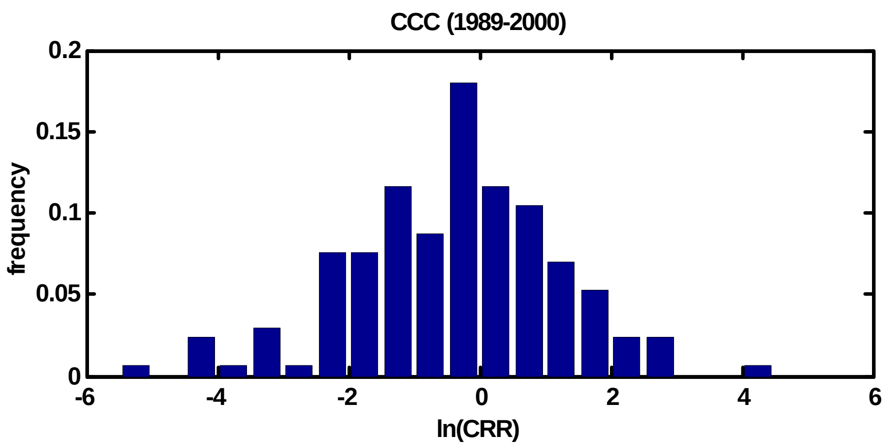
13. Page 53. In the presence-absence analysis (by brood year), why was no attempt made to use data from the period between 1992 and 1994?

13a. Page 55 and pages 58-64. These figures showing spatial patterns are critically important as they highlight the fact that, in certain watersheds, coho were absent from large subbasins in several watersheds. Greater discussion is needed to bring more attention to these patterns.

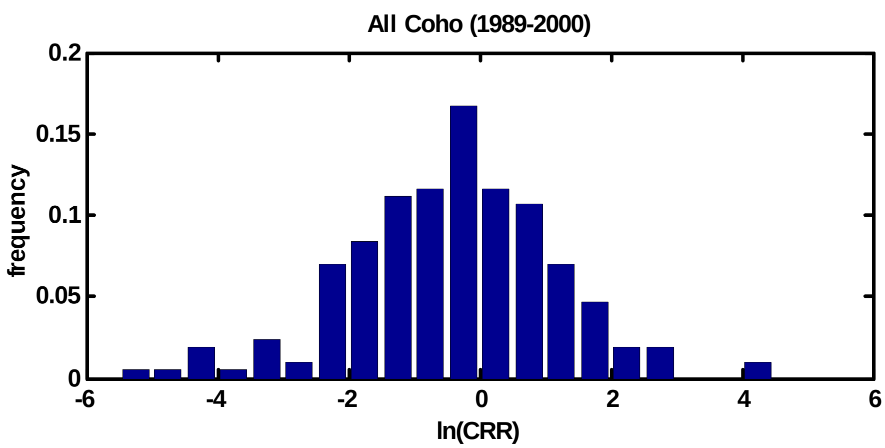
14. Page 68. A new, more appropriate analysis of the CRRs has been done for juvenile and smolt data, which suggests that the mean ln(CRR) is significantly less than 0 (i.e., mean CRR < 1) throughout California, as well as for each ESU considered separately (See plots on following page).



Analysis of Cohort Replacement Rate (CRR = n_{t+3}/n_t) for coho salmon in the California part of the Southern Oregon-Northern California ESU based on paired juvenile or smolt abundance indices within the period 1989-2000. Mean ln(CRR) (and 95% CI) is –0.4437 (-0.8953, 0.0080); p = 0.0270 for t-test of H_0: mean ln(CRR) = 0.



Analysis of Cohort Replacement Rate (CRR = n_{t+3}/n_t) for coho salmon in the Central California Coast ESU based on paired juvenile or smolt abundance indices for the period 1989-2000. Mean ln(CRR) (and 95% CI) is –0.3869 (-0.5793, -0.1946); p = 0.0010 for t-test of H_0: mean ln(CRR) = 0.



Analysis of Cohort Replacement Rate (CRR = n_{t+3}/n_t) for coho salmon throughout California based on paired juvenile or smolt abundance indices within the period 1989-2000. Mean ln(CRR) (and 95% confidence intervals) is –0.3914 (-0.6011, -0.1816); p < 0.0005 for t-test of H_0: mean ln(CRR) = 0.

Note that these estimates are calculated from available recent data for juveniles and smolts. Inclusion of historical data, including adult data, exacerbates this result by incorporating the massive declines through the 1960s-1980s. Note also that t-tests are more appropriate than the binomial test used in NMFS (2001) for evaluating whether these results indicate a mean ln(CRR) that differs significantly from zero. In all cases, the null hypothesis that mean ln(CRR) is zero is rejected.

15. Page 69. Some discussion of the Sweasy Dam counts (Mad River) would seem warranted here. (These counts are mentioned in the conclusions, but all data should be laid out before the concluding section).

16. Page 74. We're not sure of the value of fitting the decomposition time series models to the smolt and juvenile time series, and plotting predictions of future abundance. Simply plotting the data with a fitted line (or three, to capture similarities or differences in lineages) would make the point adequately.

17. The decline in occupancy in the north is partly offset by the lack of significance in CRR analysis. The argument that presence of coho in watersheds, albeit at lower abundance and reduced distribution, represents a lesser fragmentation than to the south is not fully supported, though, as the underlying analysis is confounded by differences in watershed size. (There are, for example, significant portions of the Smith, Klamath-Trinity, Eel, and Mattole Rivers where coho were absent or vary scarce in 2001.) It might be, indeed is likely, that fragmentation observed in the north is obscured by the tendency to aggregate data for larger watersheds but not for smaller watersheds. There is perhaps some biological basis for this aggregation, but this depends on untested assumptions about straying within a large watershed versus straying among smaller coastal basins. Precautionary approaches would suggest considering whether fragmentation truly is reduced in larger basins as the consequences of such fragmentation are potentially disastrous.

18. Page 78. Analysis of the CCC seems incomplete, although evidence for declines in abundance based on CRR seems stronger than for the SONC. A greater and more comprehensive consideration of presence data seems necessary, if only to highlight the relatively poor quality of these data and lack of information available.

Chapter VI. Factors Affecting the Ability to Survive and Reproduce.

1. Pages 80-81. There some important shortcomings in section dealing with ocean conditions. These shortcomings are outlined below (in no particular order), and we have also included a list of additional references that the authors should consider and cite in the text.

   The discussion in this section is heavily weighted by consideration of the El Niño Southern Oscillation (ENSO). While it seems likely that these events influence production of California coho salmon, there are certainly other climate cycles (generally at longer time scales) that influence coho production. There are hints in the text that the authors are cognizant of this fact, but the treatment is not balanced. We suggest that the authors reduce the emphasis on the ENSO and at least include discussion of the Pacific Decadal Oscillation (see Mantua et al. 1997).

   The authors have described the physics of both the ENSO and wind driven upwelling incorrectly. The ENSO is not "caused by the weakening of equatorial westerly trade wind patterns." The physics of the ENSO are complex and, in fact, the trade winds are easterlies. Similarly, the authors state that "increased thermocline depth and stratification caused by the rise in temperature results in less wind-driven upwelling," but winds, not temperatures, increase or decrease upwelling. (Upwelling continues, but the effectiveness of it in bringing nutrient-rich water to the surface is diminished because of increasing depth of the thermocline.) We suggest that the authors remove discussion of the physical mechanisms driving the various climate processes that affect coho production. The authors should, instead, simply state that these processes are physically complex and affect production from the bottom up. There are several recent references they could benefit from reviewing, including Cole (2000), Ryding and Skalski (1999), Hobday and Boehlert (2001), and Koslow et al. (2002). All deal with coho survival and ocean variability.

We agree that salmon are well suited to coping with environmental variation, but we do not agree with the authors' opinion that "healthy and stable salmon populations… are generally not at high risk of extinction due to environmental variation." There were certainly "natural" expansions and contractions of the range of coho salmon prior to anthropogenic influence. It seems plausible that these expansions and contractions (manifested by local extinctions and recolonizations) occurred because California is at the edge of the range of coho salmon. In fact, throughout the document there is insufficient attention paid to how ocean variability affects coho salmon in different parts of their range, particularly given that California is on the southern end of the range. See, for example, Hare et al. (1999). Also note that the plankton reduction noted by Roemmich and McGowan (1995) generally occurs at latitudes considerably south of where coho salmon occur.

The last sentence of the Discussion section states that "if the local extinction rate is less than the colonization rate, then overall declines will be observed." This does not make sense to us. Perhaps this is merely a typo, and overall declines will be observed if the local extinction rate is *greater* than the colonization rate. If it is not a typo, this statement certainly deserves additional support or explanation.

2. Page 81. Reword sentence. There is no question that ocean conditions play an important role in determining abundance and productivity, but that differs from "attributing the decline largely to changes in ocean conditions." Lawson, in particular, highlights the interplay between freshwater habitat conditions and ocean cycles, as illustrated in Figure 23.

3. Page 83. Although salmon are adapted to a variable environment, there are limits to their plasticity. Given that coho salmon in California are at the southern end of their range, it is reasonable to expect that for things like temperature tolerances and minimum flows, they may have little capacity to handle variation that falls outside of the natural range.

4. Page 83. Understanding of mortality caused by pathogens in the wild is poor, as it is difficult to determine the proximate and ultimate causes of death in the wild (i.e., when fish weakened by disease are consumed by predators before they die). Currently, there is insufficient data from which to draw meaningful conclusions about the importance of disease in regulating populations in the wild.

5. Page 88. Overall, this section does a good job of covering hatchery related issues. It seems, however, somewhat incongruous that the opening paragraphs highlight the

potential “positive” aspects of hatcheries when the majority of the text in the section is about adverse consequences. (In fact, since the purpose of the chapter is to identify causes of declines in salmon, then the statements regarding supposed hatchery benefits are would be most appropriate in Chapter VII). At the very least, it would seem appropriate for the content of the introduction to parallel the content of the body of the section (i.e., raise the many issues associated with hatcheries, rather than focusing on potential—and highly uncertain—benefits of hatcheries for conservation). Furthermore, potential uses of hatcheries in conservation are more effectively discussed after the reader understands the major genetic and ecological issues associated with hatcheries.

6. Page 95. Hatchery introgression is cited as a possible cause of “low levels of distinctiveness found among California coho populations”, but the data from the Bartley et al. study found a relatively high level of distinctiveness between these populations. To what extent this effect is due to the small data set is not known, but this statement is not justified.

7. Page 96. Footnote #15. The first sentence is incorrect. It should read “The probability that an individual has different alleles on the maternal and paternal chromosome.”

7a. It is probably worthwhile to draw the distinction between *total* genetic diversity and *adaptive* genetic diversity. Unique but maladaptive genes, while they contribute to overall genetic diversity, actually reduce the ability of population to respond to change.

8. Page 99. Footnote #18. This footnote should occur earlier. It is a definition for a term already in use in the text.

9. Page 100. Instead of arbitrarily choosing the high N_e/N ratio (0.33), to be conservative, you should really assume that the lower (0.1) estimate holds when estimating necessary population sizes, given all the assumptions that go into these numbers. This would result in targets that were higher.

10. Page 105. Unclear whether temperatures mentioned are average daily values, maximum summer values, etc. Also, should note that changes in diel variation are potentially as important as changes in summer maxima or average temperatures.

11. Page 108. Should note the distinction between annual water yield and peak flows. With the latter, routing of water more quickly to the stream channel likely has the greatest effect on peak flows (rather than reduced evapotranspiration).

12. Page 112. Somewhere in this section, effects on temperatures below dams (which depend on whether releases are hypolimnetic or epilimnetic) should be mentioned.

13. Overall, this chapter provides a very thorough accounting of various human activities that influence salmonids and their habitats. The major issues are identified and given treatment at an appropriate level of depth for this document. One area in which the chapter could be improved is through more consistent referencing of the primary literature. Some sections provide substantial documentation in support of various arguments. Other sections have few if any citations. We have marked a few of the more notable places where additional citations are needed, but the entire chapter should be reviewed to ensure that assertions are adequately supported.

Chapter VIII.

1. This section generally looks good. Only the comments regarding trends in SONC coho salmon need to be addressed.

Chapter IX.

1. Recommendations to list the SONC coho salmon ESU as threatened and the CCC ESU as endangered are consistent with conclusions of NMFS SWFSC scientists (NMFS 2001). Some discussion of whether stocks south of San Francisco Bay will continue to be treated separately versus lumped with the remainder of the CCC ESU is needed.

Chapter X.

1. Again, with CDFG acknowledging that metapopulation considerations are important, the omission of any mention of stocks south of San Francisco Bay is noteworthy.

2. TRTs do not develop recovery plans…their function is to develop the biological delisting criteria for each ESU within the domain. An implementation team will work with other agencies to develop the actual recovery plans.

Additional references to consider:

Cole, James. 2000. Coastal Sea Surface Temperature and Coho Salmon Production off the Northwest United States. Fisheries Oceanography. 9:1_16.

Currens, K. 1997. Evolution and risk in conservation of Pacific salmon. Ph.D. thesis, Oregon State Univeristy, Corvallis, OR.

Hare, S.R., Mantua, N.J., and Francis, R.C. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24: 6-14.

Hilborn, R. and C. Coronado. 1997. Changes in ocean survival of coho and chinook salmon in the Pacific Northwest. pp. 9_18 in: Emmett, R.L. and M. H. Schiewe. (eds). Estuarine and Ocean Survival of Northeastern Pacific salmon: Proceedings of the workshop. NOAA Tech. Memo. NMFS_NWFSC_29, 313 p.

Hobday, A. J. and G. W. Boehlert. 2001. The role of nearshore ocean variation in spatial and temporal patterns in survival and size of coho salmon. Can. J. Fish. Aquat. Sci. 58 (10): 2021_2036.

Koslow, J.A., A. Hobday and G. W. Boehlert. 2002. Climate variability and marine survival of coho salmon (Oncorhynchus kisutch) off the coast of California, Oregon and Washington. Fisheries Oceanography. 11(2): 65_77.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bull. Amer. Meteorological Soc. 78: 1069_1079.

Ryding, K.E. and Skalski, J.R. 1999. Multivariate regression relationships between ocean conditions and early marine survival of coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences 56: 2374_2384.

<u>William Trush, Ph.D., Director, Institute of River Ecosystems; Adjunct Professor, Dept. of Fisheries, Humboldt State University</u>

Date: April 17, 2002

To: Larry Week, Chief Native Anadromous Fish and Watershed Branch
From: Bill Trush, Adjunct Professor in Humboldt State University Fisheries Department
Re: Comments, as a peer reviewer, regarding the April 2002 draft of *Status Review of California Coho Salmon*

Thank-you for the opportunity to review CDFG's *Status Review of California Coho Salmon Draft* April 2002 ("Status Review"). I am not an expert on coho genetics. Rather my expertise is in assessing potential cumulative impacts to anadromous salmonids.

After reading the Executive Summary and being a self-confessed data junkie, I turned straight to the appendices (F2) to determine how well CDFG's assessment fared in portions of the Northcoast most familiar to me. I live on Lindsay Creek, a tributary to the Mad River. The Status Review comments on Lindsay Creek were detailed (p.44) given the broad scope of the Status Review, even noting the absence of coho on Grassy Creek (which historically must have supported coho). In the upper South Fork Eel River, the results from tributaries surveyed for coho presence/absence seemed accurate. I'm not sure how streams such as Fox Creek and Elder Creek are integrated into the assessment given these were likely never coho streams (though I have seen a few adults in the first 300 m of lower Elder Creek). Were these streams excluded from the presence/absence analysis? In contrast, lower Rock Creek is listed as having no coho observed. Though I have seen a few adults and juveniles in the 1980's, the lower 1.2 km has many geomorphic features favoring coho habitat, especially wide meanders through a low Eel River terrace. Rock Creek most likely received considerable historic coho use, and therefore should be included in a presence/absence analysis. To satisfy my scientific curiosity I could use more detail in the Status Review on the presence/absence analysis, though this level of detail may not be practically suited for the present draft.

The background life history section was complete. Drawing boundaries on the landscape is always difficult and somewhat arbitrary. The Mattole River population is so low that endangered status would be warranted, even though the Mattole watershed is just outside the CCC Coho ESU.

Even though suspended sediment and turbidity are discussed (p.27), the matrix of "fundamental habitat elements and suitable ranges for coho salmon life stages" (Table 4 on pp.32-33) omits the effects of turbidity on juvenile life stages and uses "ounces/gal" of sediment that affects adult coho. Given that the best physical variable for measuring cumulative watershed effects is suspended sediment, the matrix should devote considerable attention to this pivotal physical variable. There is a tremendous literature compiled by several investigators. A key to the recovery of coho in Northern California will be the formation and enforcement of credible suspended sediment and turbidity thresholds. This is a serious omission, and indicates that CDFG has not spent the necessary effort investigating meaningful quantitative criteria. I have often wondered why CDFG and the RWQCB have not produced a joint guideline for acceptable suspended sediment and turbidity thresholds, given their similar stewardship responsibilities for protecting fish and beneficial uses. Perhaps this would be a good recommendation for Chapter IX? Another recommendation, of using 30% to 50% of the annual flow for adult migration (p.32), needs revision. Davenport Creek with a 0.93 mi^2 watershed behind my house had 17 redds constructed this past December and January. Riffle depths at 50% of the annual flow ranged from 2.5 to 3.4 inches deep, not the depths recommended for threatened fish passage! Other examples for poor quantitative measures can be taken from this matrix. CDFG should consider either dramatically improving it or eliminating it (perhaps making it a recommended task in Chapter IX).

I was asked as a reviewer: “Does the report seem reasonably complete and accurate with regard to its assessment of whether the continued existence of coho salmon north of San Francisco is in serious danger or is threatened by present or threatened modification or destruction of its habitat?” The Status Review does not present an accurate assessment of recent forestry activities (pp. 147 to 154) relative to present and potential future degradation of coho habitat. State and federal agencies, except staff of the North Coast Regional Quality Control Board, continue to discount obvious significant cumulative impacts directly attributable to excessive timber harvest rates in the SONCC Coho ESU. I was a member of the Scientific Review Panel (SRP) tasked by the California Resources Agency and NMFS with evaluating the effectiveness of the forest practice rules (FPRs) and their implementation in protecting Northern California salmon. In the *Report of the Scientific Review Panel of California Forest Practice Rules and Salmonid Habitat* (June 1999) the panel concludes that: “the FPRs, including their implementation (the “THP” process) do not ensure protection of anadromous salmon populations. The prime deficiency of the FPRs is the lack of a watershed analysis approach capable of assessing cumulative effects attributable to timber harvesting and other non-forestry activities on a watershed scale.” The panel also recommended that a range of maximum harvest rates be established in lieu of having a functional watershed analysis in place for all Northcoast watersheds. The Status Review leaves the impression that the SRP’s conclusion has been adequately addressed since 1999. The Status Review states (p.149), “Based upon the SRP’s findings and recommendations, the BOF adopted interim FPRs that went into effect in the summer of 2000.” Many good measures recommended by the SRP have been incorporated into new rules changes and procedures. But concluding as a scientist in 2002, and not as spokesperson for the now-extinct Science Review Panel, the measures adopted by the Board of Forestry (BOF) in 2000 and afterwards have been insufficient to alter the conclusion of the SRP’s report. For example, the NCWAP proposal does not remotely meet what the SRP Report outlines as necessary for a functional watershed analysis program that scientifically addresses potential cumulative watershed effects.

The status quo of chronic habitat degradation, and in many watersheds accelerated degradation, has not been abetted or reversed. Many key SRP recommendations were rejected, while other key recommendations were highly altered (e.g., recent BOF changes to determining the Watercourse Transition Line along unconfined Class I channels). The Pacific Lumber Company Habitat Conservation Plan (pp. 150 and 151), portrayed in the Status Review as a model for protecting habitat, is a prime example of not addressing cumulative impacts attributable to excessive harvest rates, highlighting what the SRP hoped to prevent. While many measures to reduce impacts cited on p.151 are needed, coho habitat cannot be sustained (let alone recovered) when harvest rates exceed 80% in tributary watersheds within 10 years. Recent (since the mid-1990s) excessive timber harvest rates in Freshwater Creek and Elk River have generated some of the muddiest streams in Northern California, creating turbidities that exceed background conditions in comparable second-growth watersheds by more than one thousand percent. Notwithstanding, CDF continues to approve THPs in these watersheds, justified by an antiquated doctrine that Best Management Practices (BMPs) prevent significant cumulative watershed impacts. The agencies, with the exception noted, are focusing on how to harvest and manage an acre of timberland while side-stepping the critical issue of how many acres can be safely harvested. Until cumulative impacts due to the rate of timber harvest are part of the decision-making process (and not the lip service provided in the FPR), future prospects for healthy coho populations in many watersheds of the SONCC Coho ESU will be bleak.

CDFG in Chapter IX must recommend realistic management activities and inter-agency strategies (some painful) to aid coho recovery in order to justify threatened status in the SONCC Coho ESU. For example, how will CDFG help make CDF (p.192) “an active partner in stabilization and restoration of coho habitat within wildland areas though their authority for timberland management and wildland and rural fire control” when CDF has done such a poor job to date? Why hasn’t CDFG supported the Regional Water Quality Control Board mandate to prevent excessive harvest rates in critical coho watersheds? Can the extremely high turbidities generated in Freshwater Creek tributaries really be meeting CDFG’s expectations for recovery (p.191)? These and other critical uncertainties directly bear on the Status Review’s conclusions in the Executive Summary (p.2): “…the Department believes that coho populations in the California portion of this ESU [SONCC Coho ESU] will likely become endangered in the foreseeable future in the absence of the protection and management required by CESA.” If the recent BOF changes and development of Habitat Conservation Plans are considered by CDFG adequate to protect and manage as required by the CESA, then a threatened status for the SONCC Coho ESU is not enough because I do not share the same conclusion.

In summary, the Department has done a commendable job collecting and synthesizing the data to quantitatively, as best as possible, justify their rationale for listing coho salmon in both ESUs. It wasn’t an easy undertaking. However, the Status Review’s assessment of present and future protection of coho habitat is deficient. If the coho’s threatened status in the SONCC Coho ESU really hinges on whether coho are receiving, and will receive, adequate protection and management to prevent “foreseeable” endangerment, the Status Review does not make a sufficient argument. I must reserve my opinion of threatened status in the SONCC Coho ESU until the recommendations for future management (Chapter IX) are available.

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14 April 2002

Larry Week, Chief
Native Anadromous Fish and Watershed Branch
California Department of Fish and Game
1807 13th St, Suite 104
Sacramento CA 95814

Re: Status review of California coho

Dear Mr. Week:

Thank you for giving me the opportunity to review the draft of *Status review of California coho salmon (Oncorhynchus kisutch*). I was very impressed by the document. It was thorough and provided much new information on status of the coho, confirming the results of past studies (including my own) that coho salmon are in danger of extinction in California, even in the more northern parts of the state. While the decline of coho salmon populations in California is the result of many interacting factors, the overwhelming cause is degradation of their freshwater environments by logging, urbanization, farming, and other human activities that reduce water quality and quantity and reduce habitat complexity. I think the document demonstrates that the downward trends are so dramatic and pervasive that coho salmon should be listed as endangered throughout California, not just in the southernmost part of their range. While I agree that the danger of extinction of many populations is not as immediate in the northern part of their range, an abrupt change in ocean conditions that reduces ocean survival rates could accelerate ongoing declines in an unpredictable fashion. Listing all populations of coho in California as endangered would send a clear signal about the State's concern for their survival and the need to reverse the trends in degradation statewide of our coastal streams.

Here are some minor comments on the report itself.

Pages 21-22. There should be reference to the studies of Jennifer Nielsen which show there are multiple ways juvenile coho use stream and estuary habitats in California (See 1992, Trans. Amer. Fish. Soc. 121 617-634.)

Pages 32-33. Table 4 is very hard to understand, especially the Suitable Range column for almost all elements. In particular I have never seen turbidity and dissolved oxygen expressed as “ounces/gallon” in the recent literature.

Page 36. first paragraph. Hatcheries can be sinks for wild fish as spawning adults. Data presented elsewhere in reports shows that declines of coho often continue or even accelerate after hatcheries have been established, suggesting that the additional removal of wild spawners from the population has hurt m more than helped.

Pages 86-87. The discussion on marine predation is very thorough and rightly concludes there is no evidence of predation having a negative impact on coho salmon. It might be worth mentioning that sea lions in estuaries prey heavily on Pacific lampreys, perhaps reducing predation rates on salmon.

Pages 102. I think it is worthwhile pointing out in the text that Monschke (1996) and Lisle and Napolitano (1998) are studies in California. When the final draft of this report is prepared, any study working with California coho should clearly be identified as such, to demonstrate that much of the information on which the report does come from local sources.

Page 109. Large woody debris and elsewhere. Nickelson et al. (1992, in bibliography) and (1992, Can J Fish Aquat Sci 49: 790-794) indicate that overwintering habitat may be more critical than summer habitat for survival of juvenile coho in southern Oregon. This should be emphasized more in this section of the report and the statement on p 22 stated more strongly.

Page 164. Suction Dredging. The rather lengthy sentence ending in …(Mapstone 1995) seems to be referring to the **precautionary principle** which is being advocated by more innovative fisheries managers. Why not quote Dayton (1998) more directly and mention the possibility of using the principle widely in reference to management of coho salmon? Our failure to use the precautionary principle as a basis for management is at the root of many of our fisheries declines, including coho salmon. Timber harvest plans, for example, should be required to demonstrate they do no harm to coho, rather than having overworked CDFG biologists have to prove they harm coho.

Page 195. Final sentence. Would be more accurate to say “Eventually, extinction of coho salmon throughout California could result.”

These comments are obviously minor and I find the report to be overall of very high quality in summarizing and interpreting the existing literature. I hope that much of the report will be published as a CDFG *Fish Bulletin* in the near future, so it can be a useful ‘benchmark’ reference for fisheries biologists interested in coho salmon management for a long time to come and not lost as just another report.

Sincerely,

Peter B. Moyle
Professor

APPENDIX C

California Department of Fish and Game 2001
Coho Presence Investigation

APPENDIX C1.

Modified Ten Pool Protocol Methodology
DRAFT

California Department of Fish and Game
Northern California - North Coast Region

Modified Ten Pool Protocol
For Use During
Calendar Year 2001 Coho Salmon
Presence/Absence Surveys

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INTRODUCTION

In response to the petition to the California Fish and Game Commission to list coho salmon as an endangered species, pursuant to the California Endangered Species Act (CESA), personnel of the California Department of Fish and Game's (CDFG) Northern California - North Coast Region (NC-NCR) will determine coho salmon presence/absence in a portion of their range in Northern California (Winchuck River system south to the Mattole River system). The objective of this survey is to document coho salmon presence/absence in 396 locations identified in Brown and Moyle's 1994 coho salmon status review in Humboldt, Del Norte, Trinity, Siskiyou, Mendocino and Glenn Counties. This documentation will provide a basis for comparison of the status of coho salmon (in terms of percent presence/absence) reported by Brown and Moyle (1994) with the latest available information. Our approach has two phases: i) file review, and ii) field survey using a modified version of a Ten Pool Protocol reported by Adams et al. (1996).

File Review. CDFG personnel will collect all available current and historic files which describe fish sampling efforts and findings for each of the 396 locations in the project area. The Department of Fish and Game file records will be augmented with data obtained from other sources, including but not limited to, the Forest Science Project (FSP), Humboldt State University, Simpson Timber Company, PALCO and other Scientific Collectors. All documents will be reviewed for date, location, and coho salmon presence. If coho salmon were present, we would attempt to determine their brood year. The result of this effort will be to generate a coho salmon brood year lineage for each stream. Streams with documented coho salmon presence of three consecutive brood years during the period of 1994 through 2000 will not be surveyed in 2001. Streams with missing brood year information will be sampled by any means. If a missing brood year is not established by simpler means, then the ten pool protocol will be employed.

Field Survey. For streams where coho salmon presence/absence data is lacking, or there is no recent survey indicating the presence of coho salmon, the modified ten-pool protocol (described below) will be employed.

Sampling reaches (LOWER MIDDLE, UPPER) will be predetermined before entering the field using the best available data, including, but not limited to previous habitat and biological surveys, stream gradient, channel type, channel entrenchment, topography, size, location of tributary streams and private lands access agreements. GIS will be used to divide the anadromous section of each stream into gradients of 0 to 5%, >5 to <10%, and ≥10%. Stream segments with 0-5% gradient will be given a higher priority for sampling effort. For the purpose of this year's survey, the end of coho salmon anadromy is defined as 0.5 kilometer (0.3 miles) with ≥10% slope and the absence of perennial stream segments with ≤ 5% gradient further upstream.

Snorkel surveys (direct observation) will be the primary sampling technique employed. If project personnel encounter situations where physical habitat features render snorkel surveys ineffective (e.g., high turbidity, deep pools) or if human health hazards (e.g., dairy waste or unknown waste discharges) are present, then alternate sample methods should be employed. Minimum crew sizes for each sampling method are as follows: snorkel survey (2 people); backpack electrofishing (minimum of two people per electrofisher); seining (3 people); and baited minnow trapping (2 people). Snorkeling, electrofishing (a second backpack shocker may be used if the stream is wider than 10 feet) and seining effort will be limited to one pass. Baited minnow trapping effort should be confined to one set (30 minute soak) of at least two traps per pool.

MODIFIED TEN POOL PROTOCOL

A minimum of three reaches will be surveyed in the following sequence: LOWER - MIDDLE - UPPER. Ten pools or flatwater habitat units (hereafter referred to as pools) will be surveyed in any given reach; these ten pools constitute a Survey Section. Field crews will have the latitude to select pools based on shade, velocity and instream habitat complexity, however crews may not skip more than five pools in any given Survey Section.

The pool survey for the lowermost reach will commence where the stream has defined banks and its habitat features are defined by its stream power. This protocol excludes stream segments flowing through aggraded deltas or other areas influenced by high flow of the water to which it is tributary.

Habitats will be sampled as defined by the Level II category for stream habitat typing (riffle, pool, flatwater). The primary Level II habitat types surveyed will be pools; however, if pool habitat is lacking, flatwater habitats (glides, pocket water, run, and step-run) will be sampled. Target streams will be surveyed according to the following decision sequence:

- If coho salmon are present (presence is defined as one coho salmon) in the LOWER Reach Survey Section, then it is not necessary to examine the MIDDLE or UPPER Reaches. Complete all ten pools in the LOWER Reach Survey Section before moving onto the next stream assignment list and repeat this decision sequence.

- If coho salmon are not observed in the LOWER Reach Survey Section, then move up to the MIDDLE Reach Survey Section. If coho salmon are observed in the MIDDLE Reach Survey Section, then it is not necessary to examine the UPPER Reach Survey Section. Move on to the LOWER Reach Survey Section of the next stream on your assignment list and repeat this decision sequence.

- If coho salmon are not observed in the MIDDLE Reach Survey Section, then move up to the UPPER Reach Survey Section. Examine 10 pools and record your findings. Move on to the LOWER Reach Survey Section of the next stream on your assignment list and repeat this decision sequence.

Each surveyed reach shall be flagged at the downstream end and labeled with the following:

II DATE (dd/mm/yyyy)
II DFGCI (acronym for Department of Fish and Game Coho Investigation)
II Stream Reach designation (LOWER, MIDDLE, or UPPER)

Flagging will not be hung within State, National or City Parks, urban areas or anywhere it would be considered a visual nuisance by property owners. These areas are generally high traffic areas, within city limits or close to roads.

The upper and lower boundary of each survey section will be geo-referenced, using GPS, as a waypoint for later downloading into GIS. A Waypoint is entered as a combination of numbers and letters using the unique (Brown and Moyle) designated stream number, followed by a hyphen and A for lower, B for middle or C for the upper survey area. The numerals 1 and 2 are used to define the lower or upper survey area boundary, respectively. For example, the waypoint for the boundary of the lowermost reach of Howe Creek, Eel River is 252-A1. Conversely, the end of the uppermost sample segment of Howe Creek is 252-C2.

The defaults settings for the standard issue GPS 12XL will be the following: Position Format = decimal degrees (hddd.dddd°); Navigation Setup: Map Datum = NAD 27 CONUS, CDI = $\pm$0.25, Angle = Degrees, Units = Statute, Heading = E016; System Setup, Offset -7.00, Hours =24. GPS units will be checked prior to each days field surveys for the above settings due to the possibility of the units resetting to factory defaults when the batteries run low.

Snorkel surveyors will travel through each Survey Section in an upstream direction. Enter each pool at the downstream end, in a manner which will minimize fish disturbance, and move upstream. Record fish and other vertebrate species observed; assign an abundance category (e.g., 0 = no fish, 1 = 1 fish; 2 = 2-5 fish; 3 = > 5 fish) for each fish species present. Salmon (e.g., chinook and coho) will be identified by species. Steelhead and coastal cutthroat trout are difficult to identify at a small size, so lump them together and record your abundance rating in the "Trout" column on the data card. Separate coastal cutthroat trout from steelhead only if you can make a positive identification.

If a crew encounters a section where stream gradient exceeds 10% which was not modeled by GIS or any other barriers, the crew will determine if continuing the survey is warranted. If coho salmon passage is not possible, then survey the ten pools immediately downstream of the barrier and fully document the decision-making process through narrative and photographs. The base of the barrier should be recorded in the field notes and entered in the GPS as a waypoint. If coho salmon passage is possible, then proceed to the next reach assignment, but note and photograph this area for future reference.

While conducting your survey, it may be necessary to check a pool a second time because one or both members are not confident in their results. In this case, wait at least 20 minutes to let the fish settle down and for the pool to clear, then repeat the dive. If the team members agree that confidence is again low, flag the pool and enter its coordinates as a waypoint in the GPS, and move upstream to the next pool. Be sure not to count the problem pool as part of the ten pools. If the confidence level is high, then only record results of the second dive. In either case, clearly describe your decision-making process on the data sheet.

Record the description of each surveyed pool to Level IV Habitat Type category, if possible. Visually estimate average wetted width, average length, and maximum depth for all surveyed pools. In the case of a skipped pool (see preceding paragraph), identify its Level IV designation and visually estimate the dimensions of the pool.

Photographs. Take at least one photograph of each pool surveyed. The photograph(s) should frame the entire pool and all its significant features. Photographs should include a placard (Mylar or plastic slate) with the stream name, location, reach, and pool number. The placard with the stream name should be located in the shade to keep the lettering from washing out in the picture. Photographs of fish barriers, water diversion, sources of pollution, and examples of excellent habitat conditions should also have a placard with stream name in view. Using a fine point Sharpe, label all used rolls of film and their canisters with the date, stream name and reach. Write the same information on a separate piece (two to three inches) of flagging and also place it inside the film cannister. (Note: do not change film where a dropped roll could be lost. For example, do not sit on a rock in mid-stream and change rolls as a dropped roll of film can be swept away.)

If you use sampling methods that will give you “fish-in-hand” (e.g., electrofishing, baited minnow trapping, etc., photograph at least one coho salmon for documentation, when they are found.

At the end of each stream survey and before leaving the area, spend several minutes writing a narrative about special stream features, especially the reason for deviating from the established protocol. A journal will be included in each sample kit for this purpose.

Snorkel Survey Training

Snorkel surveyors will have a minimum of 8 dive hours in waters bearing coho salmon, chinook salmon and steelhead. Snorkel divers will be taught and practice standardized counting techniques, fish identification, and habitat type recognition. These training hours are to be supervised by a Department fisheries biologist or other trained and qualified equivalent individuals with at least three field seasons of snorkeling experience for juvenile salmonids. Records of training hours will be maintained. Snorkel surveyors will only be deployed in the field if they are capable of identifying coho salmon, chinook salmon and steelhead with no errors.

Backpack electrofishing crews will be lead by project-members who have had at least one field season of electrofishing experience. To become an electroshocking crew leader, a crew member must have at least 160 hours of supervised hands-on experience and the confidence of their lead and co-workers. This training will include familiarization with electrofisher set-up, setting controls, electrofishing techniques, fish anesthesia, fish identification and handling. Techniques to minimize the risk of fish injury and mortality will be stressed.

Each project-member will gain at least 4 hours of supervised hands-on training by an experienced Department fisheries biologist in the use of baited minnow traps and it's application in fish surveys. This training will include identifying trap locations, trap rigging and baiting, deployment, trap recovery, fish removal and handling.

All divers will be given water safety training (including swiftwater rescue technician [or equivalent] training, first aid, CPR, and other tailgate safety briefings, as appropriate.

Quality Assurance/Quality Control

Up to 5% of all streams will be selected for a re-visit by a second snorkel survey team for the purpose of Quality Assurance/Quality Control (QA/QC). The dive team conducting the QA/QC will: i) not have access to the survey data to avoid bias, ii) will employ the one pass method, and iii) conduct the dive during the same work week the first dive occurred.

If the species list resulting from the QA/QC survey varies from the list of species observed in the first survey, the first team is placed under probation. Crew members under probation will be paired up with a biologist; probation will be lifted once the biologist's confidence is regained.

Because photographs will record species composition, QA/QC will not be required for minnow trapping and electrofishing surveys.

Each data omission on the field form, without explanation, and changes of protocol without explanation constitute a QA/QC error. Five data entry irregularities per stream reach will constitute data QA/QC failure and will require data audits of the next five stream surveys.

LITERATURE CITED

Adams, P.B., T.E. Laidig, K.R. Silverberg, M.J. Bowers, B.M. Jarvis, K.M. Sakuma, K. Baltz, and D. Woodbury. 1996. Historical and Current Presence-Absence Data of Coho Salmon (*Oncorhynchus kisutch*) in the Central California Evolutionary Significant Unit. U.S. National Marine Fisheries Service. Southwest Science Center Administrative Report T-96-01. 24 p.

Adams, P.B., M.J. Bowers, H. Fish, T.E. Laidig, and K.R. Silverberg. 1999. Historical and Current Presence-Absence of Coho Salmon (*Oncorhynchus kisutch*) in the Central California Coast Evolutionarily Significant Unit. U.S. National Marine Fisheries Service. Southwest Science Center Administrative Report SC-99-02. 24 p.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical Decline and Current Status of Coho Salmon in California. North American Journal of Fisheries Management 14:237-261.

Brownell, N.F., W.M. Kier, and M.L. Reber. 1999. Historical and Current Presence and Absence of Coho Salmon, *Oncorhynchus kisutch,* in the Northern California Portion of the

Southern Oregon-Northern California Evolutionary Significant Unit. Report prepared for the U.S. National Marine Fisheries Service, Southwest Fisheries Science Center. Kier and Associates, Sausalito, California. 49 p.

APPENDIX C2

List of Streams Surveyed

Southern Oregon/Northern California Coast ESU

Stream	Basin	Coho Presence	Stream	Basin	Coho Presence	Stream	Basin	Coho Presence
South Fork Winchuck River	Winchuck River	yes	Klamth River (estuary)	Klamath River	yes	Lower South Fork Little River	Little River	yes
Broken Kettle Creek (S. Fork)	Illinois River	yes	Hunter Creek	Klamath River	yes	Upper South Fork Little River	Little River	yes
Elk Creek	Illinois River	yes	Terwer Creek	Klamath River	yes	Strawberry Creek	Coastal	no
Dunn Creek	Illinois River	yes	McGarvey Creek	Klamath River	yes	Mad River	Mad River	yes
Smith River	Smith River	yes	Blue Creek	Klamath River	yes	Warren Creek	Mad River	yes
Rowdy Creek	Smith River	yes	Nickowitz Creek	Klamath River	no	Lindsay Creek	Mad River	yes
Dominie Creek	Smith River	yes	Ah Pah Creek	Klamath River	yes	Grassy Creek	Mad River	no
Savoy Creek	Smith River	yes	Trinity River	Klamath River	yes	Squaw Creek	Mad River	yes
Copper Creek	Smith River	yes	Campbell Creek	Klamath River	yes	Mather Creek	Mad River	yes
Morrison Creek	Smith River	no	Horse Linto Creek	Klamath River	yes	Hall Creek	Mad River	yes
Jaqua Creek (Little Mill Creek)	Smith River	yes	Willow Creek	Klamath River	yes	Noisy Creek	Mad River	yes
Mill Creek	Smith River	yes	S. Fk Trinity River	Klamath River	yes	Mill Creek	Mad River	no
E Fork Mill Creek	Smith River	yes	N. Russian Creek	Klamath River	no	Leggit Creek	Mad River	no
Bummer Lake Creek	Smith River	yes	Knownothing Creek	Klamath River	yes	Kelly Creek	Mad River	no
West Branch Mill Creek	Smith River	yes	Tompkins Creek	Klamath River	no	Powers Creek	Mad River	no
South Fork Smith River	Smith River	yes	Kelsey Creek	Klamath River	no	Palmer Creek	Mad River	no
Craigs Creek	Smith River	no	Mill Creek	Klamath River	yes	Quarry Creek	Mad River	no
Coon Creek	Smith River	no	Patterson Ck	Klamath River	no	N Fk Mad River	Mad River	yes
Hurdygurdy Creek	Smith River	no	Etna Creek	Klamath River	no	Sullivan Gulch	Mad River	yes
Jones Creek	Smith River	no				Dry Creek	Mad River	no
Muzzleloader Creek	Smith River	no	French Creek	Klamath River	yes	Canon Creek	Mad River	yes
Buck Creek	Smith River	no	Miners Creek	Klamath River	yes	Maple Creek	Mad River	yes
Quartz Creek	Smith River	no	Sugar Creek	Klamath River	no	Black Creek	Mad River	no
Eightmile Creek	Smith River	yes	Big Mill Creek	Klamath River	no	Boulder Creek	Mad River	yes
Williams Creek	Smith River	no	Shasta River	Klamath	yes	Janes Creek	Humboldt Bay	no
Myrtle Creek	Smith River	no	Bogus Creek	Klamath River	yes	Jolly Giant Creek	Humboldt Bay	no
Hardscrabble Ck.	Smith River	no	Redwood Creek	Redwood Creek	yes	Jacoby Creek (Morrison Gulch)	Humboldt Bay	yes
Still Creek	Smith River	no	Prairie Creek	Redwood Creek	yes	Rocky Gulch	Humboldt Bay	no
Diamond Creek	Smith River	no	Little Lost Man Creek	Redwood Creek	yes	Cochran Creek	Humboldt Bay	no
			Lost Man Creek	Redwood Creek	yes	Freshwater Ck	Humboldt Bay	yes
Eighteenmile Creek	Smith River	no	Streelow Creek	Redwood Creek	yes	McCready Creek	Humboldt Bay	yes
Patrick Creek	Smith River	yes	May Creek	Redwood Creek	yes	Little Freshwater	Humboldt Bay	yes
Twelvemile Ck	Smith River	no	Godwood Creek	Redwood Creek	yes	Cloney Creek	Humboldt Bay	yes
Elevenmile Creek	Smith River	no	Boyes Creek	Redwood Creek	yes	Falls Gulch	Humboldt Bay	yes
Shelly Creek	Smith River	no	Brown Creek	Redwood Creek	yes	Graham Gulch	Humboldt Bay	yes
Tenmile Creek	Smith River	no	Tom McDonald Ck	Redwood Creek	yes	Ryan Creek	Humboldt Bay	yes
West Fork Patrick Creek	Smith River	no	Bridge Creek	Redwood Creek	yes	North Fork Elk River	Humboldt Bay	yes
Monkey Creek	Smith River	no	Coyote Creek	Redwood Creek	no	Martin Creek	Humboldt Bay	yes
Siskiyou Fork	Smith River	no	Panther Creek	Redwood Creek	no	South Fork Elk River	Humboldt Bay	yes
Packsaddle Ck	Smith River	no	Lacks Creek	Redwood Creek	no	Little South Fork Elk River	Humboldt Bay	yes
Griffin Creek	Smith River	no	McDonald Creek	Stone Lagoon	no	College of Redwoods Ck	Humboldt Bay	no
Knopti Creek	Smith River	yes	Fresh Creek	Stone Lagoon	no	Salmon Creek	Humboldt Bay	no
Yonkers Creek	Coastal	no	Big Lagoon	Big Lagoon	no			
Jordan Creek	Coastal	no	Little River	Little River	yes			
Elk Creek	Coastal	yes	South Fork Little River (Carson Ck)	Little River	yes			
Wilson Creek	Coastal	yes						
Eel River estuary	Eel River	yes	Bear Pen Creek	Eel River	yes	McNutt Gulch	Coastal	no
Salt River	Eel River	no	Cub Creek	Eel River	no	Mattole River	Mattole River	yes
Russ Creek	Eel River	no	Red Mountain Creek	Eel River	no	North Fork Mattole River	Mattole River	no
Reas Creek	Eel River	no	Wildcat Creek	Eel River	no	Mill Creek	Mattole River	no
Palmer Creek	Eel River	no	Hollow Tree Creek	Eel River	yes	Clear Creek	Mattole River	no

Stream	Basin	Coho Presence	Stream	Basin	Coho Presence	Stream	Basin	Coho Presence
Rohner Creek	Eel River	no	Mule Creek	Eel River	no	McGinnis Creek	Mattole River	no
Van Duzen River	Eel River	no	Walters Creek	Eel River	no	Indian Creek	Mattole River	no
Wolverton Gulch	Eel River	no	Redwood Creek	Eel River	yes	Squaw Creek	Mattole River	no
Yager Creek	Eel River	no	Bond Creek	Eel River	yes	Granny Creek	Mattole River	no
Wilson Creek	Eel River	no	Michaels Creek	Eel River	yes	Saunders Creek	Mattole River	no
Cooper Mill Creek	Eel River	no	Waldron Creek	Eel River	no	Woods Creek	Mattole River	yes
Lawrence Creek	Eel River	no	Huckleberry Creek	Eel River	yes	Upper N. Fork Mattole River	Mattole River	no
Shaw Creek	Eel River	no	Butler Creek	Eel River	yes	Oil Creek	Mattole River	no
Cuddeback Creek	Eel River	no	Cedar Creek	Eel River	no	Honeydew Creek	Mattole River	yes
Fiedler Creek	Eel River	no	Rattlesnake Creek	Eel River	no	Bear Trap Creek	Mattole River	no
Cummings Creek	Eel River	no	Cummings Creek	Eel River	no	Dry Creek	Mattole River	no
Hely Creek	Eel River	no	Tenmile Creek	Eel River	yes	Middle Creek	Mattole River	no
Root Creek	Eel River	no	Grub Creek	Eel River	no	Gilham Creek	Mattole River	no
Grizzly Creek	Eel River	no	Streeter Creek	Eel River	no	Fourmile Creek	Mattole River	yes
Stevens Creek	Eel River	no	Big Rock Creek	Eel River	no	Sholes Creek	Mattole River	yes
Hoagland Creek	Eel River	no	Mill Creek	Eel River	no	Harrow Creek	Mattole River	no
Little larabee Creek	Eel River	no	Cahto Creek	Eel River	no	Grindstone Creek	Mattole River	yes
Price Creek	Eel River	no	Fox Creek	Eel River	no	Mattole Canyon	Mattole River	no
Howe Creek	Eel River	no	Elder Creek	Eel River	no	Blue Slide Creek	Mattole River	no
Atwell Creek	Eel River	no	Jack of Hearts Creek	Eel River	yes	Bear Creek	Mattole River	no
Dinner Creek	Eel River	no	Little Charlie Creek	Eel River	no	South Fork Bear Creek	Mattole River	no
Jordan Creek	Eel River	no	Dutch Charlie Creek	Eel River	yes	Bridge Creek	Mattole River	no
Shively Creek	Eel River	no	Redwood Creek	Eel River	yes	McKee Creek	Mattole River	no
Bear Creek	Eel River	no	Rock Creek	Eel River	no	Vanauken Creek	Mattole River	no
Chadd Creek	Eel River	no	Kenny Creek	Eel River	yes	Mill Creek	Mattole River	yes
Larabee Creek	Eel River	no	Haun Creek	Eel River	no	Baker Creek	Mattole River	yes
Carson Creek	Eel River	no	Taylor Creek	Eel River	yes	Thompson Ck	Mattole River	yes
South Fork Eel River	Eel River	yes	Bear Creek	Eel River	no			
Bull Creek	Eel River	yes	Newman Creek	Eel River	no			
Squaw Creek	Eel River	no	Kekawaka Creek	Eel River	no			
Albee Creek	Eel River	no	Bluff Creek	Eel River	no			
Mill Creek	Eel River	no	Middle Fork Eel River	Eel River	no			
Canoe Creek	Eel River	yes	Mill Creek	Eel River	no			
Bridge Creek	Eel River	no	Grist Creek	Eel River	no			
Elk Creek	Eel River	no	Rattlesnake Creek	Eel River	no			
Salmon Creek	Eel River	yes	Rock Creek	Eel River	no			
Butte Creek	Eel River	no	Outlet Creek	Eel River	no			
Fish Creek	Eel River	no	Bloody Run Creek	Eel River	no			
Anderson Creek	Eel River	no	Long Valley Creek	Eel River	no			
Dean Creek	Eel River	no	Reeves Canyon Creek	Eel River	no			
Redwood Creek	Eel River	yes	Rowes Creek	Eel River	no			
Seely Creek	Eel River	yes	Ryan Creek	Eel River	no			
Miller Creek	Eel River	no	Mill Creek	Eel River	yes			
China Creek	Eel River	yes	Willits Creek	Eel River	yes			
Dinner Creek	Eel River	yes	Dutch Henry Creek	Eel River	no			
Sproul Creek	Eel River	yes	Broaddus Creek	Eel River	yes			
Warden Creek	Eel River	no	Baechtel Creek	Eel River	yes			
West Fork Sproul Creek	Eel River	yes	Haehl Creek	Eel River	no			
East Branch South Fork Eel River	Eel River	no	Rocktree Creek	Eel River	no			
Durphy Creek	Eel River	no	String Creek	Eel River	no			
Milk Ranch Creek	Eel River	no	Tartar Creek	Eel River	no			
Low Gap Creek	Eel River	no	Bear River	Bear River	no			
Indian Creek	Eel River	yes	Bonanza Gulch	Bear River	no			
Piercy Creek	Eel River	yes	South Fork Bear River	Bear River	no			
Standley Creek	Eel River	yes	Hollister Creek	Bear River	no			
McCoy Creek	Eel River	yes						

Central California Coast ESU

Stream	Basin	Coho Presence		Stream	Basin	Coho Presence
Whale Gulch Creek	Coastal	no		Doyle Creek	Coastal	yes
Jackass Creek (Wolf)	Coastal	no		Little Salmon Cr.	Big Salmon Creek	yes
Russian Gulch	Coastal	no		Flynn Creek	Navarro River	yes
Mill Creek	Navarro River	no		Mark West Creek	Russian River	yes
Indian Creek	Navarro River	no		Cottoneva Creek	Coastal	yes
Gut Creek	Navarro River	no		SF Cottoneva Creek	Cottoneva Creek	yes
Rancheria Creek	Navarro River	no		Ten Mile River	Coastal	yes
Ham Canyon Creek	Navarro River	no		NF Ten Mile River	Ten Mile River	yes
Horse Creek	Navarro River	no		Little NF Ten Mile	Ten Mile River	yes
Brush Creek	Coastal	no		SF Ten Mile River	Ten Mile River	yes
Fish Rock Gulch	Coastal	no		Smith Creek	Ten Mile River	yes
Gualala	Coastal	no		Campbell Creek	Ten Mile River	yes
NF Gualala River	Gualala River	no		Churchman's Creek	Ten Mile River	yes
Doty Creek	Gualala River	no		MF Ten Mile River	Ten Mile River	yes
SF Gualala River	Gualala River	no		Bear Haven Creek	Ten Mile River	yes
Franchini Creek	Gualala River	no		Little Valley Creek	Pudding Creek	yes
Marshall Creek	Gualala River	no		Little NF Noyo R.	Noyo River	yes
Wheatfield Fork	Gualala River	no		Duffy Gulch	Noyo River	yes
Haupt Creek	Gualala River	no		NF Noyo River	Noyo River	yes
House Creek	Gualala River	no		Marble Gulch	Noyo River	yes
Fort Ross Creek	Coastal	no		Haysworth Creek	Noyo River	yes
Russian Gulch	Coastal	no		Olds Creek	Noyo River	yes
Middle Branch	Russian Gulch	no		Redwood Creek	Noyo River	yes
East Branch	Russian Gulch	no		Big River	Coastal	yes
Willow Creek	Russian River	no		NF Big River	Big River	yes
Sheephouse Creek	Russian River	no		EB NF Big River	Big River	yes
Freezeout Creek	Russian River	no		Albion River	Coastal	yes
Austin Creek	Russian River	no		SF Albion River	Albion River	yes
Kidd Creek	Russian River	no		Railroad Gulch	Albion River	yes
Ward Creek	Russian River	no		NF Albion River	Albion River	yes
East Austin Creek	Russian River	no		Big Salmon Creek	Coastal	yes
Gilliam Creek	Russian River	no		Hazel Gulch	Big Salmon Creek	yes
Gray Creek	Russian River	no		Navarro River	Coastal	yes
Dutch Bill Creek	Russian River	no		SB NF Navarro R	Navarro River	yes
Hulbert Creek	Russian River	no		NB NF Navarro R	Navarro River	yes
Dry Creek	Russian River	no		Little NF Navarro	Navarro River	yes
Mill Creek	Russian River	no		John Smith Creek	Navarro River	yes
Wallace Creek	Russian River	no		Lagunitas Creek	Lagunitas Creek	yes
Pena Creek	Russian River	no		Olema Creek	Lagunitas Creek	yes
EF Russian River	Russian River	no		Devil's Gulch Cr.	Lagunitas Creek	yes
WF Russian River	Russian River	no		San Geronimo Cr.	Lagunitas Creek	yes
York Creek	Russian River	no		Pine Gulch Creek	Bolinas Lagoon	yes
Forsythe Creek	Russian River	no		Redwood Creek	Coastal	yes
Mill Creek	Russian River	no		Walker Creek	Tomales Bay	
Seward Creek	Russian River	no		Salmon Creek	Walker Creek	
Eldridge Creek	Russian River	no		SF Gualala River	Gualala River	
Jack Smith Creek	Russian River	no		Usal Creek	Coastal	
Salt Hollow Creek	Russian River	no		NF Cottoneva Creek	Cottoneva Creek	
Rocky Creek	Russian River	no		Hardy Creek	Coastal	
Mariposa	Russian River	no		Juan Creek	Coastal	
Fisher	Russian River	no		Little Juan Creek	Juan Creek	
Corral	Russian River	no		Mill Creek	Ten Mile River	
Scotty Creek	Coastal	no		Redwood Creek	Ten Mile River	
Salmon Creek	Coastal	no		MF NF Noyo River	Noyo River	
Finley Creek	Salmon Creek	no		Tramway Gulch	Big River	
Coleman Creek	Salmon Creek	no		SF Big River	Big River	
Fay Creek	Salmon Creek	no		Ramon Creek	Big River	
Tannery Creek	Salmon Creek	no		Daugherty Creek	Big River	

Stream	Basin	Coho Presence		Stream	Basin	Coho Presence
Johnson Creek	Big River	no				
Buckhorn Creek	Coastal	no				
Bridge Creek	Navarro River	no				
NF Indian Creek	Navarro River	no				
Greenwood Creek	Coastal	no				
Mallo Pass Creek	Coastal	no				
Elk Creek	Coastal	no				
Three Springs Cr.	Elk Creek	no				
Soda Fork	Elk Creek	no				
Sulphur Fork	Elk Creek	no				
Garcia River	Coastal	no				
Schooner Gulch	Coastal	no				
NF Schooner Gulch	Schooner Gulch	no				
Fuller Creek	Gualala River	no				
Nicasio Creek	Lagunitas Creek	no				

APPENDIX D.

HISTORICAL OCCURRENCE OF COHO SALMON IN THE UPPER KLAMATH, SHASTA, AND SCOTT RIVERS.

California Department of Fish and Game
Northern California and North Coast Region
February 2002

There has been recent public controversy regarding the historical distribution of coho (or silver) salmon (*Oncorhynchus kisutch*) in California. Some believe that coho salmon are not native to the upper Klamath River and tributaries (Siskiyou County Farm Bureau 2001a, 2001b; Interactive Citizens United 2001; California Farm Bureau Federation 2001). Others contend that coho salmon are not native to California (Greenhorn Action Grange 2001). Reasons cited are that existing natural coho salmon populations in the upper Klamath River and tributaries (primarily the Scott and Shasta rivers) are derived from hatchery stocking of non-indigenous stocks in the late nineteenth century (Siskiyou County Farm Bureau 2001a, 2001b; Interactive Citizens United 2001; California Farm Bureau Federation 2001) and natural historical habitat conditions did not provide suitable habitat conditions to support self-sustaining coho salmon populations (Siskiyou County Farm Bureau 2001a; Greenhorn Action Grange 2001). The purpose of this report is to review the available information and to provide some insight on whether coho salmon are native to the upper Klamath River and tributaries.

Written documentation regarding coho salmon in the Klamath Basin, especially in the upper Klamath River, is scarce prior to the early 1900's. Contributing to the lack of information was the apparent difficulty in recognizing that there were different species of salmon inhabiting the rivers of the state. Fortune et al. (1966), reviewed Klamath Falls newspaper accounts of salmon and possibly steelhead in the upper Klamath Basin and found that many people had difficulty properly identifying the different species of salmonids in the river. The term "salmon-trout" was a popular name used by many local inhabitants to describe any large, silvery-looking fish that appeared periodically in the river. Fortune et al. (1966) suggests that Klamath River fishermen apparently supported the use of the term salmon-trout *"in order to fish when trout season was closed, as there was no closed season on salmon-trout*". On April 9, 1912, The Evening Herald published an article that classified all trout on the Pacific Coast as "salmon-trout".

Snyder (1931) stated that *"(s)ilver salmon are said to migrate to the headwaters of the Klamath to spawn. Nothing definite was learned about them from inquiry because most people are unable to distinguish them*". It was his opinion that there was little interest in coho salmon in general because chinook salmon were so much larger and more abundant. The lack of ability to differentiate between various salmonid species was not only a problem in the Klamath Basin, but apparently occurred throughout the State. In the Twenty-Second Biennial Report to the State of California Fish and Game Commission (CFGC 1913) , W. H. Shebley, Superintendent of Hatcheries, writes *"Strange as it may appear, the presence of the silver [coho] salmon in the waters of this State remained unnoticed until Dr. Gilbert, Professor of Zoology at Stanford University, a few seasons ago called attention to them. Heretofore, all the salmon taken in our rivers have been commercially classed as Quinnat [chinook]"*.

Early Stocking History

The earliest record of coho salmon being stocked in the Klamath Basin was of a plant made in 1895. Fortune et al. (1966) reports that 460,000 coho salmon were stocked in the Klamath River (300,000 fry and 160,000 yearlings). Further examination of the original records from the U.S. Commission on Fish and Fisheries (1895) revealed those fish were raised in the Ft. Gaston facility in Hoopa and were stocked in the Trinity River and in Supply Creek, a tributary to the Trinity River. Those fish were reared from eggs taken at a facility in Redwood Creek (a substation of the Ft. Gaston facility) and also from eggs shipped from another facility not identified in the report (but were likely from out of the basin). Insight as to the purpose of this 1895 coho salmon plant may be found in the U.S. Commission on Fish and Fisheries (1895) report that states; "*Most of the salmon and steelhead eggs were taken at the* [Redwood Creek] *substation, as there was no run of either kind in the Trinity, all the fish having been taken at the cannery at the mouth of Klamath River*". Although the Ft. Gaston facility operated until 1898, 1895 was the only year coho salmon were stocked into the Klamath Basin prior to 1911 (Cobb 1931).

In anticipation of the construction of Copco Dam, the "Klamathon Racks", a fish egg taking station located near the old town of Klamathon, was built in 1910 and began operating that same year (Leitritz 1970). These racks extended across the Klamath River, effectively blocking the salmon runs. The Klamathon Racks were, "*necessary that the supply of salmon may be maintained in the Klamath River...*" (CFGC 1918). Fish trapping records beginning in the 1910-1911 season indicate that coho salmon were migrating upriver through that area, making it clear that their upstream migration encompassed areas upriver from where the Iron Gate and Copco dams now reside (Cobb 1931).

Although the construction of the Klamathon Racks began in 1910, the racks were not completed on time. The Fiscal Year 1911 report (July 1, 1910 to June 30, 1911) of the U.S. Fish Commissioner states that: *"....the racks were not completed in time to intercept the run of chinook salmon. Later in the season, before the completion of the silver salmon work, they were carried away, but not before satisfactory collections of eggs had been made"*. The actual number of coho salmon eggs taken during the 1910-1911 season at the Klamathon Racks was not given in the records, however, 2,109,000 coho salmon eggs collected there were transferred to the California Fish Commission's Sisson (Mt. Shasta) Hatchery (CFGC 1913). The resultant fry were subsequently stocked back into the Klamath and Sacramento rivers (CFGC 1913). This was the first effort made by the State of California to increase the runs of coho salmon (CFGC 1913). Beginning with the 1912-1913 season, coho salmon eggs taken at the Klamathon Racks were mostly reared and released from the US Bureau of Fisheries' Hornbrook Hatchery on the Klamath River.

Apparently, no coho salmon eggs were collected at the Klamathon Racks during the 1911-1912 and 1917-1918 seasons as coho salmon are not mentioned in the available federal and state records. However, coho salmon eggs were taken during the five consecutive seasons beginning with the 1912-1913 season (Cobb 1931). With two exceptions (1913-1914 and 1915-1916), the numbers of coho salmon eggs collected each season at the Klamathon Racks are not available, however, the number of fry reared at the Hornbrook Hatchery from coho salmon eggs taken at the Klamathon Racks are provided (Cobb 1931, Fortune et al. 1966). Number of eggs collected and number of coho salmon produced from 1910 through 1917 are summarized in Appendix Table D-1.

Appendix Table D-1. Coho salmon eggs collected at the Klamathon Racks and coho salmon hatchery production in the upper Klamath River, 1910 through 1917 (source: CFGC 1913; Cobb 1931; Fortune 1966).

Season	Eggs taken	Number of coho produced	Est. # of females[2/]	Number released to Klamath River[1/]		
				Fry	Yearling	Total
1910-1911	2,109,000 (minimum)	unknown	881	700,000	0	700,000 [3/]
1911-1912	0	0	0	0	0	0
1912-1913	unknown	117,320	49	17,320	0	17,320[4/]
1913-1914	3,129,000	2,632,300	1,307	2,548,960	0	2,548,960
1914-1915	unknown	2,375,770	992	1,098,000	0	1,098,000[5/]
1915-1916	2,823,000	2,169,050	1,179	2,169,050	0	2,169,050
1916-1917	unknown	61,000	25	50,000	11,000	61,000

1/ Released in Siskiyou County.
2/ Number of coho produced, or eggs taken if available, divided by 2,394 (average # of eggs per female coho).
3/ 719,000 were also stocked in the Sacramento River.
4/ Disposition of 100,000 remaining eggs collected is not specified in the available records.
5/ Disposition of remaining coho production is not given in the available records.

To estimate the number of females needed to obtain the number of eggs collected at the Klamathon Racks, we used the average number of eggs per female coho salmon (2,394 - see Coho Salmon Status Review, *Chapter III, Biology - Life History and Unique Characteristics*). Based on this, an estimated 881 females would have been required to obtain the number of eggs collected at the Klamathon Racks that were transferred to Sisson Hatchery during the 1910-1911 season. Greater numbers of females were required in subsequent seasons (1913-1914 through 1915-1916) (Appendix Table D-1). The 1912 -1913 and 1916-1917 seasons were drought years in which the take of salmon eggs, both chinook and coho salmon, was greatly reduced (Fiscal Year 1913 report of the U.S. Fish Commissioner, CFGC 1918). The relatively large numbers of coho salmon females required to yield the reported egg take and hatchery production indicates that significant numbers of coho salmon were in the Klamath River in the vicinity of the Klamathon Racks during those years.

The Klamathon Racks were rebuilt during the fall of 1918 and ownership of the facility was granted to the State of California by the U.S. Bureau of Fisheries. It began supplying most of the eggs utilized by the State because production from other stations, such as the Baird Station on the McCloud River, was seriously curtailed due to impacts from ocean harvest, irrigation diversions and dam building (CFGC 1921). At this time, fish culture emphasis for the State focused on the production of chinook salmon and trout, and although many coho salmon were caught at the Klamathon Racks, it was the larger chinook salmon that were selected (Bryant 1923). Since the Hornbrook Hatchery was considered by the State to be ill-equipped to rear fry and because it had an unreliable water supply, the facility was abandoned in 1919 in favor of the new Fall Creek Hatchery (CFGC 1921).

Fortune et al. (1966) indicates that hatchery coho salmon were stocked in the Klamath River on only four occasions between 1919 and 1959. Totals of 178,000, 73,380, 20,000 and 20,000 fry and fingerlings were planted in 1919, 1934, 1940 and 1941, respectively. A review of California Fish and Game Commission Biennial Reports for the years 1930 through 1950 reveals that additional plants totaling 476,000 coho salmon were made to the Klamath River (Siskiyou County) between 1930 and 1932 (CFGC 1932). These fish were reared at the Fall Creek Hatchery (CFGC 1932) and presumably originated from the Klamathon Racks, as was the practice of the day.

Hatchery Stocks

Historically, the practice of importing non-native fish was common, especially in systems where native fish had been extirpated or were in low abundance (also see Status Review, *Chapter VII, Influence of Existing Management Efforts*). Following completion of Iron Gate Hatchery in 1966, adult coho salmon returns were less than 500 fish. After the completion of Trinity River Hatchery in 1963, adult coho salmon returns at this facility rarely exceeded 1,000 fish prior to 1971. In an effort to increase returns to Iron Gate Hatchery, coho salmon from the Cascade River in Oregon were stocked in 1966, 1967 and 1969 (CDFG 1994). The first significant transfer of coho salmon to Trinity River Hatchery occurred in 1964 when Eel River coho salmon stock were brought in. This was followed by plantings of coho salmon originating from the Cascade River, Oregon in 1966, 1967 and 1969. Noyo River stock was also planted in 1969 and Alsea River stock was planted in the Trinity in 1970 (CDFG 1994). It appears the intent of these out-of-basin transfers was to augment already existing, albeit dwindling, natural coho salmon populations. Current California Fish and Game Commission policy now essentially prohibits all out-of-basin fish transfers.

Coho Salmon in the Shasta and Scott Rivers

In 1930, the California Department of Fish and Game (Department) installed and began operating a fish counting station in the Shasta River near its confluence with the Klamath River. This counting station has been operated annually since then to enumerate the return of fall-run chinook salmon. In a few years however, the counting station has been operated later into the season to count coho salmon and steelhead. Coho salmon returns to the Shasta River have been documented in almost every year since 1934. More than 291 coho salmon were counted in 2001 (Mark Hampton, pers. comm.). Similar information is lacking for the Scott River as few attempts were made to document coho salmon returns in the past. However, the Department estimated historical coho salmon escapement in the Scott River to be 2,000 fish (CDWR 1965). The basis for this estimate is not provided in the report and thus the accuracy of the estimate cannot be determined. Brownell et. al. (1999) reviewed Department warden diaries from the 1950s that showed *"coho salmon in virtually every upper Klamath and Scott stream with a ditch and hayfield"*. Prior to a federally-funded channel improvement project through the Scott River Valley, the Scott River was a low velocity, meandering stream, which is ideal for coho salmon (Brownell et. al. 1999)**.**

In the Scott River basin, adults are known to spawn in the East Fork of the Scott River upstream to Meadow Creek and in the South Fork as far as Jackson Creek. Coho salmon spawning was recently confirmed (Dec. 14, 2001) in the East Fork of the Scott River to approximately 200 yards upstream of the mouth of Kangaroo Creek, beneath the Highway 3 bridge crossings on Sugar and French creeks, and in Miners Creek immediately downstream of the lower Miners Creek Road bridge crossing. Coho salmon also utilize many other tributaries to the Scott River such as Kelsey, Tompkins, Shackelford, Mill, Kidder, Patterson, and Etna creeks (Hassler et al. 1991). Juvenile coho salmon have been recently captured in Scott River mainstem outmigrant trapping efforts (Chesney 2002).

The distribution of rearing coho salmon within the streams listed above appear to be largely confined to the relatively deeper pool (>1.5') habitat where small and large woody debris (e.g. tree branches, tree trunks, root wads or overhanging live woody-stemmed vegetation) exist. These tributary streams also have a relatively dense riparian canopy which shades the stream for much of the day, keeping stream temperatures generally below 68^{o}F throughout the summer months, thus providing marginally suitable rearing habitat conditions for juvenile coho salmon.

Juvenile coho salmon are generally found where stream gradients are less than 3 to 4 percent. A good woody debris complex within deeper pool habitats appears to override bottom substrate deficiencies. A good example of this is Miners Creek where juvenile coho salmon have been seen in three different years residing in pools whose substrate is comprised entirely of pure decomposed granitic sand overlain with fine silt.

In the Shasta River, spawning coho salmon utilize gravel areas similar to those used by steelhead (Skinner 1959). These areas include the lower seven miles of the mainstem Shasta, Big Springs Creek, mainstem Shasta above Big Springs, Parks Creek (when flows are adequate), and the lower three miles of Yreka Creek (CDFG 1997). Juvenile coho salmon habitat is restricted in the Shasta River by high summer water temperature to approximately ten miles of the upper river, roughly delineated by the Siskiyou County Road A-12 crossing at river-mile 22 to one mile upstream of the confluence of Parks Creek at river-mile 32. Suitable water temperature is maintained in this reach by spring accretions that account for the majority of the flow in this system during the summer months. No water is released from Dwinnell Dam except for deliveries of irrigation water immediately downstream of the impoundment (CDFG 1997). This reach of the river is characterized by a meandering stream course, abundant aquatic vegetation, and intermittently dense riparian vegetation that provides the requisite cover elements for coho salmon and other juvenile salmonids. Summer water temperature limits salmonid rearing in the remainder of the river when Shasta Valley air temperature exceeds 100 ^{0} F and riparian vegetation is sparse or absent. Outmigrating juvenile coho salmon have recently been captured in downstream trapping efforts in the Shasta River (Chesney 2002).

Discussion and Conclusions

Information on the historical occurrence of coho salmon in the upper Klamath River is sparse. However, lack of information is not evidence that coho salmon were historically absent because this could be due to insufficient efforts to observe or document them, or to misidentification. Lack of historical information on coho salmon in the Klamath River can be attributed, in part, to the lack of proper species identification (Snyder 1931).

Credible scientific information sources describe the native North American range of coho salmon as extending from Alaskan coastal waters to the central California coast (Evermann and Clark 1931; Shapovalov and Taft 1954; Fry 1973; Moyle 1976; Sandercock 1991), and this description is widely accepted by fishery biologists and ichthyologists. Snyder (1931) states that coho salmon in the Klamath River “occur in large numbers”. Although these sources do not specifically state that coho salmon are native to the upper Klamath River and tributaries, it is important to note that none of these references specifically exclude these streams from the described range of coho salmon.

The fact that the upper Klamath River and tributaries are: 1) contiguous with documented historical coho salmon distribution in the lower reaches of the Klamath River system and historical coho salmon streams both north and south of the Klamath River; 2) contain no natural barriers that would prevent their migration into the upper reaches and tributaries such as the Scott and Shasta rivers; 3) have physical attributes that would have produced suitable coho salmon habitat in the past (e.g. gradient, morphology, and, in some cases like the Shasta River, spring sources that provide perennial flow); and 4) still contain suitable coho salmon habitat, provides substantial evidence that coho salmon likely inhabited the upper Klamath River and tributaries prior to hatchery stocking. It is evident from the coho salmon's persistent presence, and field observations made by the Department and other biologists, that sufficient habitat still exists in the Shasta and Scott rivers to support sustainable populations of coho salmon.

Although it cannot be determined with absolute certainty that the 1895 stocking did not result in a portion of the runs observed 15 years later in the Klamath River, this initial stocking was likely too small and in the wrong area to have had much chance of establishing a new, self-reproducing population in the upper Klamath River and tributaries. At least some portion of the eggs reared and released in the Trinity system in 1895 originated from Redwood Creek; a much smaller system. Redwood Creek coho salmon are specifically adapted to swimming relatively short distances (<60 miles) to reach their customary spawning areas. It seems unlikely these fish could have strayed the additional 150 river-miles necessary to reach the upper Klamath River to successfully establish a new run. Further, the eggs hatched and reared at Fort Gaston had opportunity to imprint to the Trinity River, and this also would have reduced the chances of straying to the upper portions of the Klamath. Finally, as reported by the Klamath River Basin Fishery Task Force (1991), Withler (1982) found that no introduction of Pacific anadromous salmonids using non-native broodstock has been successful in producing new, self-reproducing populations anywhere on the West Coast.

The great majority of coho salmon returning to spawn are three-year-old fish (although a small portion of each brood year returns as two-year-old fish, these primarily consist of precocious males). Therefore, run size in any given year is strongly influenced by the number of fish produced three years prior. Hatchery records indicate both coho salmon fry and yearlings were planted in 1895. It is not clear from the records if the fry and yearlings originated from the same brood year or were from two separate brood years. Regardless, because of their three-year life cycle, coho salmon returns from the 1895 plant would have appeared at the Klamathon Racks in only one or two of every three consecutive years. Egg take records from the Klamathon Racks show that this is not the case: coho salmon eggs were taken in substantial numbers in consecutive years beginning with the 1912-1913 season (Appendix Table D-1). This would not have been possible if all the adult fish had been descendants of fry and yearling plants made in 1895.

Substantial coho salmon populations appear to have been present in the upper Klamath River in 1910 as evidenced by the egg collections made at the Klamathon racks during the initial year of operation. The relatively large number of females required to produce the number of eggs collected that year and in subsequent years suggests that native coho salmon were well established in the Klamath River upstream of Iron Gate Dam's location. For the reasons described above, it is unlikely that these runs could have originated from the plants made in the Trinity River in 1895. Coho salmon were well documented in the Shasta and Scott rivers long before the construction of Iron Gate and Trinity River hatcheries and the subsequent introductions of large numbers of non-native coho salmon at the hatcheries. Based on the above discussions, the Department believes that coho salmon are native to the upper Klamath River system, including the Scott and Shasta Rivers, and historically occurred in these streams prior to any hatchery stocking.

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Notes

Mark Hampton, Associate Fishery Biologist, California Department of Fish and Game, personal conversation, February 2002.

APPENDIX E

California Commercial and Sportfishing Regulations

APPENDIX E1

California Ocean Commercial Salmon Fishing Regulations

Chapter 6. Section 182. Commercial Salmon Fishing.

Under the authority of Section 7652 of the Fish and Game Code, Section 8210.2 and 8215 of said Code are made inoperative for the period May 1, 1998 through April 30, 1999 and the following regulations are adopted, such regulations to be effective May 1, 1998 through April 30, 1999 and at midnight on April 30, 1999 are repealed. Upon expiration of these regulations in any district or portion thereof, Section 8210.2 and 8215 of the Fish and Game Code shall become effective in such districts or portions of districts.

(a) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, and except as modified in subsection (c), no king (chinook) salmon may be possessed that is less than 26 inches in length from May 1, 1998 through September 30, 1998, such length to be measured from the tip of the snout to the extreme tip of the tail without resorting to any force other than swinging or fanning the tail. Salmon may be taken only by hook and line.

(b) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, only single barbless hooks may be used to take salmon. Single barbless hook means a hook with a single shank and point, with no secondary point or barb curving or projecting in any other direction. Hooks manufactured with barbs can be made "barbless" by removing or completely closing the barb.

(c) Frozen salmon may be possessed in a dressed, head-off condition, subject to the following minimum size limit: king salmon, 19-1/2" in dressed, head-off length when salmon no less than 26 inches total length may be possessed. Dressed, head-off length is the distance measured along the lateral line between the mid-point of the clavicle arch and the fork of the tail.

(d) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, no more than six troll lines may be used on any commercial salmon fishing vessel.

(e) In Districts 18, and 19, south of Point Sur (38º18'00" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through September 30.

(f) In Districts 10, 11, 16, 17, and 18, between Point San Pedro (37º35'40" N. lat.) and Point Sur, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from May 1 through May 31, June 16 through September 30.

(g) In Districts 10 and 11, between Point Reyes (37º59'44" N. lat.) and Point San Pedro, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from July 1 through September 30.

(h) In Districts 10, and 11, between Point Arena (38º57'30" N. lat.) and Point Reyes, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from August 1 through September 30 with exception of a test fishery between Fort Ross (38º31'00" N. lat.) and Point Reyes for July 5 thru earlier of July 31 or an overall 3,000 chinook quota. Season to be opened as follows: July 5 thru earlier of July 11 or 1,000 chinook quota; July 12 thru earlier of July 18 or 1,000 chinook quota; and July 19 thru earlier of July 25 or the lesser of a 1,000 chinook quota or the remainder of the overall 3,000 chinook quota. If sufficient overall quota remains, the fishery will reopen on July 26 thru the earlier of July 31 or achievement of the overall quota. Open only inside 6 nautical miles. Landing limit of no more than 30 fish per day. All fish caught in this area must be landed in Bodega Bay within 24 hours of each closure. Open only inside 6 nautical miles. Fish taken outside the test fishery may not be landed at Bodega Bay during the time authorized for test fishery landings.

(i) In District 7, between Horse Mountain (40º05'00" N. lat.) and Point Arena, under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30.

(j) In Districts 6 and 7, between the California/Oregon Border (42º00'00" N. lat.) and Humboldt South Jetty (40º45'53" N. lat.), under the authority of a commercial fishing license, all salmon other than silver salmon, may be taken from September 1 through September 30 or the date the Regional Director of the NMFS determines that a total of 6,000 king salmon will be taken. All salmon taken in this area at this time must be landed within the area and no more than 30 salmon per day may be landed.

(k) In Districts 6, 7, 10, 11, 16, 17, 18, and 19, it is unlawful for any person on a vessel with an ocean salmon permit from any state having salmon on board to have troll fishing gear in the water during those times that commercial salmon fishing is prohibited.

(l) Troll fishing gear is defined as one or more lines that drag hooks with bait or lures behind a moving fishing vessel.

(m) In District 6, no salmon may be taken for commercial purposes in State waters off the mouth of the Klamath River within an area bounded on the north by 41º38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the west by 124º23'00" W. long. (approximately 12 nautical miles off shore), and on the south by 41º26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth).

(n) It is unlawful for any person to take or take and retain any species of salmon in Districts 6, 7, 10, 11, 16, 17, 18, and 19: i) during closed seasons or in closed areas, except that legally caught salmon may be landed in closed areas unless otherwise prohibited by these regulations; ii) while possessing on board any species of salmon not allowed to be taken in the area at the time; iii) by means other than hook and line.

(o) All other provisions, exceptions and restrictions for commercial salmon fishing off California are described in Title 50**--**Code of Federal Regulations, Part 661 and apply to State waters as in effect May 1, 1998.

APPENDIX E2

California Ocean Recreational Salmon Fishing Regulations

Chapter 4. Article 1. Section 27.00. Definition.
The Ocean and San Francisco Bay District consists of the open seas adjacent to the coast and islands or in the waters of those open or enclosed bays contiguous to the ocean, and including San Francisco and San Pablo bays plus all their tidal bays, tidal portions of their rivers and streams, sloughs and estuaries between Golden Gate Bridge and Carquinez Bridge, and the waters of Elkhorn Slough, west of Elkhorn Road between Castroville and Watsonville. Also see Section 1.53.

27.75. Salmon Closures.
(a) No salmon may be taken in ocean waters at the mouth of the Smith and Klamath rivers within three nautical miles north and south of a line drawn due west for three nautical miles from the center of the mouth of each of said rivers.

(b) No salmon may be taken during the months of August and September in ocean waters at the mouth of the Eel River within two nautical miles north and south of a line drawn due west for two nautical miles from the center of the mouth of said river.

(c) No salmon may be taken during the month of August in ocean waters at the mouth of the Klamath River within six nautical miles north and south of a line drawn due west for three nautical miles from the center of the mouth of said river.

Attention All Ocean Salmon Sport Anglers: The following regulations are subject to change when the Pacific Fishery Management Council and the California Fish and Game Commission meet in April to determine ocean salmon sport regulations for California effective May 1. A supplemental regulation booklet containing these final regulations will be available in May. In addition, California ocean salmon sport regulations can be accessed via the Department of Fish and Game Ocean Salmon Information Hotline at (707) 431-4341.

27.80. Salmon. (amended 4/6/01)

(a) Methods of take:

(1) General Provisions. Only by angling as defined in Section 1.05. No sinkers or weights exceeding four pounds may be used, except that a fishing line may be attached to a sinker or weight of any size if such sinker or weight is suspended by a separate line and the fishing line is released automatically by a mechanical device from the sinker or weight when any fish is hooked. See sections 1.74, 28.65 and 28.70.

(2) Barbless Hooks. No more than two (2) single point, single shank barbless hooks shall be used in the ocean north of Point Conception (34º27' 00" N. lat.) when salmon fishing or salmon are onboard.

(3) Other Hook Restrictions. When fishing with bait in the ocean between Horse Mountain (40º 05' 00" N. lat.) and Point Conception, if angling by any other means than trolling, then no more than two (2) single point, single shank, barbless circle hooks shall be used. The distance between the two hooks must not exceed five inches when measured from the top of the eye
of the top hook to the inner base of the curve of the lower hook, and both hooks must be permanently tied in place (hard tied). A circle hook is defined as a hook with a generally circular shape, and a point which turns inwards, pointing directly to the shank at a 90 degree angle. Trolling is defined as angling from a boat or floating device that is making way by means of a source of power, other than drifting by means of the prevailing water current or weather conditions. See Section 28.65.

(4) One Rod Restriction north of Point Conception. Salmon may be taken by angling with no more than one rod in ocean waters north of Point Conception. See Section 28.65.

(b) Season:

(1) South of Pigeon Point (37o 11' 00" N. lat.). All waters of the ocean south of Pigeon Point are open to salmon fishing from March 31, 2001 through September 30, 2001 (Note: In 2002, the season will open March 30, the Saturday nearest April 1).

(2) Between Point Arena (38º 57' 30" N. lat.) and Pigeon Point. All waters of the ocean between Point Arena and Pigeon Point are open to fishing from April 14, 2001 through November 13, 2001 (Note: In 2002, the season will open April 13, the Saturday nearest April 15).

(3) Between Horse Mountain and Point Arena. All waters of the ocean between Horse Mountain and Point Arena are open to salmon fishing from February 17, 2001, the Saturday nearest February 15, through November 18, 2001, the Sunday nearest November 15 (Note: In 2002, the season will open February 16, the Saturday nearest February 15).

(4) North of Horse Mountain and Humboldt Bay. All waters of the ocean north of Horse Mountain and Humboldt Bay are open to salmon fishing from May 17, 2001 through July 8, 2001, and July 24, 2001 through September 3, 2001
(Note: In 2001-2002, the season will be decided in April by the Pacific Fishery Management Council and California Fish and Game Commission and the section will be amended pursuant to the regulatory process).

EXCEPTION: The ocean area surrounding the Klamath River mouth bounded on the north by 41º 38' 48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth), on the south by 41º 26' 48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth), and extending 3 nautical miles offshore is closed to salmon fishing between August 1 and August 31. No salmon may be taken at any time in ocean waters at the mouths of the Smith and Klamath rivers and during August and September at the mouth of the Eel River (See Section 27.75).

(c) Limit:

(1) North of Horse Mountain: Two salmon per day. No more than four fish in seven consecutive days from May 17 through July 8. Beginning July 24 through September 3, no more than six fish in seven consecutive days (See subsection (c)(3) below).

(2) South of Horse Mountain: Two salmon per day (See subsection (c)(3) below and Section 1.17).

(3) Statewide Silver (coho) Salmon Restrictions: No silver (coho) salmon may be retained.

(d) Minimum size:

(1) North of Horse Mountain: Twenty inches total length.

(2) Horse Mountain to Point Arena: Twenty-four inches total length through May 31 and twenty inches total length thereafter. (Note: In 2002, the season will open with a minimum size of twenty-four inches total length).

(3) South of Point Arena: Twenty-four inches total length through June 30 and twenty inches total length thereafter. (Note: In 2002, the season will open with a minimum size of twenty-four inches total length).

APPENDIX E3

California salmonid sportfishing Regulations for inland coastal waters north of San Francisco

Chapter 3. Article 2. District General Regulations

7.00. District General Regulations.

It is unlawful to take fish, amphibians, reptiles, mollusks, crustaceans, or kelp, except as provided by these regulations. The season closures in this regulation do not apply to crayfish fishing by hand or with traps. (Also see Section 5.35). Daily bag and possession limits, unless otherwise provided, mean the total number of trout and salmon in combination. Unless otherwise provided, no more than one daily bag limit may be possessed. Silver salmon are fully protected, and may not be taken in any of the waters of the State. Incidentally hooked silver salmon must be immediately released unharmed to the waters where they are hooked.

(a) North Coast District

District/Water	Open Season	Daily Bag andPossession Limit
(1) No trout or salmon may be taken in the North Coast District except as provided in subsection (2), (3) and (4) below and the Alphabetical List of Waters with Special Regulations.		
(2) All lakes and reservoirs except those listed by name in the Special Regulations.	All year.	5 per day 10 in possession
(3) Anadromous waters of the Klamath and Trinity River Systems, and those entering the ocean south of Humboldt Bay, which are not listed in the Special Regulations.	Closed to all fishing all year.	
(4) All anadromous waters tributary to Humboldt Bay, and north of Humboldt Bay, except those of the Klamath and Trinity River systems and those listed by name in the Special Regulations.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
(5) All streams except anadromous waters and those listed by name in the Special Regulations.	Last Saturday in Apr. through Nov. 15.	5 trout per day 10 in possession

(NOTE: A list of the non-anadromous waters opened to trout fishing (STREAMS AND PORTIONS OF STREAMS NOT LISTED IN THE SPECIAL REGULATIONS THAT ARE OPEN TO TROUT FISHING FROM THE LAST SATURDAY IN APRIL THROUGH NOVEMBER 15 (NEW 6-12-98), which is incorporated by reference herein) is available from the Department's Region 1 Office, 601 Locust Street, Redding, CA 96001 (Telephone: (530) 225-2362)

(6) SPECIAL BROOK TROUT BONUS BAG AND POSSESSION LIMIT: UP TO 10 BROOK TROUT PER DAY LESS THAN 8 INCHES TOTAL LENGTH MAY BE TAKEN AND POSSESSED IN ADDITION TO THE OTHER DAILY BAG AND POSSESSION LIMITS SPECIFIED FOR THE NORTH COAST DISTRICT.

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(c) North Central District

District/Water	Open Season	Daily Bag & Possession Limit
(1) All lakes and reservoirs except those listed by name in the Special Regulations.	All year.	5
(2) All streams except those listed by name in the Special Regulations.	Closed to all fishing all year.	

(3) The tidewaters of all streams except those listed by name in the Special Regulations.	Closed to all fishing all year.

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Chapter 3. Article 3. Section 7.50. Alphabetical List of Waters with Special Fishing Regulations.

(a) General Provisions:

(1) It is unlawful to take fish, amphibians, reptiles, mollusks, crustaceans or kelp, except as provided by these regulations. The season closures in this regulation do not apply to crayfish fishing by hand or with traps. (Also see Section 5.35.)

(2) Every body of water and stream section listed below is closed to all fishing except as shown.

(3) Daily bag and possession limits, unless otherwise noted, mean the total number of salmon or trout in combination.

(4) Unless otherwise provided, it is unlawful to possess more than one daily bag limit.

(5) The following special regulations deal primarily with seasons, size limits, and bag and possession limits. Please be aware that these waters may also be subject to restrictions on fishing methods and gear (sections 2.05 through 2.40), fishing hours (section 3.00), and the use of bait (sections 4.00 through 4.30).

(b)

Body of Water	Open Season and Special Regulations	Daily Bag & Possession Limit
...		
(2) Albion River (Mendocino Co.). Also see section 8.00(c).		
Main stem below the confluence of North Fork Albion.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(3) Alder Creek (Mendocino Co.). Also see section 8.00(c).		
Main stem below Tramway Gulch.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**
...		
(18) Bear River (Humboldt Co.) downstream from County Road Bridge at Capetown, excluding tributaries.	Fourth Saturday in May through Mar. 31. Only rtificial lures with barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**
...		
(21) Big Lagoon (Humboldt Co.). For purposes of this regulation, the boundary between Big Lagoon and Maple Creek is the first private road bridge, located approximately 1/2 mile southeast of the Highway 101 bridge crossing.	All year. Only barbless hooks may be used. Cutthroat trout minimum size limit: 10 inches	2 cutthroat trout. No other salmonids shall be taken.
(22) Big River (Mendocino Co.). Also see Section 8.00(c).		
Main stem below the confluence of Two Log Creek.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31.	1 hatchery trout

	Only barbless hooks may be used.	or 1 hatcherysteelhead**

...

(26) Bogus Creek (Siskiyou Co.) See Klamath River Regulations.

...

(27) Brush Creek (Mendocino Co.). Also see section 8.00(c).

Main stem below the Lawson bridge.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**

...

(47) Cottoneva Creek (Mendocino Co.). Also see section 8.00(c).

Main stem below the confluence of South Fork Cottoneva Creek.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**

...

(63) Eel River Regulations (Humboldt, Lake, Mendocino and Trinity cos.). Also see Section 8.00(b).

ALL WATERS OF THE EEL RIVER DRAINAGE EXCEPT THOSE LISTED BELOW ARE CLOSED TO ALL FISHING.

(A) Main stem.

1. From mouth to Fulmor Road, at its paved junction with the south bank of the Eel River.	Fourth Saturday in May through Mar. 31. Only barbless hooks may be used.	0
	April 1 through the Friday preceding the last Saturday in May. Only artificial lures with barbless hooks may be used.	0
2. From Fulmor Road, near east end of Cock Robin Island to South Fork Eel River.	Apr. 1 through Sep. 30. Only artificial lures with barbless hooks may be used.	0
	Oct. 1 through Mar. 31. Only barbless hooks may be used.	0
3. From South Fork Eel River to Cape Horn Dam.	Jan. 1 through Mar. 31 and Fourth Saturday in May through Sept. 30. At all times, only artificial lures with barbless hooks may be used.	0
	Closed to all fishing Apr. 1 through the Friday preceding the fourth Saturday in May and Oct. 1 through Dec. 31.	0

(B) Van Duzen River.

1. Main stem and tributaries above Eaton Falls, located about 1/2 mile upstream of the mouth of the South Fork (Little Van Duzen) and 2-1/2 miles west of Dinsmore.	Last Saturday in Apr. through Nov. 15.	5
2. Main stem from Highway 36 bridge at Bridgeville to mouth.	Fourth Saturday in May through Sept. 30. Only artificial lures with barbless hooks may be used.	0
	Oct. 1 through Mar. 31.	0

	Only barbless hooks may be used.	
(C) South Fork Eel river from mouth to Rattlesnake Creek.	Fourth Saturday in May through Sept. 30. Only artificial lures with barbless hooks may be used.	0
	Oct. 1 through Mar. 31. Only barbless hooks may be used.	0
(D) Middle Fork Eel River.		
1. Middle Fork main stem from mouth to Bar Creek.	Jan. 1 through May 31 and July 16 through Sept. 30. At all times, only artificial lures with barbless hooks may be used. Closed to all fishing Jun. 1 through July 15 and Oct. 1 through Dec. 31.	0
2. Middle Fork tributaries above Indian Dick/Eel River Ranger Station Road.	Last Saturday in Apr. through Nov. 15. Maximum size limit: 14 inches total length.	5
3. Middle Fork and tributaries above mouth of Uhl Creek.	Last Saturday in Apr. through Nov. 15. Maximum size limit: 14 inches total length. Only artificial lures with barbless hooks may be used.	2
4. Balm of Gilead Creek and tributaries above falls 1 1/4 miles from mouth.	Last Saturday in Apr. through Nov. 15. Maximum size limit: 14 inches total length. Only artificial lures with barbless hooks may be used.	2
5. North Fork of Middle Fork and tributaries above mouth of Willow Creek.	Last Saturday in Apr. through Nov. 15. Maximum size limit: 14 inches total length. Only artificial lures with barbless hooks may be used.	2

...

(65) Elk Creek (Mendocino Co.). Also see section 8.00(c).

Main stem below the confluence of South Fork Elk Creek.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(66) Elk River (Humboldt Co.) downstream from Highway 101 bridge, excluding tributaries.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**

...

(69) Freshwater Creek (Humboldt Co.) downstream from bridge at "3 Corners" on the Old Arcata Road, excluding tributaries.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(69.5) Freshwater Lagoon (Humboldt Co.).	All year.	5 per day 10 in possession

(70) Garcia River (Mendocino Co.). Also see section 8.00(c).

Main stem below the Eureka Hill Road bridge.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatcherysteelhead**

...

(72) Greenwood Creek (Mendocino Co.). Also see section 8.00(c).

Main stem below the log bridge about 1 1/2 miles east of Highway 1.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**

(73) Gualala River (Mendocino and Sonoma Cos.). Also see section 8.00(c).

Main stem below the confluence of Wheatfield and South Forks.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used. Fishing from a flotation device is prohibited from Nov. 15 through Feb. 28 from the confluence of the North Fork to the Highway 1 bridge.	1 hatchery trout or 1 hatchery steelhead**

...

(79) Illinois River and tributaries (Del Norte Co.)	Closed to fishing all year.	

...

(91) Klamath River Above Iron Gate Dam.

(A) Klamath River main stem and all tributaries above Iron Gate Dam, except Shovel Creek and tributaries. The Klamath River main stem within 250 feet of the mouth of Shovel Creek is closed to all fishing November 16 through June 15.	Last Saturday in Apr. through Nov. 15.	5 per day 10 in possession
(B) Shovel Creek and tributaries above mouth of Panther Creek.	Saturday preceding Memorial Day through Nov. 15	5
(C) Shovel Creek and tributaries up to and including Panther Creek.	Closed to all fishing all year.	

(91.1) Anadromous Waters of the Klamath River Below Iron Gate Dam (Lower Klamath River Basin). (Amended 4/6/01) The regulations in this subsection apply only to waters of the Klamath River system which are accessible to anadromous salmonids. They do not apply to waters of the Klamath River which are inaccessible to anadromous salmon and trout, for example, portions of the Klamath River system upstream from Iron Gate Dam, portions of the Trinity River system above Lewiston Dam, and the Shasta River and tributaries above Dwinnel Dam. Fishing in these waters is governed by the General Regulations for non-anadromous waters of the North Coast District (see Section 7.00(a)(5)).

(A) Special Fishing Methods Restrictions:
1. Only barbless hooks may be used.
2. Where bait use is allowed, bait may be used only with single hooks having a gap between the point and shank between 1/2 and 1 inch, or with multiple hooks having a gap between the point and shank between 1/4 and ½ inch. Exception: there is no minimum hook size below the Highway 101 bridge.
3. During closures to the take of adult salmon, anglers shall not remove any adult king salmon from the water by any means, such as by dragging the fish on shore or using a net.
4. In the Klamath River, within 100 yards of the channel through the spit formed at the mouth, weights may be used only if hard-tied to a drop line that is between 12 inches and 24 inches long and that is attached to the main fishing line no more than 36 inches above the hook.

(B) General Area Closures:
1. No fishing is allowed within 400 feet of any U.S. Fish and Wildlife Service or Department of Fish and Game seining operation and from the Ishi Pishi Falls road bridge upstream to and including Ishi Pishi Falls from Aug. 15 through Nov. 1. Exception: members of the Karuk Indian Tribe listed on the current Karuk Tribal Roll may fish at Ishi Pishi Falls using hand-held dip nets.
2. No fishing is allowed from Sept. 15 through Nov. 15 in the Klamath River within 500 feet of the mouths of the Salmon, the Shasta and the Scott

rivers.

(C) Lower Klamath River Basin King Salmon Impact Quotas: NOTE: The Lower Klamath River Basin chinook salmon take is regulated using quotas. Accounting of the tribal and non-tribal harvest each year is closely coordinated by the affected parties during the period from August 1 through November 30. The term "impact quota" is the recreational catch of adult fall-run king salmon, plus the estimated number of adult fall-run king salmon lost as a result of hook-and-release mortality.
1. Quota for Entire Basin : The 2001 Klamath River basin impact quota is 29,800 adult (over 22 inches) king salmon. Separate quotas have been established for five individual area subdivisions as listed below in subsection (b)(91.1)(C)1.a.-e., with restrictions for each area designed to assure that the quota for the entire basin is not exceeded. The restrictions triggered by quotas apply only during the period from August 1 through November 30. The department shall inform the commission, and the public via the news media, prior to any implementation of restrictions triggered by the quotas. NOTE: A Department status report on progress toward the quotas for the various river sections is updated daily, and available at 1-800-564-6479.
a. Spit Area (within 100 yards of the channel through the spit formed at the Klamath River mouth): This area is closed to all fishing after 15% of the basin impact quota has been taken below the Highway 101 bridge. In 2001, this number is 4,470. (Also, see subsection (b)(91.1)(A)4. above.)
b. Klamath River Below Coon Creek Falls: No salmon over 22 inches may be retained after 50% of the basin impact quota has been taken below Coon Creek.
c. Klamath River from Iron Gate Dam to falls at Coon Creek: No salmon over 22 inches total length may be retained after either:
(i) 17% of the Klamath River basin impact quota has been taken in the Klamath River between Iron Gate Dam and the falls at Coon Creek, or (ii) 50% of the Klamath River basin impact quota has been taken in the Klamath River basin above Coon Creek Falls. This restriction does not apply after the department determines that the adult fall king salmon spawning escapement at Iron Gate Hatchery exceeds 8,000 fish
d. Trinity River from the Old Lewiston Bridge to the Highway 299 West Bridge at Cedar Flat: No salmon over 22 inches total length may be retained after 50% of the basin quota has been taken in the Klamath River basin above Coon Creek Falls. This restriction does not apply after the adult fall king salmon spawning escapement at Trinity River Hatchery exceeds 4,800 fish.
e. Trinity River from Hawkins Bar Bridge (Road to Denny) downstream to the mouth of the Trinity:
No king salmon over 22 inches total length may be retained after either:
(i) 16.5% of the basin quota has been taken in the Trinity River fromHawkins Bar Bridge (Road to Denny) downstream to the mouth of the Trinity, or (ii) 50% of the basin quota has been taken in the Klamath River basin above Coon Creek Falls.

(D) Lower Klamath River Basin General Seasons and Bag and Possession limits:
In anadromous waters of the Klamath River basin, except for those with special bag limits provided in subsection (b)(91.1)(F) below, the daily trout/salmon bag limit is 3 king salmon, but no more than 2 king salmon over 22 inches, and 1 hatchery trout or 1 hatchery steelhead**. No more than 6 king salmon over 22 inches may be retained in any 7 consecutive days. No more than 12 king salmon may be possessed, of which no more than 6 may be over 22 inches total length. Note that salmon bag limits change in some areas when quotas are reached (see subsection (b)(91.1)(C) above).

(E) All anadromous waters of the Lower Klamath River Basin are closed to all fishing all year, except those listed in subsection (b)(91.1)(F) below.

(F) Special Seasons, Daily Bag Limits, Size Limits, and Special Fishing Methods Restrictions for Waters of the Lower Klamath River Basin Which Have Open Fishing Seasons. Waters listed below are closed to all fishing except during the open seasons listed. Bag limits are for trout and salmon in combination unless otherwise specified.

Body of Water	Open Season and Special Regulations	Daily Bag Limit (if different from general bag limits in subsection (b)(91.1)(D) above)
1. Bogus Creek and tributaries.	Fourth Saturday in May through Aug. 31. Only artificial lures with barbless hooks may be used.	0
2. Klamath River main stem from 3,500 feet below Iron Gate Dam to mouth.	All year.	Quota Area. Also see subsection (b)(91.1)(C)above.
3. Salmon River main stem, main stem of North Fork, below Sawyer's Bar Bridge and main stem of South Fork below the confluence of the East Fork of the South Fork.	Nov. 1 through Feb. 28.	0
4. Scott River main stem from mouth to Fort Jones-Greenview bridge.	Fourth Saturday in May through Feb. 28.	0
5. Shasta River main stem from Interstate 5 to 250 feet above the Department of Fish and Game counting weir.	Fourth Saturday in May through Feb. 28.	0
6. Shasta River main stem from 250 feet above the Department of Fish and Game counting weir to mouth.	Fourth Saturday in May through Aug. 31 and Nov. 16 through Feb. 28.	0
7. Trinity River and		

tributaries.		
a. Trinity River main stem from 250 feet below Lewiston Dam to Old Lewiston bridge.	Last Saturday in Apr. through Sept. 15. Only artificial flies with barbless hooks may be used.	0
b. Trinity River main stem from Old Lewiston bridge to the Highway 299 West bridge at Cedar Flat.	Fourth Saturday in May through Mar. 31.	Quota Area. Also see subsection (b)(91.1)(C) above.
c. Canyon Creek above the falls located about four miles above the wilderness area boundary.	Last Saturday in April 2 through November 15.	
d. Trinity River main stem from the Highway 299 West bridge at Cedar Flat downstream to the Hawkins Bar Bridge (Road to Denny)	Fourth Saturday in May through Aug. 31 and Dec. 1 through Mar. 31.	
e. Trinity River main stem from Hawkins Bar Bridge (Road to Denny) to the mouth of the South Fork Trinity.	Fourth Saturday in May through Mar. 31.	Quota Area. Also see subsection (b)(91.1)(C) above.
f. The Trinity River main stem downstream from the mouth of the South Fork of the Trinity.	All year.	Quota Area. Also see subsection (b)(91.1)(C) above.
g. Trinity River South fork downstream from the mouth of Grouse Creek.	Saturday preceding Memorial Day through Mar. 31.	1 hatchery trout or 1 hatchery steelhead** 0 king salmon
h. Trinity River South Fork from the mouth of Grouse Creek to the South Fork Trinity River bridge at Hyampom.	Nov. 1 through Mar. 31.	1 hatchery trout or 1 hatchery steelhead** 0 king salmon
i. Hayfork Creek main stem, from Highway 3 bridge in Hayfork downstream to the mouth.	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used.	0
...		
(95) Lagunitas Creek and tributaries (Marin Co.).	Closed to all fishing all year.	
...		
(102) Little River (Humboldt Co.) downstream from the County Road bridge at Crannell, excluding tributaries.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used. Cutthroat trout minimum size limit: 10 inches 2 cutthroat trout Nov. 1 through Mar. 31. Only barbless hooks may be used. Cutthroat trout minimum size limit: 10 inches.	2 cutthroat trout. No other salmonids shall be taken. 1 hatchery trout or 1 hatchery steelhead**
...		
(107) Mad River and tributaries (Humboldt Co.).		
(A) Mad River within a radius of 200 yards of its mouth.	Jan. 1 through July 31. Only artificial lures with barbless hooks may be used.	2 hatchery trout or 2 hatchery steelhead**
(B) Mad River main stem, from 200 yards above its mouth upstream to the confluence with Cowan Creek, excluding tributaries. Also see Section 8.00(b).	Fourth Saturday in May through Mar 31. Only artificial lures with barbless hooks may be used from the fourth Saturday in May through Oct. 31. Only barbless hooks may be used from Nov 1 through March 31.	2 hatchery trout or 2 hatchery steelhead**
(C) Mad River main stem, from the confluence with Cowan Creek to the	Closed to all fishing all year.	

confluence with Deer Creek, excluding tributaries.		
(D) Mad River main stem from the confluence with Deer Creek to Ruth Dam.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
(E) Mad River and tributaries above Ruth Dam.	Last Saturday in Apr. through Nov. 15.	5 per day 10 in possession

...

(113) Mattole River (Humboldt Co.).

(A) Mattole River main stem from mouth to 200 yards upstream.	Closed to all fishing all year.	
(B) Mattole River main stem from 200 yards upstream of mouth to confluence with Stansberry Creek. Also see Section 8.00(b).	Jan. 1 through Mar. 31. Only artificial lures with barbless hooks may be used.	0
(C) Mattole River main stem from confluence with Stansberry Creek to confluence with Honeydew Creek. Also see Section 8.00(b).	Jan. 1 through Mar 31 and Fourth Saturday in May through Aug. 31. Only artificial lures with barbless hooks may be used.	0

...

(115.2) McDonald Creek (Humboldt Co.).	Closed to all fishing all year.	

...

(129) Napa River and tributaries (Napa Co.). Also see section 8.00(c).

(A) Main stem above the Lincoln Bridge in Calistoga and all Napa River tributaries.	Closed to all fishing all year.	
(B) Main stem from the Lincoln Bridge in Calistoga to the Trancas Bridge. Note: The Napa River below the Trancas Bridge is tidewater, and is regulated by regulations for the Ocean and San Francisco Bay Distirct (see Sections 1.53 and 27.00).	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used from the fourth Saturday in May through Oct. 31. Only barbless hooks may be used from Nov. 1 through Mar. 31.	1 hatchery trout or 1 hatchery steelhead** 1 king salmon

(130) Navarro River and tributaries (Mendocino Co.). Also see section 8.00(c).

Main stem below the Greenwood Road bridge.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**

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(133) Noyo River and tributaries (Mendocino Co.). Also see section 8.00(c).

(A) Noyo River main stem from the mouth to the Georgia-Pacific logging road bridge one mile east of Highway 1.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(B) Noyo River from the Georgia-Pacific logging road bridge one mile east of Highway 1 to the confluence with the South Fork Noyo River.	Fourth Saturday in May through Oct. 1. Only artificial lures with barbless hooks may be used.	0
(C) Noyo River main stem from the confluence with the South Fork Noyo River to the Sonoma/Mendocino Boy Scout Council Camp.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0

	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**

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(149) Redwood Creek and tidewaters (Marin Co.).	Closed to all fishing all year.	

(150) Redwood Creek (Humboldt Co.). Also see Section 8.00(b).

(A) Redwood Creek main stem within a radius of 200 yards of its mouth.	Jan. 1 through Mar. 31. Only artificial lures with barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(B) Redwood Creek main stem, from 200 yards above the mouth to the mouth of Prairie Creek.	Fourth Saturday in May through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(C) Redwood Creek main stem, from the mouth of Prairie Creek to the mouth of Bond Creek.	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(D) Redwood Creek, and tributaries, above the mouth of Bond Creek.	Closed to all fishing all year.	

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(154) Russian Gulch and tributaries (Sonoma Co.). Also see section 8.00(c).

Main stem below the confluence of the East Branch.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**

(155) Russian River and tributaries (Sonoma and Mendocino Cos.). Also see section 8.00(c).

(A) Russian River main stem below the confluence of the East Branch.	All year. Only artificial lures with barbless hooks may be used from April 1 through Oct. 31. Only barbless hooks may be used from Nov. 1 through March 31.	2 hatchery trout or 2 hatchery steelhead**
(B) Russian River main stem above the confluence of the East Branch and all Russian River tributaries. (See subsections (b)(93) and (172) of Section 7.50.)	Closed to all fishing all year.	
(C) Russian River within 250 feet of the Healdsburg Memorial Dam.	Closed to all fishing all year.	

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(159) Salmon Creek and tributaries (Sonoma Co.). Also see section 8.00(c).

(A) Salmon Creek main stem below Highway 1.	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used from the fourth Saturday in May through Oct. 31. Only barbless hooks may be used from Nov. 1 through Mar. 31.	0
(B) Salmon Creek main stem above Highway 1 and all Salmon Creek tributaries.	Closed to all fishing all year.	

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(161) Salmon River. See Klamath River (Siskiyou Co.). Regulations subsection (b)(91.1)(F)3.

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(172) Santa Rosa Creek (Sonoma Co. tributary to Russian River) from Laguna de Santa Rosa to Highway 12 bridge.	Last Saturday in Apr. through Nov. 15. Open to fishing for non-salmonids only, no salmon or trout may be taken.	0

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(174) Scott River. See Klamath River (Siskiyou Co.). Regulations subsection (b)(91.1)(F)4.

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(180) Smith River Drainage (also see Section 8.00(b)).

(A) From the George Tryon bridge upstream to its confluence with Craig Creek. Note: for tributaries not listed in (B) and (C) below, see subsection (a) (4) of Section 7.00, (General Regulations for the North Coast District).	Closed to all fishing all year.	
(B) Upper Drainage: stems of the Middle Fork above the mouth of PatrickÆs Creek, the entire Siskiyou Fork, the South Fork above the mouth of Jones Creek, and the North Fork above the mouth of Stony Creek.	Main Fourth Saturday in May throughOct. 31. Only artificial lures with barbless hooks may be used. Cutthroat trout minimum size limit: 10 inches	2 cutthroat trout No other salmonids shall be taken.
(C) Lower Drainage: Main stems of the Middle Fork below the mouth of Patrick's Creek, the South Fork below the mouth of Jones Creek, and the North Fork below the mouth of Stony Creek.	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used from the fourth Saturday in May through Oct. 31. Only barbless hooks may be used from Nov. 1 through Mar. 31.	1 wild trout or steelhead over 16 inches total length, or 1 hatchery trout or 1 hatchery steelhead** 1 king salmon 2 cutthroat trout No more than 5 wild trout or steelhead** over 16 inches total length may be kept per year. Cutthroat trout minimum size limit: 10 inches.

(181) Sonoma Creek and tributaries (Sonoma Co.). Also see section 8.00(c).

(A) Sonoma Creek and tributaries above the Adobe Canyon Road bridge.	Last Saturday in Apr. through Nov. 15.	5
(B) Sonoma Creek and tributaries between the Adobe Canyon Road bridge and the Highway 121 bridge.	Closed to all fishing all year.	

Note: Sonoma Creek below the Highway 121 Bridge is tidewater, and is regulated by regulations for the Ocean and San Francisco Bay District (see Sections 1.53 and 27.00).

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(188) Stone Lagoon (Humboldt Co.).	All year. Only artificial lures with barbless hooks may be used. Cutthroat trout minimum size limit: 14 inches.	2 cutthroat trout. No other salmonids shall be taken.

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(193) Ten Mile River and tributaries (Mendocino Co.). Also see section 8.00(c).

Ten Mile River main stem below the confluence with the Ten Mile River North Fork, and the Ten Mile River North Fork below the confluence with Bald Hill Creek.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**

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(195) Trinity River. See Klamath River Regulations subsection (b)(91.1)(F)7.

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(200) Usal Creek and tributaries (Mendocino Co.). Also see section 8.00(c).		
Usal Creek main stem below the Usal-Shelter Cove Road.	Fourth Saturday in May through Oct. 31. Only artificial lures with barbless hooks may be used.	0
	Nov. 1 through Mar. 31. Only barbless hooks may be used.	1 hatchery trout or 1 hatchery steelhead**
(202) Van Duzen River (Humboldt Co.). See Eel River Regulations No. (63)(B). Also see Supplemental Regulations Section 8.00(b).		
(203.5) Waddell Creek (Santa Cruz Co.) from mouth to Highway 1 bridge.	Nov. 16 through Feb. 28, but only on Sat., Sun., Wed., legal holidays and opening and closing days. Only barbless hooks may be used.	0
(204) Walker Creek and tributaries (Marin Co.) Also see section 8.00(d).		
(A) Walker Creek main stem below Highway 1.	Fourth Saturday in May through Mar. 31. Only artificial lures with barbless hooks may be used from the fourth Saturday in May through Oct. 31. Only barbless hooks may be used from Nov. 1 through Mar. 31.	0
(B) Walker Creek main stem above Highway 1 and all Walker Creek tributaries.	Closed to all fishing all year.	
(204.5) Walker Creek (Mono Co.) from the Lee Vining Conduit to Rush Creek.	Last Saturday in Apr. through Oct. 31. Only artificial lures with barbless hooks may be used.	0

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** Hatchery trout or steelhead are those showing dorsal fin erosion and/or an adipose fin clip. Unless otherwise provided, all other trout and steelhead must be immediately released. Wild trout or steelhead are those not showing dorsal fin erosion and/or an adipose fin clip.

APPENDIX F

Research and Monitoring Activities Operating Within the Range of California Coho Salmon

Study/Goals	Agency	Watersheds	Life Stage	Method	Duration
Presence-distribution	California Dept Fish & Game	Coastal basins-Shelter cove to Russian R (excl.)	juve	snorkel/efish	1998-2001
Population estimate/ index	DAA	San Lorenzo River and tributaries	juve	efish/direct obs.	
Population estimates	Marin Municipal Water District	Lagunitas	juve	direct obs.	2000-2001
Population estimates	Marin Municipal Water District	Lagunitas	juve	efish	1993-2001
Population index	Marin Municipal Water District	Lagunitas	adult	spawner/redd	1996-2001
Pop. estimate/ pres-dist.-dist.	USDA Forest Service	Trinity River (Horse Linto)	juve	spawner/redd/carcass	1980-2001
Pop. estimate/ pres-dist.-dist.	USDA Forest Service	Trinity River (Horse Linto)	juve/ smolt	direct obs.	1990-1996
Pop. estimate	USDA Forest Service	Trinity R. (Horse Linto/Willow)	juve/ smolt	downstr. trap	1994-2001
Multiple	California State Coastal Conservancy	Gualala R. & estuary	juve	snorkel/seine	2001-2003
Adult counts	Sonoma County Water Agency	Russian River	adult	ladder/weir	1999-2001
Smolt counts	Sonoma County Water Agency	Russian River	smolt	downstr. trap	2000-2001
Multiple	California Dept Fish & Game	Shasta, Scott rivers	juve/ smolt	downstr. trap	2000-2001
Pop index/ pres-dist/ life history	California Dept Fish & Game	Klamath River (Iron Gate Hatchery)	juve	efish	2001
Genetics	University of California, Davis	Navarro R.	juve	efish	2000-2001
Economics/ ocean mgt.	University of California, Davis	NA	adult	mail survey	1992-2001
Population estimate	U.S. Geological Survey	Redwood Creek and tributaries	juve	efish	1998-2001
Population estimate	U.S. Geological Survey	Redwood Creek and tributaries	juve	direct obs.	1998-2001
Population estimate	U.S. Geological Survey	Redwood Creek and tributaries	adult	spawners	1998-2001
Population index	U.S. Geological Survey	Redwood Creek and tributaries	adult	redd	1998-2001
Population estimate	U.S. Geological Survey	Redwood Creek and tributaries	adult	carcass	1998-2001
Population index	U.S. Geological Survey	Redwood Creek and tributaries	smolt	downstr. trap	1999-2001
Population estimate	U.S. Geological Survey	Redwood Creek and tributaries	juve	minnow traps	2001-2002
Multiple	Merritt Smith Consulting	Russian River (multiple sites)	juve	seine	1993-2001
Pop. index/ pres-dist	University of California, Davis	Navarro R. (multiple sites)	juve	snorkel	1999-2001
Pop. estimate/ index/ pres-dist/ life history	California Dept Fish & Game	Noyo River	adult	spawner/redd/carcass	2000-2001
Multiple	California Dept Fish & Game	Noyo River	juve/ smolt	efish	1999-2001
Multiple	California Dept Fish & Game	Noyo River	adult	ladder-weir/spawner /redd /carcass/direct obs/efish	1999-2001

Study/Goals	Agency	Watersheds	Life Stage	Method	Duration
Multiple	California Dept Fish & Game	Noyo River + other	juve/ smolt	downstr. trap	1999-2001
Multiple	California Dept Fish & Game	Noyo River and tribs	juve/ smolt	downstr. trap/efish/fyke	2000-2001
Pop. index/ presence-dist	California Dept Fish & Game	Trinity River	adult	direct obs.	1989-2001
Pop. index/ presence-dist	California Dept Fish & Game	Trinity River (multiple sites)	adult	redd	2000-2001
Pop. index/ presence-dist/ life hist/ genetics	California Dept Fish & Game	Trinity River (multiple sites)	juve	efish	2000-2001
Pop est. of migrants	Mendocino Redwood Company	Eel R., Cottoneva, Greenwood, Elk	juve/ smolt	downstr. trap	2000-2001
Distribution/ presence	Natural Resource Management Corp.	Russian River	adult	spawner	1998-1999
Population index	Natural Resource Management Corp.	Mad, Eel, Trinity, Van Duzen	adult	direct obs.	1996-2001
Migration timing	Natural Resource Management Corp.	Mad, Eel, Trinity, Van Duzen	adult	direct obs.	1996-1999
Population density	Natural Resource Management Corp.	Gualala River	juve	direct obs.	2000
Population index	Natural Resource Management Corp.	Gualala River (multiple sites)	juve	direct obs.	1997-2001
Distribution/ presence	Natural Resource Management Corp.	Freshwater Creek	juve	direct obs.	1999
Western EMAP pilot	California Dept Fish & Game	multiple statewide	juve	efish	2000-2003
Pop. est/ index/ life history/ genetics/ demogr.	California Dept Fish & Game	Little River, Caspar Cr., Wages, Hare, SF. Noyo, Willits	juve/ smolt	downstr. trap	1986-2001
Pop. index/ life history/ genetics	California Dept Fish & Game	Eel R., Caspar Cr., Little R., Pudding, Wages, Howard, DeHaven, Gualala	juve	efish	1986-2001
Dist/ life-history/genetics	California Dept Fish & Game	Eel R., Caspar Cr., Little R., Hare, Pudding, SF Noyo	adult	spawner/redd/carcass	1986-2001
Population estimates	Simpson Timber Company	Winchuk R., Smith R. tribs, Wilson Cr., Klamath R. trib, Little R. & tribs, Mad R.tribs.	juve	snorkel/efish	1995-2001
Pop. estimates/ demogr.	Simpson Timber Company	Little River and tribs	smolt	downstr. trap	1999-2001
Genetic samples	Simpson Timber Company	Little River tribs	smolt	downstr. trap	1999-2001
Population index	Simpson Timber Company	Winchuk R., Smith R., Wilson Cr., Little R. tribs, Mad R. tribs, and others	adult	spawner/redd/carcass	1994-2001
Population est/ pres-dist	Simpson Timber Company	Mad R., Redwood Cr.	juve	snorkel/efish	1999-2001
Population index/ pres-dist	Simpson Timber Company	Mainstem Mad River	adult	direct obs.	1995-2001
Distribution/ presence	Simpson Timber Company	Multiple in Del Norte and Humboldt Co.	juve	snorkel/efish	1994-2001
Presence-distribution	California Dept Fish & Game	Coastal California basins (300 sites)	juve	direct obs.	2001
Pop. index/ pres-dist/ demog.	National Marine Fisheries Service	Scott Cr., Gazos Cr., Redwood Cr. and Willow Cr. estuaries	juve/ smolt	direct obs.	2000-2001
Genetics	Humboldt State University	Little River, Humbodt Bay trib, Ah Pah Cr.	juve	efish	2000
Population index	California Dept Fish & Game	Caspar Creek	juve	efish	1995-2001
Population index	California Dept Fish & Game	Soquel Creek	juve	efish	1995-2001
Fish passage-reservoir travel time	Sonoma County Water Agency	Russian River	smolt	telemetry	2000-2001

Study/Goals	Agency	Watersheds	Life Stage	Method	Duration
Pop. estimate/ index/ pres-dist	Sonoma County Water Agency	Russian River and tribs	juve	direct obs./efish	1999-2001
Genetics	University of California, Davis	widespread in CA	NA	no direct sampling	
Pop. index/ pres-dist	USDA Forest Service	Smith River	adult	direct obs.	1989-2001
Pop. index/ pres-dist	USDA Forest Service	Smith River and tributaries	adult	redd	1980-2001
Pop. index	Forest Sciences Project	Multiple, N. CA coast	juve	direct obs./efish?	
Presence-absence	Forest Sciences Project	Multiple, N. CA coast	juve	direct obs.	1999-2001
Pop. index/ pres-dist/ demogr.	USDA Forest Service	S. Fk. Eel R., multiple tribs	juve	efish	2001-2003
Pop. estimate/ index/life history/genetics	California Dept Fish & Game	Noyo River	adult	ladder/weir	2001
Pop. estimate/ index/life history/genetics	California Dept Fish & Game	Noyo River (lower watershed)	adult	gillnetting	2000
Pop. index/ pres-dist	California Dept Fish & Game	San Gregorio Cr and tribs	juve	efish	1995-1997
Pop. index	California Dept Fish & Game	Pescadero Creek (San Mateo Co)	juve	efish	1995-1999
Pop. estimate/ index	California Dept Fish & Game	Scott Cr., Gazos Cr.	juve	efish	1993-1995
Pop. index/ pres-dist	California Dept Fish & Game	Fall Cr (San Lorenzo), San Vicente Cr and trib	juve	efish	1995-2000
Presence-distribution	California Dept Fish & Game	San Loreonzo (multiple sites)	juve	efish	1997
Presence-distribution	California Dept Fish & Game	Soquel and Aptos Cr. and tribs	juve	efish	1997-2000
Population estimates	Environmental Science Associates	Russian R. (Squaw Cr.)	juve	efish	1984-2001
Multiple	California Dept Fish & Game	Freshwater Creek and tributaries	adult	ladder/weir	2000-2001
Multiple	California Dept Fish & Game	Bear River, Freshwater Cr and tribs	juve/ smolt	downstr. trap	2001
Pres-dist/ genetics/ harvest est.	California Dept Fish & Game	Smith River	adult	angler survey	1998-2001
Pop. index/ genetics	San Jose State University	Redwood/ Gazos/ Waddell/ Scott creeks	juve	efish/seine	1988-2001
Pop. estimate/ index	California Dept Fish & Game	Redwood Cr., Mad River	juve/ smolt	downstr. trap	2000-2001
Pop. estimate/ pres-dist.-dist.	California Dept Fish & Game	Mad River	adult	ladder/weir	1998-2001
Hatchery fin clip effectiveness	California Dept Fish & Game	Mad River Hatchery	smolt	hatchery ponds	2000-2001
Population estimate/ index	California Dept Fish & Game	Mad River	adult	creel survey	1999-2001
Habitat use/ migration patterns	California Dept Fish & Game	Mad River	adult	telemetry	2000-2001
Fish relocation	Salmon Protection & Watershed Network	Lagunitas Cr., multiple tribs	juve	unknown	1999-2001
Multiple	Salmon Protection & Watershed Network	Lagunitas Cr., multiple tribs	adult	spawner/redd/carcass	1997-2001
Genetics	National Marine Fisheries Service	Coastwide (Oregon border to Morro Bay)	juve	efish	2001
Habitat associations	National Marine Fisheries Service	Santa Rosa Cr. (SLO Co).	juve	efish/direct obs.	2000
Hatchery brood stock coll.	Monterey Bay Sal. & Trout Enhanc. Prog.	San Lorenzo River/Scott Creek	adult	ladder/weir/direct obs.	1982-2001

Study/Goals	Agency	Watersheds	Life Stage	Method	Duration
Pop est./genetics	Eel River Salmon Restoration Project	S. Fk. Eel River: Sproul Creek	juve/ smolt	downstr. trap	1999-2001
Broodstock trapping	Eel River Salmon Restoration Project	S. Fk. Eel River: Redwood Creek	adult	ladder/weir	1983-2001
Presence-distribution	Eel River Salmon Restoration Project	S. Fk. Eel River	juve/ smolt	direct obs.	1986-2001
Population index	California Dept Fish & Game	Soquel Cr., Caspar Cr., Noyo R.	juve	efish	1967-2001
Pop. index/ life-history/ restoration	Natural Resource Services, Inc.	San Joaquin (Merced)	juve	downstr. trap	1999-2001
Spawner distributions	Mendocino Redwood Company	Albion River	adult	spawner/redd/carcass	1992-2001
Juvenile presence/ dist	Mendocino Redwood Company	Multiple in Mendocino/ Sonoma Co.	juve	snorkel/efish	1994-2001
Pop. estimate/genetic samples/restor.	Rowdy Creek Fish Hatchery	Rowdy Creek, Smith River	smolt	hatchery releases	1977-2001
Presence-distribution	National Marine Fisheries Service	Noyo River and tribs	juve	direct obs.	2000-2001
Presence-distribution	National Marine Fisheries Service	Noyo River and tribs	adult	spawner/redd/carcass	2000-2001
Pop. estimate	National Marine Fisheries Service	S. Fk. Tenmile River and tribs	juve	direct obs./efish	2000
Pop. index/ pres-dist	Campbell Timberland Management	Numerous, Mendocino, Sonoma, Humboldt Co.	juve	efish	1993-2000