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# Status of Coho Salmon in California

Report to the National Marine Fisheries Service

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## Foreword

We originally intended to obtain much of the information for this report by using a questionnaire that required a semi-quantitative knowledge of particular populations. It quickly became apparent, however, that few people, if anyone, had enough information to provide the data requested. Our subsequent experience in preparing this report was that data on wild coho salmon populations are very limited. This was more or less expected because coho salmon are dispersed among many small and sometimes inaccessible drainages but the extreme paucity of knowledge concerning coho salmon in many areas was surprising. As a result, much of this report is based on personal communications of very qualitative data from persons associated with particular streams. These contacts and sources of unpublished data are listed after the references.

## Executive Summary

Anecdotal evidence and a few publications have indicated that coho salmon populations have suffered major declines in California but quantitative evidence for this decline is largely lacking. We reviewed the limited data available, much of it from unpublished sources, and found that wild stocks of coho have declined or disappeared from all waters for which data is available.

We found records of the historic occurence of coho salmon in 582 streams, from the Smith River near the Oregon border to the Big Sur River on the central coast. No recent records were located on the presence or absence of fish in 58% of these streams. Of the streams for which we could find data from recent surveys, 54% still contained coho salmon and 46% did not. The status of coho salmon populations is best understood from Mendocino County southwards because of the historic importance of coho salmon in these streams compared to chinook salmon, concern for the effects of urbanization, and presence of agency fisheries biologists and others who have been concerned about the status of coho salmon. Generally, the farther south a stream is located, the more likely it is to have lost its coho population. In Del Norte County, 45% of the streams for which we have reliable records have lost their coho populations, mainly in the Klamath-Trinity system. In Humboldt County, this drops to 31%, rising to 41% in Mendocino County, and 86% in Sonoma County. For streams south of Sonoma County, the figure is 56% but this is probably low as it does not include streams from the Sacramento drainage and includes streams with extremely low populations that are enhanced by hatchery production. Early accounts indicate that the Sacramento drainage did support coho salmon in the 19th century but the salmon were extirpated before any good records were kept.

Historically, estimates of state-wide coho salmon abundance were simply guesses made by fisheries managers, presumably based on limited catch statistics, hatchery records, and personal observations of runs in various streams. In the 1940s, there were assumed to be about 1 million coho salmon spawning in the state, which dropped to about 100,000 fish in the 1960s. In the 1980s, the total was estimated to average around 33,500. Unfortunately, there is no way to test the reliability of these estimates and they should best be regarded as "ball-park" or "order of magnitude" estimates. Using the data available and guesses for streams without data (based on assumptions that should have resulted in overestimates of fish numbers), we estimated that the total number of adult coho salmon entering California streams in the last 3-5 years has averaged about 31,000 fish per year. However, fish from hatchery populations make up 57% of this total and many other populations probably contain at least some fish of recent hatchery ancestry.

Probably the largest concentration of wild fish (little or no hatchery influence) occurs in the South Fork of the Eel River drainage, which we estimated to have runs of around 1,300 fish, although recent (1990) surveys indicate that this estimate may be too high by a factor of 2-3. We would consider 5,000-7,000 naturally spawned coho adults returning to California's streams each year since 1987 to be a realistic assessment of the state's coho populations outside of hatcheries. This estimate is further reduced when "natural" stocks containing fish of recent hatchery ancestry are excluded. There are now probably less than 5,000 wild coho salmon spawning in California each year. Many of these fish are in populations that contain less than 100 individuals, which is quite likely below the minimum population size required to preserve the genetic integrity of the stock and buffer it against

natural environmental disasters. There is every reason to think, therefore, that California's coho populations are continuing to decline, even if hatchery stocks are counted in the total. Populations today are probably less than 1% of what they were in the 1940s and there has probably been at least a 70% decline since the 1960s.

The general reasons for the decline of coho salmon in California are many and well known: poor land use practices, especially related to logging and urbanization, that alter streams and are exacerbated by floods and drought; alteration of the genetic integrity of wild stocks through planting of hatchery fish from distant locations; introduced diseases; over harvest; climatic change etc. However, the problems have not been well defined for individual drainages, which is where management efforts must be focussed. Management goals put forward by the California Department of Fish and Game could reverse the trends if properly implemented but this will require a major effort involving increased funding, considerable interagency cooperation, and development of an extensive monitoring program.

The challenges of managing such a diffuse resource as coho salmon are considerable but if we do not start reversing the population declines soon, we are likely to lose the southernmost populations of this species, a unique genetic, aesthetic, and economic resource. Coho salmon in California probably qualify for listing as a threatened species under state law and a number of populations may qualify for listing as threatened or endangered under federal law. We recommend, however, that state-wide listing be postponed provided immediate efforts are made to reverse the decline, to see if cooperative rather than coercive methods can be made to work to protect the species. We do suggest, however, that the population in Scott Creek, Santa Cruz County, be

listed as endangered, to ensure the continued existence of the southernmost, genetically pure population.

## Introduction

Populations of anadromous fishes in California have generally declined in recent years, as indicated by decreased catches in both commercial and sport fisheries (Lufkin 1991). Coho salmon are caught in both sport and commercial fisheries but are especially important in the sport catch. In the 1980s California's combined commercial and sport catch averaged 83,000 fish annually of which 30,200 were caught in the sport fishery (Sheehan 1991). However, 90% of these fish probably originated in Oregon (see below). There is widespread agreement among experts familiar with coho salmon that wild stocks in California have declined significantly in recent years but the extent of the decline is unknown, in part because the species is divided into many small populations few of which are monitored closely, if at all. Moyle et al. (1988) listed coho salmon as a species of special concern in California. They classified coho salmon as a Class 3 species, meaning it is an uncommon species throughout much of its natural range, but formerly more abundant, with pockets of abundance within its range. Recently, the American Fisheries Society listed 214 native naturally spawning stocks of anadromous salmonids that are declining and rated their risk of extinction in the near future (Nehlsen et al. 1991). California coho populations south of San Francisco Bay were rated at a high risk of extinction, populations north of San Francisco Bay were at moderate risk of extinction, except Klamath populations which were classified as special concern (declining but in no immediate danger). A recent estimate places the present population of coho salmon at one-third of its size 25 years ago. In the 1980s the average annual run of spawners was estimated at 33,500 fish (Sheehan 1991). This is less than the 40,000 fish estimated to use the Eel River alone as late as the 1960s (U.S. Heritage

Conservation and Recreation Service 1980). An earlier estimate placed the California run at 100,000 fish, representing a decline of 80-90% from levels in the 1940s (California Advisory Committee on Salmon and Steelhead Trout 1988).

An unpublished tagging study (cited in Baker and Reynolds 1986) indicates that the majority of the California ocean catch actually originates in Oregon with Columbia River fish appearing to be the largest component of the catch. In 1977, over 80% of the coho salmon released along the Pacific coast were released into the Columbia River (Scarnecchia and Wagner 1980). Northern California fish make up only about 10% of the California ocean catch. Tagging experiments conducted in 1971 indicated that 6 to 7% of California native stocks were taken in Oregon and Washington while exotic stocks (Alsea River, Oregon and Klaskanine River, Washington), released from California hatcheries, were taken at the rate of 20%. Of the total ocean recoveries, 25% of the native fish planted were taken but only 13% of marked exotics (Jensen 1971). A recent study in Oregon indicated that 75% of the coho caught off the Oregon coast in 1977 were released from hatcheries as smolts (Scarnecchia and Wagner 1980). The percentage of California fish produced in hatcheries may be even higher given the present low productivity of natural populations. For example, it has been noted that production of coho salmon on the central Mendocino County coast centers around the Noyo River which is stocked with hatchery raised fish. The number of coho salmon utilizing Mendocino County streams declines both north and south of the Noyo River (W. Jones, pers. comm.).

This report summarizes published and unpublished information concerning the distribution and status of coho salmon in California.

## Life History

The life history of coho salmon is well known (Shapovalov and Taft 1954, Hassler 1987). In California, coho salmon spawn in coastal streams ranging in size from the Klamath River to small coastal streams such as Scott and Waddell Creeks, tributaries to Monterey Bay. The streams in and around Monterey Bay support the southernmost populations of the species. The juveniles spend one year in freshwater, where they require cold water (10-15$^{0}$C), deep pools and abundant instream cover, especially fallen trees. Such streams are typically associated with heavily forested areas. The juveniles then migrate to the sea, where they spend the next two growing seasons, and return to spawn as three-year olds, except for some proportion of the males which return after two years (termed grilse). Although coho salmon are remarkably flexible in their life history, there seem to be two basic strategies: short-run populations which utilize the smaller coastal streams and long-run coho that may migrate considerable distances (up to 100-200 kilometers) to utilize tributaries of the large coastal rivers.

Since hatchery-raised coho salmon constitute a significant portion of the population in some streams, coho salmon populations can be divided into three stock types: wild stocks are populations which have few or no hatchery-raised fish in their ancestry; natural stocks are populations which have included a large proportion of hatchery fish at some time but are the progeny of fish that have spawned naturally; hatchery stocks are populations which include large numbers of hatchery fish every year and show little evidence of successful natural reproduction.

## Distribution and Status

In California, coho salmon spawn in streams from the northern part of Monterey Bay, Santa Cruz County, north to the Oregon border (Fry 1973). The southernmost record of ocean distribution is an individual caught by a sportfisherman on June 20, 1937 near the Los Coronados Islands (Scofield 1937). The southernmost stream where juveniles have been captured or spawning noted is the Big Sur River, Monterey County (Hassler 1988). However, the southernmost naturally spawning populations at the present time are in Scott and Waddell Creeks, about 50 miles to the north. Streams which support a population of coho salmon or have done so in the past are listed in Table 1. For some streams, specific numbers of fish present are noted in the text or in the Appendix. The past and present status of various populations are discussed below following the discussion of hatchery populations.

## Hatchery Populations

Long-run coho salmon stocks are now dominated by hatchery production, except in the Eel River. A number of short-run populations also receive regular plants of hatchery fish. The hatchery stocks used to maintain these populations have, without exception, included fish from outside the river system and often from outside California. These same hatchery stocks are also used to reestablish extirpated populations or supplement populations at low levels of abundance. The records of each hatchery are reviewed below. Also included is the Noyo River egg taking station.

### Klamath River: Iron Gate Hatchery

From 1963 to 1968 adult returns never exceeded 500 fish (Fig. 1, data from published hatchery records). Subsequent to an intensive stocking

program begun in 1966, adult returns to the hatchery exceeded 2,000 fish on several occasions most recently in 1987 (Hiser 1991), although numbers have typically ranged from 500 to 1,500 fish. The intensive stocking of hatchery-raised coho salmon began with the importation of eggs from the Cascade River, Oregon, which were hatched and released as yearlings in 1966. Additional stockings of Cascade River stock occurred in 1967 and 1969. Thus, though the hatchery has been able to produce substantial returns of adult fish, it has done so with what is basically an exotic stock of fish.

Trinity River: Trinity River Hatchery

The Trinity River Hatchery has also been successful in establishing a run of coho salmon which has continued to increase in size (Fig. 2, data from published hatchery records). Adult returns rarely exceeded 1,000 fish previous to 1971 but have done so consistently since then. Returns exceeded 5,000 coho in 1973, and 1984-1988. Returns exceeded 10,000 coho in 1988 and 20,000 in 1987. Like the Iron Gate stock, the Trinity River stock is also primarily of exotic origin. Eel River stock were planted in 1964, the first year significant plants occurred, followed by plants of Cascade River, Oregon stocks in 1966, 1967 and 1969. Fish of Noyo River, California stock were planted along with Cascade River fish in 1969 and Alsea River, Oregon stock were planted in 1970. Besides the fish returning to the hatchery, significant numbers of fish, estimated at 40% of adult escapement, spawn naturally in the Trinity River, primarily in the area between Lewiston Dam and Douglas City (Rogers 1973). Downstream migrant coho salmon, not of hatchery origin, have also been captured in the Trinity River (Healey 1973), indicating that natural spawning still occurs in the Trinity River. However, the relative contribution of wild and hatchery stocks to this natural production is unknown.

Mad River: Mad River Hatchery

The Mad River Hatchery has been less successful than the Klamath system facilities at establishing a run of coho salmon to the hatchery (Fig. 3, data from published hatchery records). Adult returns have fluctuated, never exceeding 2,000 fish and seldom exceeding 1,000 (2 of 18 years). The Mad River Hatchery stock has the most diverse heritage of any in California. Planting began in 1970 with fish from the Noyo River. Noyo River fish were planted in 7 subsequent years. Klamath River fish (derived from Cascade River stocks) were planted in 1981, 1982, 1986, and 1987. Trinity River fish (derived from exotic stocks) were planted in 1971. Klaskanine River, Oregon stock was planted in 1973. Trask River, Oregon stock was planted in 1972. Soos River, Oregon and Sandy River, Oregon stocks were planted in 1978 and 1979, respectively. Finally, fish from Prairie Creek (Redwood Creek drainage, California) were planted in 1987 and 1989.

Russian River: Warm Springs Hatchery

Similar to Mad River Hatchery, the Warm Springs Hatchery has not established a consistent run of coho salmon since it began planting fish in 1980 (Fig. 4, data from published hatchery records). Adult returns have varied from just below 1,000 fish to 0 fish. The Warm Springs Hatchery stock is derived from the Iron Gate Hatchery (derived from Cascade River stock), Noyo River, Hollowtree Creek, and Prairie Creek stocks.

Noyo River Egg Taking Station

The Noyo River egg taking station began operations in 1962 with the purpose of establishing a supply of California stock eggs for enhancement of depleted coho salmon stocks and hatchery production. The station is located on the South Fork Noyo River. The number of fish trapped at the weir varied

between about 1,500 and slightly over 3,000 coho during the period 1964 to 1976 (Fig. 5, data from published records). Returns then declined during the period 1977 to 1986, exceeding 1,500 fish only in 1981. In 1987, the adult population was over 2,500. Depending on the size of the run, a number of fish are passed over the dam to spawn naturally. The river is also routinely planted with fish hatched from Noyo River eggs and raised to yearling size at various hatchery facilities. These plants began in 1964. Significant natural spawning takes place in the South Fork Noyo River below the station and in Kaas Creek the first tributary below the station (Nielsen 1991). The genetic heritage of these spawners is unknown. The station has been very successful at supplying eggs as can be seen from the planting of Noyo River fish at the above hatcheries. Noyo River stock has also been planted in a number of coastal streams.

Prairie Creek Hatchery

Prairie Creek Hatchery did not have facilities for capturing returning adult fish until 1972 (S. Sanders, pers. comm.). Since records of hatchery returns have been kept, the run has generally exceeded 100 fish and there appears to be an increasing trend in the population with a maximum of 1,799 coho in 1988. Returns have declined in subsequent years with 682 in 1989 and 186 in 1990 (as of 23 January 1991) (Fig. 6, S. Sanders, unpubl. data). The main problem for the Prairie Creek population appears to be insufficient flow for fish to make it upstream to the hatchery (S. Sanders, pers. comm.). The years from 1975 to 1977 were particularly poor years for adult returns to the stream. Prairie Creek coho salmon now tend to return later in the season than previously. Most adults now return in January or February. Most adults trapped in the hatchery are returning planted fish, few naturally

produced fish are found. In the early 1970s, stray coho of Columbia River stock were commonly captured but are now rare in Prairie Creek. In most years Prairie Creek stock is planted but some exotic stocks have also been planted. Exotic stocks include Soos River, Oregon (1978), Sandy River, Washington (1979), Klamath River, California (derived from Cascade River Oregon stock, 1981), and Noyo River, California (1982).

## Wild Populations

There is very little data available on the status of wild populations of coho salmon. The little information that is available suggests that wild stocks are at very low levels. The commercial troll catch of coho salmon declined drastically in the late 1970s despite continued high levels of planting of hatchery fish (Fig. 7). Because hatchery returns were increasing or fluctuating in no specific direction at this time, it is likely that wild fish had been providing a significant portion of the fish being harvested and that those populations were declining. The coho salmon in the California catch consist of both salmon produced in California streams and hatcheries and those produced in Oregon (Hassler 1987). Increases in hatchery production are believed to be the major factor resulting in the increased catches of the 60s and 70s. The bulk of fish produced by California waters are harvested there. The coho salmon count at Benbow Dam on the South Fork Eel River showed a gradual but steady decline from the 1940s to middle 1970s when no fish were counted (Fig. 8). In contrast, the population in the Mad River fluctuated at a low level through the early 1960s and no declining trend was ever apparent (Fig. 9). However, the coho population was never as large as that in the South Fork Eel River. Counts at Waddell Creek, Santa Cruz

County, from the 1930-1931 season to the 1939-1940 season, before the period of decline, tended to fluctuate without an overall trend, though the time span of the study was short (Fig. 10)(Shapovalov and Taft 1954).

Data for a number of individual streams are presented below. We primarily address streams for which we have some recent data or a considerable amount of historical data. A number of streams for which little data existed are listed in Table 1 along with the more well known streams. Any data for the former less known streams are included in the Appendix. The Appendix also includes some additional data for some of the streams discussed in the text.

Smith River

West Branch Mill Creek

A study section 1.7 miles long has been surveyed once a week from November through February since 1980 (Waldvogel 1988). The primary purpose of the study was to document chinook salmon escapement but coho salmon were also present. The Smith River system does not support a large run of coho salmon (Waldvogel 1988). The number of coho salmon counted each year starting with the 1980 season was 11, 2, 4, 3, 6, 28, 11, 27, 5, and 13. No coho were counted in the 1990-1991 season as of 24 January 1991 (J. Waldvogel, pers. comm.). The run of 27 fish counted in 1987 included 14 fish planted from the Rowdy Creek Hatchery (Rowdy Creek, Smith River). These fish were counted from 16 December 1987 to 4 January 1988. The remainder of the fish were of wild origin and were observed later in the season (13 January 1988 to 2 February 1988). The hatchery fish were returning adults from a plant of 22,000 smolts planted two years earlier. A large return to the hatchery was expected in 1987 but did not occur. The presence of the fish in Mill Creek,

upstream of Rowdy Creek, suggests that a substantial amount of straying took place. Historical counts of adults were not found for Mill Creek; however, Hallock et al. (1952) seined a total of 60,602 juveniles from Mill Creek in 1951, indicating that the stream has supported a substantial population of coho salmon in the past.

Klamath River

Data on wild coho salmon in the Klamath River are somewhat limited. Snyder (1931) indicated that coho salmon were abundant in the lower river, but that there was little interest in the population because chinook salmon were so much larger and more abundant. Snyder (1931) recorded a total catch by the commercial gill-net fishery of 11,162 coho salmon (83,836 pounds) in the time period of September 20, 1919 to 22 October, 1919. Gibbs and Kimsey (1955) estimated an annual catch of 1,187 coho salmon by the sport fishery in 1951. The estimated sport catch in the lower Klamath in 1954 was 4,000 fish (McCormick 1958). Coots (1957a) states that a small run of coho salmon spawned in Fall Creek (about 200 miles from the sea), now above Iron Gate Dam. Three hundred ten coho salmon were counted at the Shasta River counting racks from 13 to 31 October 1957 (175 miles from the sea)(Coots 1958a). However, none were counted in 1955 during the trapping period of 24 August 1955 to 8 November 1955 (Coots 1957b). At Klamathon racks (187 miles from the sea), Bryant (1923) described coho salmon as being abundant, but stated that eggs were only taken from chinook salmon. Snyder (1931) reported a count of 295 coho salmon (269 males and 26 females) at Klamathon Racks in 1925. Coots (1958b) reported no coho salmon at the racks in 1956. The sporadic nature of these counts may have resulted from variable use of [illegible] for spawning from year to year but more likely reflected

differences in migration times which determined whether fish arrived when the facilities were operating. Recent data from the mainstem Klamath River indicate substantial numbers of fish. Tuss et al. (1989) and Kisanuki et al. (1991) monitored the Native American gill net fishery on the Hoopa Valley Reservation and documented the capture of 588 coho salmon in 1988 and 525 in 1989. The proportions of wild and hatchery fish in the catch was unknown, though some tagged fish were caught in both years. At present, hatchery production from Iron Gate and Trinity hatcheries is considered the source of most of the Klamath River coho run and natural spawning is believed to be minor (Klamath Fishery Management Council 1991).

In the Trinity River, coho salmon have been reported as spawning in the mainstem Trinity River, South Fork Trinity River, and the tributaries. The upstream limit in the mainstem has been reported as Lewiston (personal communications by Smith and Sharp, cited in Fredericksen, Kamine and Associates, Inc. 1980). From the 1958-1959 season to the 1962-1963 season, escapement of wild fish at Lewiston ranged from 7 to 583 fish, mean = 228)(data from published records). In 1970, Rogers (1973) estimated a spawning population of 2,098 fish in the mainstem below Trinity hatchery, though all or most of these fish were probably hatchery returns. Healey (1973) captured downstream migrant yearlings in the Trinity River that were likely spawned in the river, but the genetic heritage of these fish is unknown. Juvenile coho salmon were not trapped from the South Fork Trinity River indicating that any wild stock may be very depleted or gone (Healey 1973). Historical data on the abundance of coho salmon in the tributaries is minimal. Coho salmon have been reported from 113 tributary streams in the Klamath-Trinity River drainage (Table 1). Streams where quantitative data exist are

discussed below.

Klamath River tributaries

No reliable records appear to exist on the contribution of lower Klamath tributaries to the production of coho salmon but it probably was high. Recent work has included electrofishing during the rearing period and outmigrant trapping. Many of the lower tributary streams have been degraded by various land use practices such as logging and roadbuilding (T. Kisanuki, pers. comm.). Their production of all salmonid species has probably been reduced from historic levels but the degree of decline is difficult to assess. Also, flows in many of the tributary streams have been low during the recent drought period (1986-present) and carrying capacity of the streams appears to be reduced accordingly (T. Kisanuki, pers. comm.). Data from individual streams are presented below. Recent surveys failed to find coho salmon in Tully Creek and Pine Creek in 1989 and outmigrants were not captured from Pecwan Creek, though juveniles were found in previous years (T. Kisanuki, pers. comm.). Hoppaw Creek has produced coho in the past with the number of juveniles rescued ranging from 60 to 1,153 (Shapovalov 1940, 1941, Murphy 1951, Kimsey 1952, 1953). Recent records were not found for this stream.

Small tributary streams in the middle and upper reaches of the Klamath River still support coho salmon and many of the populations may be wild. Available records indicate no stocking in some of the streams surveyed (see below). Of the larger tributary systems the Scott River probably holds the largest number of wild fish. The Salmon River probably has few or no coho salmon (J. West, pers. comm.).

Hunter Creek

Fish rescue operations in Hunter Creek (fish seined out of cutoff pools

etc. and returned to flowing water) accounted for 152 to 25,226 juvenile coho salmon from 1939 to 1945 (Shapovalov 1940, 1941, 1942, 1944, 1945a, 1945b, 1949). Rescue numbers varied from 535 to 5,641 during 1950 to 1952 (Murphy 1951, Kimsey 1952, Hallock et al. 1952, Kimsey 1953). It should be noted at this point that the fish rescue records only apply to streams where significant stranding of fish in side pools of perennial streams occurs or fish become trapped in pools of downstream sections that become intermittent during the summer. The numbers thus represent minimum values since fish in upstream, *flowing areas would not be sampled.*

Two tributaries to Hunter Creek also produced significant numbers of coho juveniles. High Prairie Creek accounted for 380 to 3,537 coho juveniles from 1950 to 1952. Ten thousand juveniles were rescued from Mynot Creek in 1940 (Shapovalov 1941) and 1,274 were rescued in 1952 (Kimsey 1953).

During the Spring of 1989 outmigrant trapping accounted for 1 coho salmon captured during 1 of 9 overnight trapping periods.

Turwar Creek

Turwar Creek has also accounted for significant numbers with values ranging from 318 to 13,685 (Shapovalov 1940, 1941, 1942, 1944, 1945a, 1945b, Murphy 1951, Kimsey 1952, Hallock et al. 1952, Kimsey 1953). During 15 nights of outmigrant trapping in 1989, coho salmon were caught on 7 nights. The total number of coho captured was 37 fish (T. Kisanuki, pers. comm.).

McGarvey Creek

McGarvey Creek was electrofished in August 1988 and 1989 to determine populations of coho salmon and steelhead (D. McLeod, unpubl. data). This effort represents the beginning of an annual survey of an index section on McGarvey Creek. Within the 42.4 m reach surveyed the estimated number of

coho salmon was 0.30 fish/$m^2$ (0.90 coho/m) in 1988. No coho salmon were captured in 1989. Biomass was 0.94 g/$m^2$ in 1988. The site was not sampled in 1990 due to budgetary constraints. The mean of these two years is well below the mean for Mendocino County coho salmon streams (0.41 fish/$m^2$, W. Jones, unpubl. data). Hallock et al. (1952) seined 220 juvenile coho from McGarvey Creek in 1951.

**Tarup Creek**

Historical data for Tarup Creek were not found. Two coho salmon outmigrants were captured during 1 of 6 overnight trapping periods in 1989 (T. Kisanuki, pers. comm.).

**Ah Pah Creek**

Historical data for Ah Pah Creek were not found. A total of 7 coho salmon were caught during 5 of 12 overnight trapping periods in 1989 (T. Kisanuki, pers. comm.). The South Fork of Ah Pah Creek was electrofished in August 1988 and 1989 to determine populations of coho salmon and steelhead (D. McLeod, unpubl. data). This effort represented the beginning of an annual survey of index sections along the North coast. Within the 33.4 m reach surveyed the estimated number of coho salmon was 0.31 fish/$m^2$ (0.63 coho/m) in 1988 and 0.72 fish/$m^2$ (1.74 coho/m) in 1989. Biomass was 1.20 g/$m^2$ in 1988 and 3.47g/$m^2$ in 1989. The site was not sampled in 1990 due to budgetary constraints. These values compare favorably with densities found in Mendocino County coho streams (W. Jones, unpubl. data, see below).

The relatively low numbers of outmigrants caught in 1989 compared to the density of juveniles noted during electrofishing in 1988, highlights the fact that sporadic trapping is best used to establish presence rather than abundance.

Bear Creek

Bear Creek was trapped for outmigrants during 6 overnight trapping periods in 1989. A total of 3 coho were captured during 2 of the 6 trapping periods (T. Kisanuki, pers. comm.).

Tectah Creek

A total of 6 coho salmon were captured from Tectah Creek during 2 of 11 overnight trapping periods in 1989 (T. Kisanuki, pers. comm.). Comparative data were not available for this stream.

Roach Creek

Outmigrant trapping was conducted on Roach Creek for 8 overnight periods in 1989. A total of 2 coho salmon were captured, each on a separate night (T. Kisanuki, pers. comm.). No historical data were found for this stream.

Irving Creek

Irving Creek was surveyed in December 1988 (A. Olson, unpubl. data). No adult coho salmon were observed. No redds were seen; however, some coho salmon fry were observed. No hatchery plants of coho salmon have occurred in recent years. Coho salmon have not previously been reported from this stream in the published literature.

Independence Creek

This stream was surveyed in 1990 (A. Olson, unpubl. data). One redd identified as a coho salmon redd was observed. No adult or juvenile fish were seen. Though listed in Table 1, this population should be considered questionable.

Elk Creek

Elk Creek and its tributaries East Fork Elk Creek, Cougar Creek and

Mill Creek were surveyed in 1988 (A. Olson, unpubl. data). Eleven coho salmon were observed in the mainstem of Elk Creek and 4 fish were seen in East Fork Elk Creek. Mainstem Elk Creek was surveyed in 1989 and 1990 and fewer than 10 coho were seen in both years. Juveniles were present in all years in the mainstem but were not seen in the tributaries. Juvenile density ranged from 0 to 0.142 fish/$m^2$, depending on the habitat type. These densities are rather low compared to densities in Mendocino County streams (W. Jones, unpubl. data). Elk Creek received plants of coho salmon from 1986 to 1989. The size and location of the juveniles during the above studies indicated that naturally spawned fish were observed (A. Olson, pers. comm.). It is unknown whether the adults observed were wild fish, the result of hatchery plants or naturally spawned from previously planted fish.

**Indian Creek**

Indian Creek and its tributaries, Mill Creek and East Fork Indian Creek, were surveyed for adults, redds, and juveniles in 1987 (A. Olson, unpubl. data). Twenty-four adults were counted in 1987, 14 in 1988, and less than 10 in 1989 and 1990. All adult fish were observed in the mainstem. Streams were surveyed one or two times in December. Fry were present in the mainstem and the tributaries indicating that spawning was taking place in the tributaries. Data on juvenile densities from the summer of 1989 indicated densities ranging from 0 to 0.143 fish/$m^2$. Indian Creek did receive plants of coho salmon from Iron Gate Hatchery from 1986-1989; however, comparison of the survey locations and size of fish seen with the location of the plants and size of the fish planted indicated that the surveyed fish were naturally spawned (A. Olson, pers. comm.). Again, the densities of fish observed were

China Creek

China Creek was surveyed twice in December 1988. Two adult fish and one redd were observed (A. Olson, unpubl. data). Coho salmon fry were also present. China Creek has not been planted with hatchery fish in recent years.

Thompson Creek

This stream was surveyed twice in December 1988 (A. Olson, unpubl. data). Two adult coho salmon and one redd was observed. Coho salmon fry were also present. There have been no recent plants of hatchery fish so the fry were most likely naturally spawned.

Grider Creek

Grider Creek was surveyed for juvenile abundance in 1989 (A. Olson, unpubl. data). A total of 32 juvenile salmon were observed. Coho salmon density ranged from 0 to 0.056 fish/$m^2$, depending on the habitat type.

Redwood Creek

Early data on the Redwood Creek coho salmon population is lacking. Coho salmon were first reported in Redwood Creek by Snyder (1908). Juveniles have been captured or adults noted in Redwood Creek, its major tributary Prairie Creek, and several tributaries to Prairie Creek including Little Lost Man Creek, Lost Man Creek, May Creek, Godwood Creek and Boyes Creek during various fish rescue operations (fish rescue records) and other studies (Hallock et al. 1952, Fisk et al. 1966). During a 1973 survey of Redwood Creek the Bureau of Reclamation estimated that 2,000 spawners utilized the stream, though the criteria for that estimate were not stated. They also noted extensive habitat damage above Redwood National Park, which they attributed to poor logging practices. Poor land use in association with

high flows in 1955, 1964, and 1965 resulted in pool filling and widening of the channel. Fisk et al. (1966) classified 68.5 of 84 miles of available habitat as severely to moderately damaged. The total population of coho salmon may still number more than 2,000 fish in some years but most of those fish occur in the Prairie Creek system and probably are hatchery fish rather than wild fish (S. Sanders, pers. comm. and D. Anderson, pers. comm.).

Prairie Creek

As noted above, most of the coho in this stream are probably hatchery returns rather than wild fish. Older data indicate that a substantial wild coho population existed at one time. Briggs (1949) noted that Prairie Creek was used extensively for spawning by both coho and chinook salmon and that coho salmon outnumbered chinook salmon by about 6 to 1. He also estimated from 61 to 171 juvenile coho salmon in a 300 yard section of Prairie Creek (approximately 0.19 to 0.52 fish/m). 1/14' — 1/5'

Little Lost Man Creek

Little Lost Man Creek is a tributary to Prairie Creek which is part of the Redwood Creek drainage. An index section was electrofished in August of 1988 and 1989 (D. McLeod, unpubl. data). Coho salmon were captured in both years. In 1988 the density of coho was 0.63 fish/$m^2$ and density of biomass was 1.57 g/$m^2$. In 1989 the values were 0.82 fish/$m^2$ and 1.82 g/$m^2$. The index section was not sampled in 1990. This creek is in close proximity to the Prairie Creek Hatchery and some portion, if not the majority, of the adults using the stream are probably hatchery returns.

Godwood Creek

Burns (1971) conducted quantitative sampling on this Prairie Creek tributary from 1967 to 1969. Estimates of the coho salmon population were

1186, 961 and 352 juveniles in 1.1 km, respectively. More recent data are not available for this stream. If coho are still utilizing this stream, hatchery returns probably contribute substantially to the population.

Mad River

Numbers of coho salmon passing over Sweasey Dam on the Mad River fluctuated from 0 to 1,000 fish from 1938 to 1961. An extremely high population was counted in 1962 when over 3,500 fish passed over the dam. Counts in 1963 and 1964 dropped to 1,500 and less than 500 fish, respectively (Fig. 9). Counts at Mad River hatchery, near Blue Lake have fluctuated in about the same range (500-1,000) from 1971 to 1988 (Fig. 3). Thus it appears that overall numbers have remained relatively steady though the relative contribution of hatchery and wild fish to the population is not known. Besides the tributaries listed below, juvenile coho salmon have been captured from Grassy Creek, Noisy Creek, and Camp Bauer Creek.

Lindsay Creek

Lindsay Creek and its tributary Squaw Creek have produced significant numbers of coho salmon. Hallock et al. (1952) seined 10,663 and 6,810 juveniles from these streams in 1951. Murphy (1951) captured 11,672 juveniles from Squaw Creek in 1950 and Kimsey (1953) rescued 1553 juveniles from Squaw Creek in 1952. We did not obtain more recent data for this stream.

Canon Creek

An index section of Canon Creek was electroshocked in August 1988 and 1989 (L. Preston, unpubl. data). The index section was 28 m long. Fish density was 0.2 and 0.5 fish/m2 in 1988 and 1989, respectively. Biomass density was 0.9 and 0.2 g/m2, respectively.

Humboldt Bay

Freshwater Creek has been the focus of much of the enhancement and habitat restoration efforts of the Humboldt Fish Action Council which began rearing coho and chinook salmon for enhancement of salmon populations in Humboldt Bay tributaries in the early 1970s (Hull et al. 1989). Efforts to use native fish as an egg source had limited success between 1978 and 1982 because only a temporary trap was available. These efforts were successful after the construction of a permanent weir in 1983. Hull et al. (1989) noted that runs at the beginning of their work were much reduced from historical levels, though numbers were not available. Hallock et al. (1952) seined 8,642 juveniles from Freshwater Creek, 17,671 from Elk Creek, and 14,243 from Jacoby Creek indicating a substantial population in each stream. Total escapement in the Freshwater Creek drainage was estimated at 454 coho salmon in 1986/1987 and 834 coho salmon in 1987/1988. The estimated hatchery contribution in these two seasons was estimated at 0% (no plants in 1985) and 68% (267 naturally spawned fish), respectively. In 1991, enhancement efforts will shift to chinook salmon because it is suspected that the production of coho salmon has reached a maximum (D. Hull, pers. comm.). Initial enhancement efforts used exotic stocks including fish from Alsea River, Oregon (1971/1972), Trask River, Oregon (1972/1973), Trinity River, California (1974/1975 and 1977/1978), Skagit River Washington (1976/1977), Soos River, Washington (1978/1979), Sandy River, Oregon (1979/1980), Noyo River, California (1975/1976, 1978/1979 and 1982/1983), Klamath River, California (1981/1982, 1982/1983, 1983/1984 and 1985/1986), and Minter River, Washington (1981/1982). Reliance on exotic stocks has declined as populations have become established in Humboldt Bay tributaries, including Freshwater Creek (Hull 1987). Other

enhancement and habitat restoration efforts have been made on other tributaries including Janes Creek, Jolly Giant Creek, Jacoby Creek, Cochran Creek, Ryan creek, Elk River and Salmon Creek.

Eel River

The Eel River, especially the South Fork of the Eel River, probably supports the largest remaining wild populations in California. The most recent official estimate places the run at 40,000 fish annually (U.S. Heritage Conservation and Recreation Services 1980). However, this figure exceeds a more recent estimated statewide coho population of 33,500 spawners (Sheehan 1991) At present, coho salmon are known to spawn mainly in the South Fork Eel River, primarily in the tributaries, upstream almost to the headwaters above the town of Branscomb. In the mainstem Eel River, coho salmon are still known to spawn in several small tributaries to Outlet Creek, including Willits, Broaddus, and Baechtel Creeks (G. Flosi, unpubl. data, W. Jones, unpubl. data). The lower mainstem does not appear to be used as rearing habitat to any significant degree (Murphy and DeWitt 1951). In the Van Duzen River, coho salmon have been reported from a number of tributaries upstream to Grizzly Creek; however, downstream migrant trapping on the Van Duzen River near Carlotta in November 1967 and March to August 1968 (1-11 days per month) did not capture any outmigrating juveniles. This indicates that the populations may be relatively small. Coho salmon juveniles were recently captured in small numbers from the mainstem Van Duzen River, Grizzly Creek, and Cummings Creek (Brown and Moyle 1991).

Older records indicate that coho salmon were even more widespread in the Eel River drainage in the past. CDFG file information indicates that coho salmon have used Indian Creek (mainstem tributary above Outlet Creek) and

several tributaries to Tomki Creek. During the 1946-1947 season, 47 coho salmon were recorded passing through the Van Arsdale fish facility, 156.8 miles from the sea. They have not been recorded there since (Grass 1990). The Tomki Creek drainage has been intensively studied since 1986 and no coho salmon outmigrants have been captured or adults observed (SEC 1990). There are also records indicating the presence of coho salmon in Bluff Creek, a tributary to the North Fork Eel River, the Middle Fork Eel River, tributaries to Middle Fork Eel River including Mill Creek, its tributary Grist Creek, Rattlesnake Creek and Rock Creek, a tributary to the North Fork of the Middle Fork Eel River (Table 1). No outmigrants were captured during trapping in the Middle Fork Eel River during May to September 1959 (2-4 days per month)(Puckett 1976). These populations are extinct (W. Jones unpubl. data and pers. comm., L. Brown, pers. obs.).

**Outlet Creek (tributary to mainstem Eel River)**

Outlet Creek is a tributary to the mainstem Eel River. Nielsen et al. (1991) conducted surveys on 8.1 miles of the mainstem and 34.8 miles of tributary streams. The tributary streams surveyed were Baechtel Creek, Bloody Run Creek, Broaddus Creek, Cherry Creek, Davis Creek, Haehl Creek, Long Valley Creek, Dutch Henry Creek, Ryan Creek, Reeves Creek, Upper Little Lake and Willits Creek. All except, Davis, Cherry, Dutch Henry and Upper Little Lake have been reported to support coho salmon at some time (Table 1). None of the streams surveyed were reported to have coho salmon during the 1989-1990 season. Surveys of juvenile fish have consistently indicated that coho spawning has occurred in the recent past (W. Jones, unpubl. data), though residents of the area have noted a sharp decline in spawning in the two years previous to the Nielsen et al.'s study (1987-1988 and 1988-1989).

Adult fish have been detected in the system as recently as the 1988-1989 seasons. Flosi (unpubl. data) reported the following counts. On the mainstem Outlet Creek 1 live fish and 41 carcasses in 1987-1988 and 2 carcasses in 1988-1989. In Long Valley Creek, 2 carcasses were seen in 1987-1988 and 7 carcasses in 1988-1989. Juvenile coho salmon were present in Long Valley Creek in good numbers in 1987 (Brown and Moyle 1991) and 1990 (L. Brown, unpubl. data). Reeves Canyon Creek contained 3 live coho and 48 carcasses in 1987-1988 but none were counted in 1988-1989. Surveys of Ryan Creek found 6 live coho and 10 carcasses during the 1987-1988 season and 2 carcasses during the 1988-1989 season. No juveniles were found in Ryan Creek in 1990 (W. Jones, pers. comm.). One carcass was found each season in Willits Creek. Coho were found in Broaddus Creek during the 1987-1988 season only, with 23 live coho and 1 carcass reported. Five carcasses were counted in Haehl Creek during the 1987-1988 season. Baechtel Creek contained 3 carcasses in 1987-1988 and 4 carcasses in 1988-1989.

South Fork Eel River

As noted previously, the number coho salmon counted at Benbow Dam have declined to low levels since counts began in the 1930s (Fig. 8). In 1952, Murphy (1952) suggested that the South Fork population was being held at a low level through a strong relationship between spawning escapement and the adult populations in subsequent years. In other words, by increasing escapement to the maximum, more fish would be available for harvest. Murphy suggested that commercial and sport fishing were the factors limiting the population.

Nielsen et al. (1991) observed coho salmon in the South Fork Eel River from 19 December 1989 to 25 January 1990. The surveys included three

sections of the mainstem South Fork Eel River and several tributary systems. The mainstem sections were a lower section extending from Redwood Creek near Redway to McCoy Creek, a middle section extending from McCoy Creek to Ten Mile Creek and an upper section from Ten Mile Creek to Windem Creek. Carcasses were recovered from and live fish observed in the middle and upper sections. Based on carcasses the estimated population was 11-23 coho salmon. The estimate based on the live counts was 20-33 coho salmon. Flosi (unpubl. data) reported both live coho adults and carcasses from the mainstem South Fork Eel River during the 1987-1988 and 1988-1989 seasons, indicating that some mainstream spawning may occur in most years. Nielsen (pers. comm.) and Brown and Moyle (1991) have captured juvenile coho salmon from the mainstem South Fork Eel River in its upper reaches near Branscomb. Data from some tributaries to the South Fork Eel River are presented below.

**Bull Creek**

Historical records from the Bull Creek drainage are restricted to 4,844 juveniles rescued in 1939 (Shapovalov 1940) and 3,000 juveniles seined for a tagging study in 1951 (Hallock et al. 1952). It is likely that the Bull Creek runs once numbered in the thousands, given the size of the drainage. Recent use of the Bull Creek drainage appears to be occasional. Flosi (unpubl. data) conducted single carcass surveys in December 1987, January and December 1988, and January 1990. Two carcasses were found during the 1987-1988 surveys. A live coho adult was observed in Squaw Creek, a tributary to Bull Creek, during the 1987-1988 season. Downie (unpubl. data) conducted downstream migrant trapping in 1988 and captured 38 coho salmon smolts. Brown and Moyle (1991) conducted electrofishing surveys of Bull Creek from 1987 to 1989. They did not collect juvenile coho salmon but most of the effort

was concentrated in the middle reaches where salmonid habitat was marginal. Bull Creek is presently having a great deal of habitat restoration work done (T. Taylor, pers. comm.). Past logging in the upstream reaches has resulted in heavy erosion which has significantly reduced habitat quality. The middle reaches are in especially poor shape with few pools and little shade (L. Brown, pers. obs.).

Redwood Creek

Shapovalov (1940) recorded 87 juveniles rescued from Redwood Creek in 1939. Puckett (1976) reported 211 outmigrants trapped in 1966 and Downie (unpubl. data) trapped 133 juvenile coho salmon in 1988. Coho have also been reported from several tributaries (Mills 1983) including Seely, Miller, China, and Dinner Creek, but it is unknown whether these streams are still used.

East Branch South Fork Eel River

Coho salmon appear to use the stream in low numbers. Puckett (1976) reported 14 juveniles caught during outmigrant trapping. More recently, Downie (unpubl. data) captured a single outmigrant in 1988. Coho salmon have also been reported from the tributary, Squaw Creek (Mills 1983), though use of this stream has not recently been verified.

Low Gap Creek

California Department of Fish and Game file data indicates that coho salmon have utilized Low Gap Creek in the past (Mills 1983). However, coho salmon were not recorded in three surveys by Flosi (unpubl. data). Also, the stream was surveyed 5 times from 5 December 1989 to 30 January 1990 (Nielsen 1991). No fish of any kind were observed.

Indian Creek

This tributary to the South Fork Eel River was surveyed 11 times from

29 November 1989 to 26 February 1990, covering 30.3 stream miles (Nielsen et al. 1991). No coho salmon were observed. Eleven carcasses and 3 live fish were noted by Flosi in 1987-1988 season and 1 carcass was counted during the 1988-1989 season (unpubl. data). Historical data are not available for comparison but the present population appears to be low.

Piercy Creek

Piercy Creek was surveyed 9 times by Nielsen et al. (1991). One coho salmon carcass was tagged. No other coho salmon were identified in the stream. Coho salmon have not previously been recorded from Piercy Creek (Table 1).

McCoy Creek

McCoy Creek was surveyed 5 times from 4 December 1989 to 8 February 1990. McCoy Creek used to contain coho salmon (Table 1) but no fish were observed (Nielsen et al. 1991).

Red Mountain Creek

Coho salmon have been reported from Red Mountain Creek (Table 1) but none were observed in 8 surveys between 10 January 1990 and 26 February 1990 (Nielsen et al. 1991). A 10-12 ft. high waterfall about 0.25 miles about the confluence with the South Fork Eel River appears to limit the spawning habitat available. Flosi (unpubl. data) did not record coho salmon during a January 1988 survey.

Hollowtree Creek

Surveys of Hollowtree Creek covered 20 miles of the mainstem and six tributaries including Redwood Creek, Bond Creek, Michaels Creek, Huckleberry Creek, Bear Wallow Creek, and Butler Creek (Nielsen et al. 1991). All but Bear Wallow have supported coho salmon in the past (Table 1). Coho salmon were

observed in the system from 24 January 1990 to 13 February 1990. Fourteen coho salmon carcasses were tagged. Population estimates based on these data indicated 11-17 spawners. Estimates from live counts indicated 146-158 spawners in the stream (coho and chinook combined) of which roughly two-thirds may have been coho salmon based on the proportion of coho salmon and chinook salmon carcasses observed. There is an egg taking station on Hollowtree Creek so exact counts of fish released above the weir could be recorded. In 1989-1990 162 coho salmon (53 males, 87 females and 22 grilse) were released above the weir. Of the carcasses recovered, two were found below the station, 11 were tagged from the mouth of Redwood Creek to the mouth of Bond Creek, and one was found on Huckleberry Creek. As on the Noyo River (see below), estimated populations were well below actual numbers when the actual population is known. Coho spawning, indicated by skeleton, live and redd counts occurred in Michaels, Huckleberry, Redwood and Butler creeks.

The Hollowtree Creek station has been in operation since 1979 and provides both chinook and coho salmon eggs for population enhancement and hatchery operations (Sanders 1982a, 1982b, 1982c, 1983). For example, eggs were supplied for hatchboxes on Big River in 1981 and 1982. Coho salmon eggs from the egg taking station are reared off stream and later released into the South Fork Eel River (Nielsen et al. 1991). Counts of adults captured at the weir indicate substantial fluctuation in the number of coho salmon using Hollowtree Creek. Counts were 53 coho in 1979, 145 coho in 1980, 142 coho in 1981 and 14 coho in 1982 (Sanders 1982a, 1982b, 1982c, 1983).

Earlier surveys by Flosi (unpubl. data) found 3 live coho salmon and 16 carcasses on the mainstem Hollowtree Creek during the 1987-1988 season and

12 live fish and 11 carcasses during the 1988-1989 season. Twenty live coho and 5 carcasses were counted in Redwood Creek during the 1987-1988 season and 1 live fish and 1 carcass during the 1988-1989 season. Walters Creek, another tributary to Hollowtree Creek, has been reported to support coho but recent surveys indicate little or no use (W. Jones, pers. comm.).

Cedar Creek

This tributary to the South Fork Eel river was surveyed six times from 29 November 1989 to 22 February 1990 (Nielsen et al. 1991). One coho carcass was tagged on 19 January 1990. Four skeletons were observed from the beginning of the survey to 29 January 1990. Estimates based on these data indicated 11-23 coho spawning in Cedar Creek. Estimates based on live fish indicated a spawning population of 20-33 fish.

Rattlesnake Creek

Rattlesnake Creek a South Fork Eel River tributary was surveyed 7 times between 29 November 1989 and 22 February 1990 (Nielsen 1991). Three tributary streams, Elk Creek, Cummings Creek, and Twin Rock Creek, were included in the study area. Only one anadromous salmonid was noted along with an anadromous lamprey. Steelhead spawning was reported by residents in February and March but no coho salmon were reported. Coho salmon apparently still use Rattlesnake Creek to some degree but not Cummings Creek (W. Jones, pers. comm.).

Ten Mile Creek

This South Fork Eel River tributary was surveyed from the mouth to 13.9 miles upstream on 6 occasions from 30 November 1989 to 22 February 1990 (Nielsen 1991). Mill Creek, Streeter Creek and Big Rock Creek were included in the surveys. No coho salmon were seen. One live coho and 3 carcasses

were counted in Ten Mile Creek during the 1987-1988 season (Flosi, unpubl. data). Flosi (unpubl. data) also reported a single carcass from Streeter Creek during the 1987-1988 season. Juvenile coho salmon were rescued from Ten Mile Creek in both 1951 and 1952 with 3,475 and 4,369 fish captured, respectively (Kimsey 1952, 1953). Downstream migrants were reported by Puckett (1976) with 21 juveniles trapped during the period March-May 1966 (1-9 days per month). Coho were not found in other recent surveys of Streeter Creek, Big Rock Creek and Cahto Creek (W. Jones, pers. comm.).

Jack of Hearts Creek

Another upper tributary to the South Fork Eel River, this stream was surveyed 11 times from 28 November 1989 to 20 February 1990. Three coho carcasses were tagged. Based on live counts 29-39 coho and chinook salmon combined spawned in the stream. In an earlier carcass survey Flosi (unpubl. data) reported 2 carcasses from the stream in the 1987-1988 season.

Redwood Creek

Nielsen et al. (1991) surveyed Redwood Creek from the mouth to 1.3 miles upstream on 11 occasions. Six coho salmon carcasses were tagged. A total spawner population of 34-38 fish, including both coho salmon and steelhead, was estimated. The habitat for coho salmon was described as excellent and capable of supporting a much larger population of salmon. *Stream surveys conducted by Moyle (unpubl. data) in 1985 and Brown and* Moyle (1991) in 1987 found coho juveniles to be abundant in this stream. Coho salmon and steelhead juveniles were present in roughly equal proportions.

*Deer Creek*

An upper tributary to the South Fork Eel River, Deer Creek was

surveyed once during 1990 (Nielsen et al. 1991). No fish were seen. Local residents indicated that domestic diversions result in stream drying in the summer. CDFG records indicate that coho were present in this stream in earlier years (Mills 1983).

**Little Charlie Creek**

This upper South Fork Eel River tributary was only surveyed once. No fish were observed (Nielsen et al. 1991).

**Dutch Charlie Creek**

This tributary to the upper South Fork eel river was surveyed 8 times, covering 17.9 miles (Nielsen et al. 1991). These surveys were conducted from 4 December 1989 to 20 February 1990. No coho salmon were observed during the surveys. Flosi (unpubl. data) reported 6 carcasses during the 1987-1988 season.

**Kenny Creek**

This South Fork tributary was surveyed 8 times from 30 November 1989 to 15 February 1990. No coho salmon were identified from the stream though coho have utilized it in the past (Table 1).

**Mud Creek**

Mud Creek, another upper South Fork tributary stream, was surveyed 6 times from 30 November 1989 to 20 February 1990 (Nielsen et al. 1991). Two live fish were observed but could not be identified. A local resident indicated that chinook salmon, coho salmon, and steelhead used the stream in the past but not within the last 4 to 5 years. Coho salmon have not previously been reported from this stream.

Mattole River

The Mattole River has been the subject of community based restoration

efforts for a number of years. Coho have been an incidental species during chinook salmon spawning surveys and other work (G. Petersen, pers. comm.). The run is probably much reduced from historic levels, numbering in the hundreds in recent years. There is only a "good" run in one year out of three (G. Petersen, pers. comm.). Coho salmon supplementation efforts have not noticeably increased spawner returns but the program has been successful at establishing populations in tributary streams (Miller et al. 1990).

South Fork Bear River

An index section located in the South Fork Bear River was electrofished in 1988 and 1989 (L. Preston, unpubl. data). The index section is located approximately 12 miles from the confluence with the Mattole River and at least twice that far from the Pacific Ocean. The index section was 34.1 m long. Fish density was 0.5 and 0.1 fish/$m^2$ in 1988 and 1989. Density of biomass was 1.7 and 0.9 g/$m^2$. These data indicate that coho salmon are still able to migrate far up the Mattole River and its tributaries but the total numbers of migrants is unknown.

Mendocino County

Mendocino County contains about 999 streams many of which supported coho salmon at some time. In recent surveys of 146 of these streams, coho salmon were found in 40 (27%)(W. Jones, unpubl. data). At only one site were coho salmon found alone. At all other sites they were found in association with steelhead rainbow trout. In a total of 71 stations, coho salmon density varied from 0.01 to 1.61 fish/$m^2$, with a mean of 0.41 fish/$m^2$. Biomass in these stations ranged from 0.11 to 44.5 kg/hectare, with a mean of 33.97 kg/hectare (W. Jones, unpubl. data). Coho salmon appear to be absent or very rare in many of the streams they historically occupied. Coho salmon have not

recently been observed in Whale Gulch Creek, Jackass Creek, Usal Creek, Hardy Creek, Juan Creek, Howard Creek, Wages Creek, Duffy Gulch (tributary to South Fork Noyo River), tributaries to North Fork Big River (Arvola Gulch and James Creek), Buckhorn Creek, several tributaries to the Navarro River (Mill Creek and Indian Creek), Greenwood Creek, Mallo Pass Creek, Elk Creek, Brush Creek, Garcia River (recently planted with smolts), Schooner Gulch and Fish Rock Gulch (W. Jones, pers. comm., Nielsen et al. 1990). Of these streams, early data only exists for Brush Creek and Usal Creek. Murphy (1950) recorded 80 juvenile coho salmon from Brush Creek in 1948. Fish rescue records from Usal Creek indicate 3,963 juveniles collected in 1940 (Shapovalov 1940), 60,510 in 1944 (Shapovalov 1945b), 61,133 collected in 1945 (Shapovalov 1949), 11,455 in 1951 (Kimsey 1952), and 13,864 collected in 1952 (Kimsey 1953). Considering that only fish considered in danger were collected during these operations, Usal Creek supported a substantial juvenile population.

A recent survey of 82 streams and tributaries (355 stream miles) in Mendocino County in 1989-1990 found low populations of coho salmon spawners in all of the streams surveyed (Nielsen et al. 1991). Only the Noyo River had a population of coho salmon exceeding 500 fish. The Noyo River is routinely planted with large numbers of fry and smolts. It is unknown how important natural reproduction is to this population or if any natural reproduction that does occur can be attributed to wild fish rather than planted fish. A number of streams are discussed separately below. Unless otherwise noted, the information is cited from Nielsen et al. 1991. We also note that Nielsen et al. (1991) indicated that the methods used tend to underestimate the actual number of spawners but also state that the numbers seem low even if off by several orders of magnitude. They also noted that the magnitude of the

effects of the ongoing drought on salmonid populations are unknown.

Ten Mile River

This stream was surveyed 12 times between 28 November 1989 and 28 February 1990. Coho were observed in the stream from 30 November 1989 to 13 February 1990. Calculations based on carcass and skeleton counts indicated anywhere from 31-55 coho salmon spawners in Ten Mile River. Live counts indicated 80-92 spawners, but the estimate includes chinook salmon and steelhead. Coho enhancement in the river included the planting of 6,000 coho juveniles in June 1987. Most of the carcasses, skeletons and redds were observed in the lower Middle Fork and lower South Fork of Ten Mile River. Redds were also noted in Bear Haven Creek. Extensive barrier removal took place in Ten Mile River in the 1970s-1980s. Redwood Creek and the upper South Fork had many barriers removed at this time. Live coho were seen in these streams along with 18 redds and 2 skeletons. Churchman Creek was opened to anadromous fishes in 1982 and 1983. Three live coho were seen in this stream, 2 redds were counted, and 1 skeleton found.

Bureau of Reclamation personnel estimated the run size as 6,000 coho spawners in 1973 (Bureau of Reclamation 1973). Even if the 1973 estimate is high by a factor of 10, the present population is well below this level. Siltation due to poor land use practices including poorly constructed logging roads, skid trails, and cattrails was noted in 1973 (Bureau of Reclamation 1973). The upper tributaries were noted to be full of slash debris, and silt making them unusable for spawning or rearing. The lower drainage was described as being in the early stages of recovery.

Pudding Creek

Pudding Creek was surveyed 8 times between 28 November 1989 and 8

February 1990. Only one coho grilse carcass and 4 coho skeletons were observed. Counts of live fish indicated 38-50 coho spawners using Pudding Creek in 1990. Redds were found throughout the creek at a density of about 1.57 per mile. Surveys of juveniles in the summer of 1990 indicated that the entire stream was being used as rearing habitat. Density of juveniles ranged from 0.12 fish/$m^2$ in August to 0.03 fish/$m^2$ in October (J. Nielsen, unpubl. data). The live counts and juvenile densities indicated that carcass and skeleton counts underestimated use of the stream by coho, even though the density of juveniles was relatively low compared to other Mendocino County streams (W. Jones, unpubl. data).. Little Valley Creek, a tributary, which supported coho at one time (Table 1) apparently no longer supports a spawning population (W. Jones, pers. comm.).

Earlier data indicate a more substantial population of coho salmon. Allan (1958) counted 1,357 coho salmon (728 male, 529 female, and 100 undetermined) at the Pudding Creek Egg Collecting Station (no longer operating) during the period from 15 November 1957 to 7 February 1958. The station was closed that year due to lack of funds rather than lack of fish. It is interesting to note that the number of eggs requested from the station that year was cut back when out of state coho salmon eggs became available, indicating a preference for exotic stocks by the fish culturists at the time. The population estimated in 1990 was roughly one-twentieth of the 1957-1958 run. Even allowing for a substantial underestimate in 1990, it seems that the run has declined.

South Fork Noyo River

Coho salmon were present in the stream during all surveys from 30 November 1989 to 28 February 1990. Both males and females returned to this

stresm at two years of age. Scale analysis indicated that 81% of the females and 72% of the males returned at 3 years old. Female 2 year olds were larger than male 2 year olds. Identification of these small females was based on qualitative external features and was not verified by dissection or other methods. Thus, the actual proportion of 2 year old females is unknown. Grilse were more common near the weir and egg taking station than in the rest of the drainage. A total of 319 adult coho and 91 grilse were passed over the weir. A release of 214,230 coho fry occurred in 1987 contributing to the 3 year old population. It was estimated that the total spawning population in the South Fork Noyo River was 3,511 coho salmon. Kass Creek and the South Fork Noyo River below the weir contributed 80% of the carcasses indicating that a substantial amount of natural reproduction was occurring. Carcasses were recovered in both Parlin Creek and North Fork of South Fork Noyo River, indicating natural reproduction above the weir as well. It is not known how many of these fish were the result of plantings or natural reproduction.

In 1973 a population of 6,000 coho salmon was estimated for the whole Noyo River drainage (Bureau of Reclamation 1973). Without counts from the North Fork Noyo River it is impossible to determine if the present population is comparable. Given the 1990 estimate of over 3,500 coho in the hatchery supplemented South Fork Noyo River, the 1973 estimate is probably high for the system as a whole but by less than a factor of 2. Logging and associated activities were noted as having the largest impact on the system but overgrazing and urban encroachment on the estuary were also noted. The drainage was described as being in the early stages of recovery.

Caspar Creek

Caspar Creek was surveyed 11 times during the winter of 1989-1990. Length of stream surveyed was 26.5 on the mainstem, 13.3 miles on the North Fork, and 9.4 miles on the South Fork. The only carcass found was a single coho in the mainstem. Calculations based on coho skeletons indicated a spawning population of 30-35 fish. Calculations based on live fish indicated a total of 38-43 live spawners, of all species combined. Redds were most abundant in the mainstem. Successful spawning occurred above weirs on both the North and South Fork Caspar Creek. Juvenile density was 0.25 coho/$m^2$ in the South Fork Caspar Creek and 0.04 coho/$m^2$ in the North Fork Caspar Creek in 1990 (Rod Nakamoto, USFS, Redwood Sciences Lab, Arcata, CA, unpublished data, cited in Nielsen et al. 1990). Only 2 live fish and 3 redds were observed above the weir on the North Fork and none above the weir on the South Fork during the spawning surveys. These data again indicate that spawning surveys may underestimate numbers of spawners.

Historical data consists of juvenile population estimates and outmigrant trapping. Graves and Burns (1970) trapped 613 juveniles in 1964 from South Fork Caspar Creek and 1,770 in 1968. Burns (1971) estimated 9.59 kg of juvenile coho salmon in a 3.1 km stretch of South Fork Caspar Creek in 1967. Burns (1971) also estimated juvenile populations in a 2.4 km reach of North Fork Caspar Creek in 1967, 1968, and 1969. These estimates were 122 to 313, 194 to 359, and 1,105 to 2,724 juveniles, respectively. More recently, Jones (unpubl. data) captured 1,697 yearlings and 34,955 young-of-year coho salmon during outmigrant trapping on Caspar Creek during the period 1 April 1989 to 18 June 1989. The adult population producing these juveniles is not known. Juveniles appeared in the estuary in March indicating that the trapping effort

missed the beginning of the outmigration period.

South Fork Big River

Streams surveyed in this drainage included the South Fork Big River and tributary streams including Ramon Creek, Mettick Creek, Anderson Creek, Daugherty Creek, Soda Creek, Gates Creek and Kelly Gulch. No carcasses or skeletons were observed during winter surveys in 1989-1990; however, 4 live fish were observed in Ramon Creek and were tentatively identified as coho salmon. These identifications could not be verified from carcasses. An estimate of number of spawners ranged from 17 to 23 fish. Redds were identified in Ramon Creek (13), Daugherty Creek (6), and the mainstem South Fork Big River (58). The species digging the redds could not be identified. Johnson Creek, a tributary not included in the surveys had a coho enhancement project running from 1981-1987. The 1987 plant consisted of 2,500 fry which could account for some or all of the spawning activity observed. Spawning by wild fish or progeny of previously planted fish may also have occurred. Survey personnel commented that the mainstem South Fork had excellent spawning gravels and good holding pools but few fish. Hillside erosion, high turbidity, and log jams were observed in Gates and Soda Creeks, tributaries to Daugherty Creek, and were coincident with commercial logging in the drainage.

The estimated coho salmon spawning run was placed at 6,000 fish in 1973 (Bureau of Reclamation 1973) for Big River as a whole. The present population appears to be well below this earlier estimate even allowing for estimation errors on the order of 10 times in both years. The 1973 report noted poor logging practices leading to siltation, removal of streamside vegetation, debris dams, and pool filling, the same conditions noted in some tributaries in 1990.

Recent surveys of most of the other tributaries historically supporting coho salmon indicate that coho are still present though the size of the runs are not known (W. Jones, pers. comm.).

Little River

Two live fish identified as coho salmon were identified in the lower mainstem of Little River. Redds (total of 9) were observed from 17 January 1990 to 9 February 1990. Summer surveys of juvenile coho salmon rearing in the river resulted in an estimate 0.17 coho/$m^2$. Outmigrant trapping data indicated more spawning in Little River than was indicated by the carcass surveys (W. Jones, unpubl. data). In 1988, 1,111 yearlings and 565 young-of-year were captured. During the period of 22 March 1989 to 21 June 1989 2,123 yearlings and 503 young-of-year were captured.

South Fork Garcia River

The lower 2 miles of the South Fork Garcia River were surveyed from the confluence with the mainstem upstream on 6 occasions between 30 November 1989 and 22 February 1990. No coho were identified though Pister (1965) collected them in his study.

Both Weldon Jones and Bill Cox (CDFG, pers. comm.) indicated that a small remnant run persists somewhere in the Garcia River though the number and location of spawners is unknown. Also, the system received a stocking of smolts in the late 1980s. Present logging practices in the drainage appear to be good but aggradation of gravel from earlier poor practices has been a problem for many years (W. Jones, pers. comm.).

Sonoma County

In Sonoma County coho salmon are present in Salmon Creek, Russian River, Gualala River, and their tributaries. Coho salmon have also been

reported from Fort Ross Creek and Russian Gulch but these streams have not been recently surveyed.

Salmon Creek

The Salmon Creek population is small at present and its survival appears to be shaky (B. Cox, pers. comm.). Coleman Valley Creek, one of its tributaries no longer supports coho (W. Jones, pers. comm.). Tannery, Fay, and Finley Creek are relatively short tributary streams that have been degraded primarily by grazing but also by logging and development. The whole Salmon Creek drainage was heavily damaged by a large storm in 1982 that affected riparian vegetation.

Gualala River

Spawning coho salmon have been reported from the Gualala River and it probably does still support a small run (B. Cox, pers. comm.). Pister (1965) captured coho while electrofishing the Gualala River in 1965. The Wheatfield and South Forks are open, hot, and eroding and do not provide good coho habitat (B. Cox, pers. comm.). Any wild fish that are present most likely use the North Fork which is small but well forested; however, recent surveys of the North Fork Gualala failed to find coho (W. Jones, pers. comm.). The Little North Fork was recently planted with hatchery fish in an effort to reestablish a population. In 1973, the spawning population of coho salmon was estimated at 4,000 fish (Bureau of Reclamation 1973). Obviously, this population has declined precipitously from historic levels.

Russian River

Coho salmon have been reported from the Russian River and 27 tributary streams (Table 1). Most of these streams no longer maintain populations. Willow Creek, the lowermost tributary, still maintains a run of

50-75 fish per year (B. Cox, pers. comm.). The stream contains excellent nursery habitat despite poor logging practices in the 1940s-1960s and a large input of debris during the 1982 flood. Present logging practices in the area appear not to threaten the remaining population.

Austin Creek had a run of coho in the past but none have been observed in the last 10 years. The Austin Creek drainage is geologically unstable and logging and mining practices have resulted in lots of slide activity. Over the last 10 years aggradation of up to 10 feet has been noted in some places.

Several streams have good habitat or are rumored to contain coho salmon but have not been sampled in recent years. These streams include Green Valley Creek, and Redwood Log Creek (a tributary to Pena Creek) (B. Cox, pers. comm.). Dry Creek and Warm Springs Creek had wild populations before the construction of Sonoma Reservoir. These populations are now gone (B. Cox, pers. comm.). Warm Springs hatchery is located below the dam and accounts for yearly plants of coho into the system. All production in the East Fork Russian River was lost with the construction of Mendocino Reservoir. Recent surveys of Pena Creek and all West Fork Russian River tributaries indicate that none of the streams support populations of coho salmon (W. Jones, pers. comm.).

Marin County

Several coastal streams in Marin County still maintain small runs of coho (B. Cox, pers. comm.), though there is no good historical data to determine historical trends. The most well known streams, Walker and Lagunitas Creek, are discussed separately.

Olema Creek and its tributaries are believed to support a run of about

200 wild coho salmon (B. Cox, pers. comm.), though there are no data to determine long term trends in the system. Pine Gulch Creek, the primary tributary to Bolinas Lagoon, has been reported to support coho salmon in the past (Table 1) but there is no data on the present status of this population. Redwood Creek, the stream flowing through Muir Woods National Monument, still maintains a coho run of about 75 fish or more (B. Cox, pers. comm.).

Walker Creek

Walker Creek, a tributary to Tomales Bay, had a run of coho salmon in the past but the run is now restricted to occasional sightings of fish (B. Cox, pers. comm.). Emig (1984) noted that Walker Creek had unstable soils and had been overgrazed resulting in heavy erosion. A motorcycle club and abandoned mercury mine contributed to the resulting siltation. Two stockings of coho salmon failed to produce a measurable increase in the population. A 1979 plant was considered a failure because of the lack of juveniles during a survey targeted on expected progeny. A 1980 plant failed because of high water temperatures and poor fish condition resulting in high mortality.

Lagunitas Creek

Lagunitas Creek is a tributary to Tomales Bay and empties into the southern part of the bay. Lagunitas Creek also known as Papermill Creek, produced a state record coho salmon in 1959 (Giddings 1959). Presently the population appears to be very low. The primary reason for the decline appears to be the construction of Kent and Nicasio Reservoirs, which restricted anadromous fishes to the lowermost portions of Nicasio and Lagunitas Creek. When Nicasio Reservoir was first constructed adults were trapped below the dam and transported above the reservoir where they were allowed to spawn naturally. Outmigrant juveniles were trapped in Nicasio and

Halleck Creeks and transported below the dam. These programs began in 1961 upon completion of the project (Quinn and Alan 1969a). During the 1962-1963 season 44 adult coho salmon were released above the reservoir and in 1963-1964, 151 adult coho salmon were released above the reservoir (Quinn and Alan 1969a). Six hundred twenty adult coho salmon were captured in the 1964-1965 season (Quinn and Alan 1969b). No juvenile downstream migrant coho salmon were capture in 1961 or 1962. No data are available for 1963. In 1964, 943 coho salmon juveniles were captured and in 1965, 41,697 were captured. This extremely large number was the result of a plant of hatchery-reared coho salmon during the previous winter. The ratio of hatchery yearlings to natural yearlings was roughly 260 to 1. Large numbers of naturally produced young of year also migrated, suggesting that space may have been limiting. This program was eventually discontinued (L. Cronin, pers. comm.).

A redd count conducted in 1991 indicated only 20 pairs of coho salmon spawning in the stream (L. Cronin, pers. comm.). Flows were so low that coho never reached a trapping site where eggs have been taken in previous years for enhancement of natural reproduction and to maintain the natural gene pool in the event of scouring flows. The success of the limited spawning in 1991 may be in jeopardy because of superimposition of steelhead redds. Steelhead entered the stream in March 1991 and spawned in the same areas used by the coho salmon (L. Cronin, pers. comm.).

Emig (1985) recommended planting of riparian vegetation, erosion control measures and additional stockings of 100,000 coho smolts for 3 years to restore the depleted coho population. He also recommended using native eggs. At the time, 40,000 smolts were stocked annually as mitigation for the Nicasio project. He also suggested that regulations prohibiting fishing should

continue.

Lack of appropriate spawning gravel is one of the problems affecting coho salmon in this creek. Construction of the reservoirs has prevented recruitment of new gravel into most of the system resulting in a streambed dominated by relatively large and angular particles. Most spawning now takes place in San Geronimo Creek, an unregulated tributary, and the region immediately downstream of its confluence with Lagunitas Creek (L. Cronin, pers. comm.). Though no numbers are available, the present population appears to be only a small remnant of the population in the early 1900s when special trains brought anglers from the Bay area to fish for adult coho salmon and steelhead (Smith 1986).

San Francisco Bay

Within San Francisco Bay, coho salmon appear to have been extirpated or nearly so. Skinner (1962) indicated that there were spawning migrations of coho salmon in most streams with suitable habitat before human disturbance. Spawning migrations were noted in Walnut Creek during the 1950s to mid-1960s (Leidy 1983). Coho salmon have also been recorded from Corte Madera (San Anselmo) Creek (Fry 1936). Hallock and Fry (1967) stated that spawning migrations may have existed in Corte Madera and Mill Valley Creek. In the most recent, extensive survey of San Francisco Bay streams, Leidy (1984) captured several juvenile coho from both Corte Madera and Mill Valley Creek. A few coho have been observed in Corte Madera Creek more recently (B. Cox, pers. comm.). Whether these fish are the result of successful reproduction or are strays from other systems is unknown. It seems likely that the populations in these streams were more extensive in the past though there are no records from which the extent of the decline can be determine. The

threats to these populations are urban development and the habitat degradation and decline in water quality that usually accompany development.

Sacramento River

Recent authors indicate that coho salmon occurred in the Sacramento River only as strays (Shapovalov 1947, Hallock and Fry 1967, Fry 1973). Recent records tend to support this view. Hallock and Fry (1967) reported that in the period from 1949 to 1956 only two coho salmon had been identified from the Sacramento River, both entering Coleman National Fish Hatchery. One was collected in the fall of 1949 and the other in the fall of 1950. One additional coho salmon was reported at Coleman previous to 1949 (J. Pelnar, pers. comm., cited in Hallock and Fry 1967).

Older records suggest that coho salmon may have been more abundant in the Sacramento River. Jordan and Jouy (1881) list a museum specimen as coming from the Sacramento River and Jordan and Gilbert (1881) describe coho salmon as occurring from the Sacramento River northward. Lockington (1881) cites a personal communication from Jordan that coho salmon were taken in the Sacramento River. Jordan also reported a fall run of coho salmon in the Sacramento River to the U.S. Commission of Fish and Fisheries (1892). Eigenmann (1890) listed coho salmon as one of the four species of salmon occurring in the Sacramento River and that it runs in the Sacramento River in the summer and fall. He also states that many are probably confused with young chinook salmon. Eigenmann (1890) did not term coho salmon "rare" as he did pink and chum salmon, indicating a higher level of abundance. The lack of more definitive statements about the abundance of coho salmon may be due to the difficulty in identification mentioned by Eigenmann, as well as a general lack of interest in a species which, at that time, was numerically

insignificant compared to the chinook salmon. For example, Snyder (1931) states that coho salmon occurred in large numbers in the Klamath River, but no statistics on coho salmon were kept until 1919 and none after that year. It also seems likely that coho salmon would be the first species to disappear from the Sacramento River in response to the hydraulic mining, dams, diversions and other perturbations occurring at the time. Coho salmon are especially vulnerable because of the one year residence of the juveniles in freshwater and the obligatory three-year life cycle. Juveniles would be subjected to dewatering of streams and high silt loads. Spawning populations would not be buffered by multiple age classes within a single brood year; therefore, a three year interruption in spawning would result in the extirpation of the population. Coho salmon have been noted in the Walnut Creek which is tributary to Suisun Bay. It seems unlikely that in the absence of any physical barrier the range of coho salmon would simply stop at Walnut Creek, especially given the great distances coho salmon are known to migrate in other large rivers such as the Columbia River and Klamath River. Thus, while the evidence is minimal, it seems likely that the Sacramento River system did support populations of coho salmon at some time.

The California Department of Fish and Game attempted to introduce (or reintroduce) coho salmon into the Sacramento River system in 1956. In March 1956, 43,025 yearlings were released into Mill Creek followed by 53,505 yearlings in February and March 1957, and 48,000 yearlings in April 1958 (Hallock and Fry 1967, Fry 1973). These fish were Lewis River, Washington stock. The returning adults scattered throughout the drainage with the largest concentrations occurring at Battle Creek, where the fish had been raised, and Mill Creek, where they were planted. The fish did spawn (Hallock

and Fry 1967) but failed to establish a self-sustaining population. The fish had apparently gone out to sea because a number were captured near Fremont, California on the lower Sacramento River (Hallock et al. 1957, Van Woert 1958). Also, a number of grilse were captured in 1955 (Van Woert 1957). Some of the fish returning to the Coleman Fish Hatchery were spawned and the fish transferred to the Nimbus hatchery for rearing and release (Hallock and Fry 1967, Hinze 1961). Subsequent to this plant, 99 adult salmon returned to Nimbus Hatchery in 1960 and 87 in 1961. By 1963, coho salmon again became rare in the Sacramento River, though Fry (1973) and Hallock and Fry (1967) state that they were not as rare as formerly. Small numbers of coho salmon have consistently been identified at Nimbus Hatchery (Jochimsen 1971, 1973a, 1973b, 1974, 1976, 1978a, 1978b, 1978c) and coho salmon have also been identified from the Feather River (Schlichting 1974, Painter et al. 1977). In 1970, 23 adult males and 35 adult females entered the Feather River Hatchery, were spawned, and the young released as swimup fry (Schlichting 1974). Whether these increased occurrences of coho salmon in the Sacramento River are the result of increased straying or the presence of a small spawning population is unknown. It is also interesting that the failure to establish a population in the Sacramento River system is taken as evidence that the system never supported the species. Given the great physical changes that have taken place in the system and the absence of any evidence that hatchery propagated populations in other California rivers such as the Klamath, Trinity and Russian Rivers would be self-sustaining if plants were discontinued, the argument seems weak.

Streams South of San Francisco Bay

All natural production of coho salmon in the smaller streams south of

San Francisco Bay is believed to be lost, primarily due to the 1976-1977 drought in California which exacerbated the cumulative effects of stream alterations caused by agriculture, logging, and urbanization (D. Strieg, pers. comm.). The drought dewatered most of these small streams. This group of streams includes Aptos Creek, Soquel Creek, Pescadero Creek, San Gregorio Creek, and San Vicente Creek. Apparently stray fish occasionally reproduce in these streams (Coots 1973 reported occasional spawning in San Gregorio Creek) and might conceivably found new populations. For example, a juvenile coho salmon was caught in the lagoon of Pescadero creek in 1985 and 5 were caught in San Vincente Creek in 1981 (J. Smith, unpubl. data). Waddell and Scott Creek still maintain natural runs of fish and a hatchery maintained population exists in the San Lorenzo River. These streams are discussed below.

Waddell Creek

Waddell Creek was the site of Shapovalov and Taft's (1954) classic study of the life history of coho salmon and steelhead in California. Though Waddell Creek still maintains a natural run of coho salmon, the run is much reduced. A number of exotic stocks have been introduced by private aquaculturists in recent years, though records of egg sources were not kept (D. Strieg, pers. comm., cited in Bartley et al. 1991). Over the time span of Shapovalov and Taft's study the population varied from 120 to 633 spawners (Shapovalov and Taft 1954). The present run is around 50 fish in a "good" year and much less in poor years (J. Smith, pers. comm.). Surveys of juveniles indicate that Waddell Creek only has a "good" run every third year, the most recent being 1990. The year class produced in 1988 was very weak and the one produced in 1989 was intermediate. Jerry Smith (pers. comm.) attributed the decline in

the population to the effects of winter storms which have been magnified in recent years due to poor land-use practices.

Scott and Big Creek

Scott Creek and its tributary Big Creek have been the subject of an intensive rehabilitation effort by the Monterey Bay Salmon and Trout Project. Dave Strieg and Jerry Smith both indicate that Scott Creek provides the best habitat for coho salmon south of San Francisco Bay. The run averages 30-40 fish per year. When available, the project captures coho, spawns them artificially, then releases smolts to augment natural reproduction. Only native stock are used. Trapping records and planting of resident gene pool fish are given in Table 2. All released smolts are marked by fin clips and are not used as brood stock in subsequent years. The population in Scott Creek appears fairly secure if no major changes occur in the condition of the habitat; however, if a major random event did occur this population could be severely affected. No data on historic numbers of coho salmon using Scott Creek were found.

San Lorenzo River

The San Lorenzo River, Santa Cruz County is one of the streams that lost its coho in the 1976-1977 drought, although much or all of the population was the result of stocking from the 1950s through the mid-1970s (J. Smith, pers. comm.). Dave Strieg (pers. comm.) attributes the loss of wild coho in the San Lorenzo to habitat loss, habitat degradation, and urban development. Johansen (1975) noted a decline in the annual catch of coho salmon and steelhead in the San Lorenzo River from levels recorded in the previous two decades. He attributed the decline to logging and related activities, subdivision development and water project construction resulting in habitat

loss and increased siltation. The main result of these factors is that the stream is less buffered against high peak flows. Input of urban runoff and lack of vegetation and soils capable of holding storm flows have resulted in flood peaks that are very intense and of short duration resulting in an increased probability of scour. Also development has decreased access to appropriate tributary habitat forcing any natural spawning to take place in the main channel of the river where these problems are most severe. Planting of smolts of Noyo River, Prairie Creek, and Scott Creek stocks have reestablished coho returns to the system and coho returning to the river have been trapped and spawned in an effort to establish a resident stock (Table 2). The number of adult fish trapped from the river reached a peak in 1989 at 183 fish. Some natural reproduction was indicated by the presence of coho smolts in 1989 (J. Smith pers. comm.) but it is unknown if there is adequate habitat for a self-sustaining population to become established.

Summary of Presence/Absence Data

We characterized the streams in Table 1 as having coho salmon from any source (coho present), streams where coho salmon are known to be very rare or extirpated, and streams without sufficient data for classification. The results are presented in Table 3 and discussed by county below. County classifications were made on the position of the mouth of the system and not by individual stream.

In total, 582 streams are listed in Table 1 as supporting coho salmon at some time. At present we lack data on the recent use of 58% of these streams by coho salmon. Of the streams where we have some idea of presence/absence, 54% have coho salmon and 46% do not. The amount of data varied from county to county. The percentage of streams that could not be

classified was greatest in the north of the state and least in the south. The reason for this pattern is presumably related to the fact that the northern part of the state has more streams and they are less accessible than those in the south. A difference in emphasis by fisheries managers may also be responsible. The greatest concern for coho salmon appears to occur in Mendocino County southward. This is probably because the smaller river systems in the south supported a higher proportion of coho salmon to chinook salmon than the larger systems in the north. Also, in the far south (Sonoma County and below) there is concern for preserving habitat for any species of anadromous fishes because of the rapid urbanization that is occurring.

In Del Norte County, 73% of the streams could not be classified. Of the remaining streams all were classified as having coho in the coastal systems and Smith River. In the Klamath, 50% of the streams that could be classified had coho and 50% did not. Most of the streams classified as not having coho salmon occurred in the South Fork Trinity River and Salmon River. In all, 45% of the streams for which there were records in Del Norte County no longer contain coho salmon.

In Humboldt County, 70% of the streams were unclassified but if the Eel River is omitted the percentage increases to 86%. Only the Eel River system contained streams that were classified as not having coho salmon. The high level of interest in the Eel River is somewhat misleading because the bulk of the streams included in this number actually lie in Mendocino County and indicate the high level of concern with coho salmon. Overall, 31% of Humboldt County coho streams for which there are recent records are without coho salmon.

In Mendocino County the percentage of streams that could not be

classified ranged from 8 to 58% depending on the system. Of the 103 streams listed, 24% could not be classified, 31% did not contain coho, and 45% did contain coho. Forty-one percent of classified streams had no recent record of coho salmon.

Sonoma County contains 53 streams that historically contained coho salmon. Of those 47% could not be classified. Of the remaining 28 streams, 4 (14%) contained coho and 24 (86%) did not.

From Marin County south only 30 streams were listed as historically containing coho salmon. The actual number of historic coho streams may actually be higher if, as we suspect, some of the Sacramento River tributaries also supported runs. There was no data for 3 streams, 15 have lost their populations, and 12 are still at least occasionally used by coho salmon. We should note that most of the streams listed as having coho salmon in this geographic area are very small, actually support very few salmon, and are supplemented by hatchery plants. If these streams occurred in the north, some (ca. 8) would have been classified as not having coho salmon because of the few fish occurring.

Estimates of Abundance

There is little data on which to base estimates of true abundance of coho salmon in California. As a rough estimate we have assumed that each stream which contained coho salmon or for which there was no data had a population of 20 spawners. For hatchery populations, we assumed the average population based on available data starting in 1981-1982. For streams where estimates of adult populations were available, the largest estimate or 20 fish, if it was larger, was used. For streams where hatcheries were located we included both the average hatchery population and the estimated wild or

natural population. These estimates are presented in Table 4 and discussed below.

In most cases, when estimates of adult populations were available they were similar to or less than the estimated number based on 20 fish per stream. Numbers of coho salmon passing over Sweasey Dam on the Mad River fluctuated between 0 and 1,000 fish between 1938 and 1961, the estimated number of coho salmon in the system exclusive of fish returning to the hatchery was 460 coho. This number is nicely in the middle range of the historic range. The population in the Outlet Creek drainage of the mainstem Eel River was estimated at 240 fish but in 1989-1990 no evidence of coho spawning was seen in the drainage. In the South Fork Eel River drainage, the population in Hollowtree Creek was estimated at 180 fish using the 20 fish per stream which is comparable to the 162 fish counted at the egg taking station in 1989-1990 and exceeds counts in several other years. Also in the South Fork Eel system, the 20 fish rule predicts 140 coho in the Ten Mile Creek drainage when none were seen in the 1989-1990 season. Nielsen et al. (1991) estimated fewer than 100 spawners of all species combined in the Ten Mile River system. Our estimate was 160 fish in the drainage. Similar overestimates occur for Big River, Little River, Garcia River, and Gualala River. Exceptions to the 20 fish per stream rule mainly occurred where there was ongoing hatchery supplementation such as in the Noyo River, streams tributary to Humboldt Bay, Scott Creek and San Lorenzo River. Thus, in most cases the estimates for natural fish are probably overestimates. The degree of overestimation is probably extreme especially because all of the streams that were classified as having insufficient data were assumed to contain coho salmon. Also, as noted in the Eel River system and some Klamath tributaries

the ongoing drought has reduced some small populations to extremely low levels.

Even given that we have probably overestimated numbers of natural and wild coho salmon, their populations appear to be at low levels. The total California coho salmon population is estimated at about 31,000 fish which is roughly equivalent to the latest estimate of 33,500 fish statewide (Sheehan 1991). However, hatchery populations contribute over half of the fish (57%). Natural and wild stocks make up the remainder. Of the natural spawning stocks probably the largest concentration of fish with little hatchery influence occurs in the South Fork Eel River system, which is estimated to have 1,320 fish based on the 20 fish rule. However, as noted above, this is likely a gross overestimate given the absence of fish from many of the tributaries in 1989-1990 (Nielsen et al. 1991). Our estimate of 13,240 natural and wild fish could easily be high by 50% and possibly even more. We would consider an estimate of 5,000-7,000 naturally spawned coho adults returning to California's streams each year since 1987 to be a realistic assessment of the state's coho populations. This estimate is further reduced if natural stocks are eliminated. Wild coho stocks in California have probably numbered less than 5,000 fish in recent years. Further, many of the populations in the smaller systems probably number fewer than 100 fish, which is probably below the minimum population size required to preserve the genetic integrity of the stock and buffer it against random environmental disasters. Clearly, the abundance of naturally spawning coho salmon is at a low level, particularly wild stocks. The trends indicate that coho numbers are continuing to decline statewide. Our numbers show that coho salmon stocks in California are less than 1% of what they were in the 1940s, even if hatchery stocks are included. There has

probably been at least a 70% decline in coho numbers since the 1960s.

## Threats to Wild Populations

The types of threats to the maintenance of wild stocks are well known. The major ones are loss of spawning and rearing habitat due to urbanization, industrialization, timber and agricultural industry watershed disturbances, and water diversions (Baker and Reynolds 1986). There are also dangers involved in attempting to enhance wild populations with hatchery stocks. Some of these problems are reviewed below.

### Loss of Stream Habitat

Loss of stream habitat has always been recognized as a major threat to anadromous salmonids, particularly coho salmon which utilize the streams as juveniles. Testimony given to the State Interim Committee on Stream and Beach Erosion in 1956 indicated that 925 miles of streams had been damaged or destroyed by early 1955 and the estimate by the end of 1956 was 1,000 miles (Fisk et al. 1966). Calhoun and Seeley (1962) indicated that 33 streams totaling about 55 miles, were damaged that year. Fisk et al. (1966) did preliminary surveys of stream damage on the Garcia River and Redwood Creek. The Garcia River was found to be severely to moderately damaged by ongoing logging and road building for 52 miles of its 104 miles of available habitat. In Redwood Creek, 68.5 of 84 miles of available habitat fell into these categories. This damaged was attributed to erosion and land slippage during floods that were increased in severity by logging operations such as construction of roads, skid trails and the removal of vegetative ground cover. On the Noyo River in the late 1950s, Holman and Evans (1964) estimated that all of the 70 miles of the potential fisheries habitat had been adversely affected by past

logging activities, most of which took place at least 50 years ago. They cited old log jams, unstable gravels, and areas of heavy silt deposits as the result of these past activities.

Graves and Burns (1970) compared yields of downstream migrant salmonids from 1964 to yields in 1968 after logging road construction and right-of-way logging on the South Fork Caspar Creek, in Jackson State Forest, in 1967. During the operations, large quantities of rocks and trees fell into the stream and approximately 79 meters of stream were relocated. Bulldozers operated through 41% of the stream's length. Upon completion of stream clearance over 99% of the 3,183 meter study reach had been disturbed (Burns 1970). The number of coho salmon smolts was 41% less in 1968 compared to 1964. Eighty-three percent of the coho salmon juveniles died or emigrated to refuge pools during the logging operations. In addition, in 1968 a large number of emigrating coho salmon were fry (81% versus 5% in 1964). This was most likely due to physical stress caused by physical changes due to logging.

The Bureau of Reclamation (1973) surveyed Redwood Creek, Ten Mile River, Noyo River, Big River, and the Gualala River and found all of the streams to be negatively affected by logging practices, road building, grazing, or urbanization. The detrimental effects of logging on salmonid fishes and ways to avoid them are reviewed by Burns (1972), with an emphasis on California streams.

The destruction of estuaries and winter habitat are also factors to consider. Coho salmon rearing in estuaries have rates of growth and survival that are better than and independent of those of stream fry, and independent of adverse conditions upstream (Tschaplinski 1982 cited in Hassler 1987).

Similarly, Smith found extremely rapid growth rates for steelhead in several small, California coastal lagoons (Smith 1987). Puckett (1977) noted coho salmon in all areas of the Eel River estuary, but noted that many of the fish may have been hatchery fish. Still the high use of the estuary is significant and other, smaller wild fish were also present. Both Smith (1987) and Puckett (1977) noted that the value of the estuaries as fish habitat had been degraded by increased siltation caused by human activities that widened and shallowed the habitat. Tschaplinski and Hartman (1983) found that many juvenile fish left the main channel of Carnation Creek (British Columbia, Canada) for low gradient, low velocity habitats such as side-channel sloughs or tributaries on the valley floor. Mainstream habitats utilized were deep pools with undercut banks and instream woody cover. Cover was also an important component of the valley floor habitats.

Reeves et al. (1989) have organized some of the factors limiting the production of coho salmon into a formalized key. The key is meant to help fishery managers identify the factors limiting production in Oregon and Washington in streams up to large fourth-order and small fifth-order in size. The key emphasizes stream gradient, summer and winter water temperatures, and habitat type (pool, riffle, glide, etc.). Summer temperatures and percent area of habitat types are both factors that can be influenced by man-induced changes by removal of riparian vegetation, factors increasing sedimentation.

The methods for correcting many of the above problems are well known. Reeves and Roelofs (1982) reviewed many of the current methods for rehabilitating and enhancing stream habitat. Many local organizations in California are now involved in rehabilitation and enhancement efforts (Toole et al. 1983, Hashagen et al. 1984, Sommerstrom 1984). As mentioned by Reeves

and Roelofs (1982), many restoration projects are not followed up by either qualitative or quantitative evaluations of increases in production of salmon, or if they are, the information is not readily available to others.

Genetics

The majority of coho salmon streams in California have been planted with fish from outside their native drainage. The genetic effects of these plantings of exotic stocks on native wild populations are unknown. Sommarstrom (1984) estimated that, in Mendocino County, only 10 streams retained coho salmon stocks minimally affected by hatchery outplantings, these being (listed north to south) Whale Gulch Creek, Jackass Creek, Usal Creek, Cottoneva Creek, Hardy Creek, Howard Creek, Juan Creek, Wages Creek, Albion River, and North Fork Gualala River. All but the populations in Albion River and Cottoneva Creek are reported to be at low levels or absent (W. Jones, pers. comm.).

Bartley et al. (1991) used electrophoresis to study the genetic structure of 27 populations of California coho salmon. Specimens for study were captured from 1983 through 1986 from the following streams: 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, Two Log 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 Creek, Cottoneva 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 hatchery, Deadwood Creek (Trinity River), West Branch Mill Creek (Smith River). Allozyme variation occurred at 24 of 45 loci

(53%). Much of the variation was due to rare alleles (frequency<5%) present in only a few samples. Of 30 variant alleles found, 20 (67%) were found at three or fewer locations; however, the distribution of these alleles did not follow any particular geographic pattern. Estimates of gene flow were high (>1 fish per generation).

The results for California coho salmon were similar to results obtained in Oregon, Washington and Canada. Bartley et al. (1991) also noted that undocumented transplants of different stocks in the past may have obscured any genetic differentiation that may have previously existed. In particular, they point out that Waddell Creek salmon had the highest level of heterozygosity recorded. This population is known to have been augmented with exotic stocks of fish. Nearby Scott Creek has not been planted with exotic stocks and had the lowest heterozygosity recorded (0). The difference suggests that the populations are maintaining some degree of reproductive isolation. Genetic changes in hatchery stocks of Pacific salmon have been documented and recently models have been constructed to aid in understanding the consequences of these changes for the preservation of wild genotypes (Waples 1990a, Waples 1990b, Waples and Teel 1990). In a recent review Steward and Bjornn (1990) noted that large differences in the genetic structure of wild and hatchery stocks can potentially lead to lower survival. They also note that supplementation with hatchery stocks can have negative, neutral or positive effects depending on the size of the wild population. Positive effects are primarily restricted to the situation where the wild stock has been reduced to such low levels that much of the genetic variability is lost. Negative effects relate to the stocking of hatchery fish poorly adapted to the local natural environment. Such fish contribute genetic material

influenced by selection in the hatchery or other stream systems rather than in the local environment.

While genetically distinct populations may not exist on a small scale, it seems likely that differentiation on a larger geographic scale may exist. The lack of small scale variation may be a natural response to the utilization of geographically unstable coastal streams. Straying is an advantage in this situation. It is also likely that there are small genetic differences that will be detected with more sensitive techniques or examination of different loci. The importance of the stock concept in managing Pacific salmonids has been stressed many times (Larkin 1981, Helle 1981, Nehlesen et al. 1991) and should be followed in the management of California coho. Hatchery production has a place in the maintenance and recovery of wild stocks but only with adequate consideration of possible genetic problems. Steward and Bjornn (1990) provide a number of recommendations on ways to minimize the genetic effects of hatchery supplementation. These include monitoring the genetics of wild and hatchery fish, maintaining large effective population sizes in the wild and in the hatchery, avoiding inbreeding through selective mating, supplement with non-smolt life history stages, and using hatchery stocks started from wild stock for supplementation. A study covering the entire Pacific Coast, using the same methodology, will probably be necessary to establish the degree of stock differentiation existing today.

Competition with Hatchery Stocks

Introduction of hatchery raised fish into the natural environment can result in competition between hatchery and wild fish if densities are increased to a high level. Researchers in Oregon discovered that the release of hatchery presmolts reduced the density of wild juvenile coho salmon by 40-

50%. They also found a net loss of adult returns when hatchery presmolts were stocked (Miller et al. 1990). The implication is that stocking of presmolts should only be done when natural densities are very low.

There are several possible mechanisms leading to the net losses observed. Juvenile coho salmon are territorial and fish with territories have an energetic advantage over those unable to hold a territory (Puckett and Dill 1985). Hungry fish are less responsive to predators so mortality at high densities would be higher (Dill and Fraser 1984). At high densities, growth of coho salmon is depressed through intra-specific competition for resources and mortality is increased (Fraser 1969). Fry select and defend territories, often in relatively deep pools with overhanging logs (Shapovalov and Taft 1954). Shapovalov and Taft (1954) noted an inverse correlation between the number of downstream migrants and adult return, implying that in years when intraspecific competition is low, downstream migrants are better able to survive ocean life.

Competition for spawning sites among adults can occur. When wild stocks are small and hatchery supplementation occurs, hatchery fish may outnumber wild fish and monopolize the available spawning habitat. The effect of such competition can be magnified by the fact that naturally spawning hatchery fish sometimes are less successful than wild fish. A number of studies have found that hatchery adults may produce fewer smolts and returning adults than wild fish (reviewed in Steward and Bjornn 1990).

Climatic Factors

The decline of coho salmon in California has probably been exacerbated by natural climatic events. The droughts of 1976-1977 and 1986-1991 have clearly made conditions worse in many streams, in some cases drying them up.

Several El Nino events have probably made oceanic conditions less favorable for coho salmon survival in recent years. The effects of the record 1964 floods on North Coast streams can still be seen in the streambeds and the reduced amount of high-quality habitat that resulted. Coho salmon in California have no doubt persisted through worse natural events in the past, but the fish did not have to deal simultaneously with the human-related degradation of their spawning streams due to factors like water diversions and increased erosion.

Other Concerns

During the preparation of this report a number of people noted other mechanisms that may be contributing to the present low populations of coho salmon. First, there is much concern about the influence of oceanic conditions on survival. Nielsen et al. (1991) noted that many of the streams surveyed during their study had good to excellent spawning and rearing habitat. Jones (pers. comm.) also noted the quality of many Mendocino County streams. Yet, salmonids are underutilizing or not using these streams, sometimes when enhancement efforts are ongoing. Botsford et al. (1980) demonstrated a pattern of cyclic covariation between the catch of Dungeness crab and both chinook and coho salmon (cycle period of 10 years). The coho salmon data only covered the period from 1952 to 1976, before the subsequent decline in catch but the linkage of the two salmonids to the crab does indicate a significant ocean component to survival. Ocean survival and the factors influencing it deserve more attention.

Other concerns voiced were that populations are so low that males and females may not be able to find each other efficiently. Also, at small population sizes sexual segregation in timing of migrations may assume more

importance than with large populations. Inbreeding of hatchery stocks was another concern mentioned. Overharvest was not mentioned often, perhaps because catches are now so low that they may be perceived as a minimal influence. However, continued harvest of small stocks may prevent recovery. Finally, the introduction of disease into wild stocks was a concern, particularly BKD (bacterial kidney disease). The effects of the disease on wild stocks are not known. Steward and Bjornn (1990) could find little evidence for the importance of transmission of disease from hatchery to wild stocks primarily because little work has been done. They concluded that the full impact of disease on supplemented stocks is probably underestimated.

## Management

As noted in many of the stream accounts and in the section on threats, most of the problems facing California coho salmon populations are well known and have been for many years. The major reasons that little has been done specifically for coho salmon seems to be that they are less important than chinook salmon to the commercial fishery and less important than chinook salmon and steelhead to the sport fishery. Also, coho salmon are a very diffuse resource, utilizing streams of all sizes along the coast. As a result management efforts have focused on chinook salmon and steelhead with the hope that coho salmon would be aided incidentally. Coho salmon have probably benefitted from these efforts to some degree. Another problem is that juvenile coho salmon require deep, cold, pool habitat for good survival. Pool filling and water temperature increases are two of the major results of poor land use practices during logging, grazing, and urbanization. Further, once these changes have occurred, often as the result of activities in the past (logging 50 years ago or

more), natural recovery can take many, many years and stream rehabilitation efforts are expensive and time consuming.

The present management goal of the California Department of Fish and Game is to double the size of the present run (33,500 spawners by their estimate) by the year 2000 (Sheehan 1991). The emphasis will be on restoring and improving habitat. Hatchery production will continue at current levels, and private cooperative fish-rearing projects will be encouraged when short-term localized enhancement efforts are appropriate. Specific goals for the next five years are:

1. Inventory streams within the historic range of coho salmon to determine the present distribution and abundance of the species and assess the condition of the habitat.
2. Set up priorities for the improvement of coho salmon streams on the basis of their potential for improvement.
3. Identify streams with the highest potential for restoration and enhancement by the Department of Fish and Game and streams suitable for restoration and enhancement by private organizations.
4. Set up priorities for restocking streams affected by droughts to speed recovery of the population
5. Fund and accomplish habitat restoration projects.
6. Restock coho salmon streams according to priorities and in keeping with the Department's genetic stock management policy.

We would add little to this outline. However, the addition of a monitoring component seems necessary. Without a baseline it will be difficult to determine the success or failure of enhancement and restoration efforts. A monitoring

program should include:

1. Annual population surveys of selected streams throughout the range of coho salmon. The selected streas should include both streams with ongoing management efforts and streams without such efforts. Surveys of both juvenile and spawner abundance should be included to help determine what types of activities will best contribute to recovery.
2. Quick presence/absence surveys of all historic coho streams in the state at least once every five years to determine if juveniles are present and to rate stream conditions.

Also, there should be greater cooperation between the many different agencies and organizations involved with coho salmon both within California and in other states and Canada. A greater exchange of ideas and information may prevent duplication of both effort and failures. We also urge that the restoration goals be focussed on wild coho salmon, with hatchery stocks not counted toward whatever numerical goals are set. All use of hatchery stocks should be carefully evaluated for their potential effects (genetic, behavioral, disease) on wild stocks and an effort made to increase the use of native strains of fish in hatcheries.

Finally, the above program must be funded and implemented continuously for it to be successful. The management effort must be focused on the recovery of the resource rather than the economic effects of necessary actions on resource users. This point has been made many times in the management of salmonid fisheries (Larkin 1979, Wright 1981). Otherwise, it is likely coho salmon will continue to decline.

Source: STATUS OF COHO SALMON in Calif.
Brown and Moyle 1991



## Conclusions

It is clear that wild stocks of coho salmon have declined or disappeared from most of California's streams. The lack of historical or recent data makes it difficult to evaluate trends in many systems. Based on our review of the existing data we suggest the following.

1. Coho salmon were known to inhabit at least 582 streams in California. Populations have been extirpated or nearly so from 19% of the streams, are known to persist in 23%, and the status of 58% are unknown. If the presence/absence data for streams in which the status of coho salmon is known is consistent for all streams, then 46% of California's streams that once contained coho salmon no longer support populations.
2. The percentage of streams that have lost coho salmon appears to increase in the southern part of the range but the status of most of the northern streams is unknown.
3. The evidence that the Sacramento River system never supported populations of coho salmon is less than convincing. Based on historical accounts from around the turn of the century, it seems likely that the species inhabited the drainage to some degree.
4. Even very generous estimates of abundance place the number of naturally spawning fish at only 13,240 fish. Over half of the coho salmon produced in the state are from 5 large hatcheries and many smaller systems are supplemented with hatchery fish. The number of naturally spawned fish is probably about 5,000-7,000. Wild fish make up an unknown proportion of this number but have probably numbered less than 5,000 fish in recent years.

5. The general reasons for the decline are relatively well known, primarily erosion, water temperature increases and changes in flow characteristics resulting from poor land use practices. However, the problems have not been well defined for individual drainages. Strict enforcement of existing regulations concerning land use is needed. Research into coho salmon biology are needed to determine if the formulation of new regulations is needed.

6. Droughts, ocean survival, genetics of wild and hatchery stocks, spawning behavior at small population sizes, and transfer of disease from hatchery to wild stocks are probably factors contributing to the decline and deserve study.

7. Hatchery production has apparently slowed the decline of coho salmon in some river systems (e.g. Klamath River, Trinity River, Noyo River) but has not in others (e.g. Russian River). Overall, hatchery production has had little positive effect on reversing the decline of coho salmon state-wide and may have had significant negative effects, by introducing strains of fish poorly adapted for local conditions, introducing diseases, and other factors.

8. The management plan put forward by the California Department of Fish and Game should be implemented and supported. Additional elements that could be added to the plan include a monitoring component and the development of interagency coordination concerning the management of coho salmon.

The challenge of managing such a diffuse resource as coho salmon are considerable. Proper management is especially important in California because we are responsible for the southernmost populations of this species. California populations are likely unique in many respects because they inhabit one of the

most stressful areas in the species' range. Only with a concerted, well funded, management effort will the decline of wild coho salmon be stopped and reversed.

## Threatened and Endangered Status

In the past 50 years, wild coho salmon numbers in the state have apparently declined by over 99%. Many local populations have been extirpated. There is every reason to think that the decline in coho numbers is continuing and that many more small, localized populations will go extinct in the next few years. Moyle et al. (1989), largely on the basis of annecdotal information, recommended that coho salmon be listed as a Species of Special Concern by the California Department of Fish and Game, a designation certainly supported by the findings of this report. In a report on the status of West Coast salmon stocks, Nehlsen et al. (1991) found that:

1. Coho salmon stocks south of San Francisco Bay were at a high risk of extinction, probably qualifying for listing as threatened or endangered under the federal Endangered Species Act.
2. Coho salmon stocks in small coastal streams north of San Francisco Bay were at a moderate risk of extinction, near the threshold of being qualified for listing under ESA.
3. Wild coho salmon in the Klamath River drainage were of special concern, because of low and declining numbers. According to the Klamath Fishery Management Council (1990), hatcheries are the source of most Klamath drainage cohos and "natural spawning is thought to be minor."

It appears that coho salmon statewide would qualify for listing as a threatened

species under state law and that a number of distinct populations, most notably that in Scott Creek, Santa Cruz County, would qualify for threatened or endangered status under federal law, using the definition of Waples (1991) that these populations are Evolutionarily Significant Units.

The question remains, however, should coho salmon be listed under state and federal endangered species laws? These laws are among the strongest environmental protection laws we have and they can be used to force the "concerted, well funded management effort" recommended above that is needed to reverse the decline of wild coho stocks. Because formal listing often seems to turn species management into an adversarial rather than cooperative process, we do not recommend immediate state-wide listing of the coho salmon. Instead, we recommend treating wild coho in every stream as if they were threatened species, as part of a state-wide effort to restore them. If this effort does not result in significant recovery of at least some coho populations, or at least evidence that the declining trend is being reversed within five years, the process for formal listing under both state and federal laws should proceed. One exception to this recommendation is to list, as soon as possible, the coho population in Scott Creek as endangered, as this represents the southernmost, genetically distinctive population of the species; it is very small and could become extinct just through random demographic processes. Listing of this population would not only provide additional protection for it, but signal the need for state-wide protection for coho salmon.

Acknowledgements

We thank the many interested parties who contributed ideas, observations, manuscripts, and unpublished data.

Table 1. List of streams hist[illegible]e coho salmon, type of evidence (SS = stream survey, FR = fish rescue operation, CC = carcass count, AT = adult trap, JT = juvenile trap, LIT = literature search, OT = other), and source. Streams were listed as they occur on the California coast from north to south. Only the most recent field sighting was included. Compilations of file reports and personal communications were only cited when no other source was available. Numbers of fish sighted are described in the text or Appendix 1. Hatchery returns are not included. Sources followed by an asterisk were obtained from the Preserve Design Diversity Database (1989) maintained at the University of California, Davis by Peter Moyle, rather than directly from the source listed.

| Drainage | Stream | Method | Source |
|---|---|---|---|
| *SF Winchuck River* | *SF Winchuck River* | FR | Shapovalov 1940 |
| Illinois River | | | |
| WF Illinois River | Broken Kettle Cr. | LIT | Hassler 1988 |
| WF Illinois River | Elk Creek | LIT | Hassler 1988 |
| EF Illinois River | Dunn Creek | SS | P. Moyle, unpubl. data |
| Smith River | Smith River | LIT | Hassler 1988 |
| | Rowdy Creek | FR | Kimsey 1953 |
| Rowdy Creek | Dominie Creek | LIT | Hassler 1988 |
| Rowdy Creek | Savoy Creek | LIT | Hassler 1988 |
| Rowdy Creek | Copper Creek | LIT | Hassler 1988 |
| | Morrison Creek | FR | Kimsey 1953 |
| | Jaqua Creek | OT | Hallock et al. 1952 |
| | Mill Creek | OT | Hallock et al. 1952 |
| Mill Creek | EF Mill Creek | LIT | Hassler 1988 |
| Mill Creek | WF Mill Creek | LIT | Hassler 1988 |
| Mill Creek | Bummer Lake Cr. | SS | Burns 1971 |
| | MF Smith River | LIT | Hassler 1988 |
| MF Smith River | Hardscrabble Creek | LIT | Hassler 1988 |
| MF Smith River | Myrtle Creek | LIT | Hassler 1988 |
| MF Smith River | NF Smith River | LIT | Hassler 1988 |
| NF Smith River | Peridotite Creek | LIT | Hassler 1988 |
| NF Smith River | Still Creek | LIT | Hassler 1988 |
| NF Smith River | Diamond Creek | LIT | Hassler 1988 |
| MF Smith River | Eighteen Mile Creek | LIT | Hassler 1988 |
| MF Smith River | Patrick Creek | LIT | Hassler 1988 |
| Patrick Creek | Twelve Mile Creek | LIT | Hassler 1988 |
| Patrick Creek | Shelly Creek | LIT | Hassler 1988 |
| Patrick Creek | Eleven Mile Creek | LIT | Hassler 1988 |
| Patrick Creek | Ten Mile Creek | LIT | Hassler 1988 |
| Patrick Creek | WF Patrick Creek | LIT | Hassler 1988 |
| MF Smith River | Monkey Creek | LIT | Hassler 1988 |
| MF Smith River | Siskiyou Fork | LIT | Hassler 1988 |
| MF Smith River | Packsaddle Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Miner's Creek | LIT | Hassler 1988 |
| | Pine Creek | LIT | Hassler 1988 |
| Pine Creek | Little Pine Creek | LIT | Hassler 1988 |
| | Bluff Creek | LIT | Hassler 1988 |
| | Slate Creek | LIT | Hassler 1988 |
| | Red Cap Creek | LIT | Hassler 1988 |
| | Boise Creek | LIT | Hassler 1988 |
| | Irving Creek | SS | A. Olson, unpubl. data |
| | Camp Creek | LIT | Hassler 1988 |
| | Dillon Creek | LIT | Hassler 1988 |
| | Ukonom Creek | LIT | Hassler 1988 |
| | Independence Creek | SS | A. Olson, unpubl. data |
| | Clear Creek | LIT | Hassler 1988 |
| | Elk Creek | LIT | Hassler 1988 |
| Elk Creek | EF Elk Creek | SS | A. Olson, unpubl. data |
| | Indian Creek | LIT | Hassler 1988 |
| Indian Creek | SF Indian Creek | LIT | Hassler 1988 |
| Indian Creek | EF Indian Creek | LIT | A. Olson, unpubl. data |
| Indian Creek | Mill Creek | SS | A. Olson, unpubl. data |
| | China Creek | SS | D. Maria, unpubl. data* |
| | Thompson Creek | LIT | Hassler 1988 |
| | Seiad Creek | LIT | Hassler 1988 |
| | Grider Creek | SS | D. Maria, unpubl. data* |
| Grider Creek | West Grider Creek | LIT | Hassler 1988 |
| | Horse Creek | LIT | Hassler 1988 |
| Horse Creek | Buckhorn Creek | LIT | Hassler 1988 |
| Horse Creek | Middle Creek | LIT | Hassler 1988 |
| Horse Creek | Salt Gulch | LIT | Hassler 1988 |
| | Barkhouse Creek | LIT | Hassler 1988 |
| | Beaver Creek | LIT | D. Maria, unpubl. data* |
| | Humbug Creek | LIT | Hassler 1988 |
| | Cottonwood Creek | LIT | Hassler 1988 |
| | Shasta River | LIT | Hassler 1988 |
| Shasta River | Big Springs Creek | LIT | Hassler 1988 |
| | Willow Creek | LIT | Hassler 1988 |
| | Bogus Creek | LIT | Hassler 1988 |
| | Shasta River | AT | Coots 1958 |
| | Klamathon racks | AT | Bryant 1937 |
| | Fall Creek | OT | Coots 1957 |
| Trinity River (trib. to Klamath River) | Trinity River | LIT | Hassler 1988 |
| | Scottish Creek | LIT | Hassler 1988 |
| | Mill Creek | LIT | Hassler 1988 |
| | Hostler Creek | LIT | Hassler 1988 |
| | Supply Creek | LIT | Hassler 1988 |
| | Campbell Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| MF Smith River | Griffin Creek | LIT | Hassler 1988 |
| MF Smith River | Knopki Creek | LIT | Hassler 1988 |
| | SF Smith River | LIT | Hassler 1988 |
| SF Smith River | Craigs Creek | LIT | Hassler 1988 |
| SF Smith River | Coon Creek | LIT | Hassler 1988 |
| SF Smith River | Hurdy Gurdy Cr. | SS | P. Moyle, unpubl. data |
| SF Smith River | Jones Creek | LIT | Hassler 1988 |
| Jones Creek | Muzzle Loader Cr. | LIT | Hassler 1988 |
| SF Smith River | Buck Creek | LIT | Hassler 1988 |
| SF Smith River | Quartz Creek | LIT | Hassler 1988 |
| SF Smith River | Eight Mile Creek | LIT | Hassler 1988 |
| Eight Mile Creek | Williams Creek | LIT | Hassler 1988 |
| SF Smith River | Prescott Fork | LIT | Hassler 1988 |
| Coastal (Lake Earl) | Jordan Creek | OT | Hallock et al. 1952 |
| Coastal (Lake Earl) | Yonkers Creek | LIT | Hassler 1988 |
| Coastal | Elk Creek | LIT | Hassler 1988 |
| Coastal | Wilson Creek | FR | Kimsey 1953 |
| Klamath River | estuary | OT | Gibbs and Kimsey 1955 |
| | Hunter Creek | FR | Kimsey 1953 |
| Hunter Creek | Salt Creek | LIT | Hassler 1988 |
| Salt Creek | High Prairie Creek | FR | Kimsey 1953 |
| Hunter Creek | Mynot Creek | FR | Kimsey 1953 |
| | Richardson Creek | LIT | Hassler 1988 |
| | Saugep Creek | LIT | Hassler 1988 |
| | Waukell Creek | LIT | Hassler 1988 |
| | Hoppaw Creek | FR | Kimsey 1953 |
| | Turwar Creek | FR | Kimsey 1953 |
| | McGarvey Creek | OT | Hallock et al. 1952 |
| | Tarup Creek | LIT | Hassler 1988 |
| | Omagar Creek | LIT | Hassler 1988 |
| | Blue Creek | LIT | Hassler 1988 |
| Blue Creek | WF Blue Creek | LIT | Hassler 1988 |
| WF Blue Creek | Potato Patch Creek | LIT | Hassler 1988 |
| Blue Creek | Nickowitz Creek | LIT | Hassler 1988 |
| Blue Creek | Crescent City Fork | LIT | Hassler 1988 |
| | Ah Pah Creek | LIT | Hassler 1988 |
| Ah Pah Creek | SF Ah Pah Creek | SS | D. McCleod, unpubl. data |
| | Bear Creek | LIT | Hassler 1988 |
| | Tectah Creek | LIT | Hassler 1988 |
| | Pecwan Creek | LIT | Hassler 1988 |
| | Mettah Creek | LIT | Hassler 1988 |
| | Roach Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Tish Tang A Tang C | LIT | Hassler 1988 |
| | Horse Linto Creek | SS | P. Moyle, unpubl. data |
| | Willow Creek | LIT | Hassler 1988 |
| | SF Trinity River | LIT | Hassler 1988 |
| SF Trinity River | Ectapom Creek | LIT | Hassler 1988 |
| SF Trinity River | Pelletreu Creek | LIT | Hassler 1988 |
| SF Trinity River | Hayfork Creek | LIT | Hassler 1988 |
| Hayfork Creek | Olsen Creek | LIT | Hassler 1988 |
| SF Trinity River | Butter Creek | LIT | Hassler 1988 |
| SF Trinity River | Rattlesnake Creek | LIT | Hassler 1988 |
| | New River | LIT | Hassler 1988 |
| | Manzanita Creek | LIT | Hassler 1988 |
| | NF Trinity River | LIT | Hassler 1988 |
| EF NF Trinity R. | Indian Creek | LIT | Hassler 1988 |
| | Canyon Creek | LIT | Hassler 1988 |
| | Browns Creek | LIT | Hassler 1988 |
| | Rush Creek | SS | D. Painter, pers. comm.* |
| | Deadwood Creek | LIT | Hassler 1988 |
| Salmon River (trib. to Klamath River) | Salmon River | LIT | Hassler 1988 |
| | Wooley Creek | LIT | Hassler 1988 |
| | Nordheimer Creek | LIT | Hassler 1988 |
| | NF Salmon River | LIT | Hassler 1988 |
| NF Salmon River | North Russian Cr. | LIT | Hassler 1988 |
| NF Salmon River | South Russian Cr. | LIT | Hassler 1988 |
| | SF Salmon River | LIT | Hassler 1988 |
| SF Salmon River | Knownothing Creek | LIT | Hassler 1988 |
| SF Salmon River | Methodist Creek | LIT | Hassler 1988 |
| SF Salmon River | EF SF Salmon River | SS | D. Maria, pers. comm.* |
| EF SF Salmon R. | Taylor Creek | LIT | Hassler 1988 |
| Scott River (trib. to Klamath River) | Tomkins Creek | LIT | Hassler 1988 |
| | Kelsey Creek | LIT | Hassler 1988 |
| | Canyon Creek | LIT | Hassler 1988 |
| | Shackleford Creek | LIT | Hassler 1988 |
| Shackleford Creek | Mill Creek | LIT | Hassler 1988 |
| | Kidder Creek | LIT | Hassler 1988 |
| Kidder Creek | Patterson Creek | LIT | Hassler 1988 |
| | Etna Creek | LIT | Hassler 1988 |
| | French Creek | LIT | Hassler 1988 |
| French Creek | Miners Creek | LIT | Hassler 1988 |
| | Sugar Creek | LIT | Hassler 1988 |
| | EF Scott River | LIT | Hassler 1988 |
| EF Scott River | Big Mill Creek | LIT | Hassler 1988 |
| | SF Scott River | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| Redwood Creek | Redwood Creek | FR | Kimsey 1953 |
| | Prairie Creek | FR | Kimsey 1952 |
| Prairie Creek | Little Lost Man Cr. | OT | Hallock et al. 1952 |
| Prairie Creek | Lost Man Creek | OT | Hallock et al. 1952 |
| Prairie Creek | May Creek | OT | Hallock et al. 1952 |
| Prairie Creek | Godwood Creek | SS | Burns 1971 |
| Prairie Creek | Boyes Creek | OT | Hallock et al. 1952 |
| Prairie Creek | Browns Creek | LIT | Hassler 1988 |
| Prairie Creek | Streelow Creek | LIT | Hassler 1988 |
| | Tom McDonald Cr. | LIT | Hassler 1988 |
| | Bridge Creek | LIT | Hassler 1988 |
| | Coyote Creek | LIT | Hassler 1988 |
| | Panther Creek | LIT | Hassler 1988 |
| | Lacks Creek | LIT | Hassler 1988 |
| Big Lagoon | Big Lagoon | OT | Bailey and Kimsey 1952 |
| Stone Lagoon | McDonald Creek | FR | Kimsey 1953 |
| | Fresh Creek | LIT | Hassler 1988 |
| Little River | Little River | OT | Hallock et al. 1952 |
| | SF Little River | LIT | Hassler 1988 |
| SF Little River | Lower SF Little R. | LIT | Hassler 1988 |
| SF Little River | Upper SF Little R. | LIT | Hassler 1988 |
| Coastal | Strawberry Creek | LIT | Hassler 1988 |
| Mad River | Mad River | FR | Kimsey 1952 |
| | Warren Creek | LIT | Hassler 1988 |
| | Lindsay Creek | OT | Hallock et al. 1952 |
| Lindsay Creek | Squaw Creek | FR | Kimsey 1953 |
| Lindsay Creek | Grassy Creek | OT | Hallock et al. 1952 |
| Lindsay Creek | Mather Creek | LIT | Hassler 1988 |
| | Hall Creek | LIT | Hassler 1988 |
| Hall Creek | Mill Creek | LIT | Hassler 1988 |
| Hall Creek | Noisy Creek | OT | Hallock et al. 1952 |
| | Camp Bauer Creek | OT | Hallock et al. 1952 |
| | Leggit Creek | LIT | Hassler 1988 |
| Leggit Creek | Kelly Creek | LIT | Hassler 1988 |
| | Powers Creek | LIT | Hassler 1988 |
| | Quarry Creek | LIT | Hassler 1988 |
| Quarry Creek | Palmer Creek | LIT | Hassler 1988 |
| | NF Mad River | FR | Shapovalov 1940 |
| NF Mad River | Sullivan Creek | LIT | Hassler 1988 |
| NF Mad River | Long Prairie Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Cannon Creek | SS | L. Preston, unpubl. data |
| | Maple Creek | LIT | Hassler 1988 |
| | Black Creek | LIT | Hassler 1988 |
| | Boulder Creek | LIT | Hassler 1988 |
| Humboldt Bay | Janes Creek | OT | Hull 1987 |
| | Jolly Giant Creek | OT | Hull 1987 |
| | Jacoby Creek | OT | Hull 1987 |
| | Rocky Gulch Creek | LIT | Hassler 1988 |
| | Cochran Creek | OT | Hull 1987 |
| | Freshwater Creek | OT | Hull 1987 |
| Freshwater Creek | Ryan Creek | LIT | Hassler 1988 |
| Freshwater Creek | McCready Gulch | LIT | Hassler 1988 |
| Freshwater Creek | Little Freshwater C | LIT | Hassler 1988 |
| Freshwater Creek | Cloney Gulch | LIT | Hassler 1988 |
| Cloney Gulch | Falls Gulch | LIT | Hassler 1988 |
| Freshwater Creek | Graham Gulch | LIT | Hassler 1988 |
| | Martin Slough | LIT | Hassler 1988 |
| | Elk River | OT | Hallock et al. 1952 |
| Elk River | NF Elk River | LIT | Hassler 1988 |
| Elk River | SF Elk River | LIT | Hassler 1988 |
| SF Elk River | Little SF Elk R. | LIT | Hassler 1988 |
| | College of Redwoods Creek | LIT | Hassler 1988 |
| | Salmon Creek | LIT | Hassler 1988 |
| Eel River | estuary | OT | Puckett 1977 |
| | below Van Duzen R. | OT | Murphy and DeWitt 1951 |
| | Salt River | SS | Mills 1983 |
| Salt River | Russ Creek | LIT | Hassler 1988 |
| Salt River | Reas Creek | SS | Mills 1983 |
| | Rohner Creek | SS | Mills 1983 |
| | Price Creek | FR | Shapovalov 1941 |
| | Howe Creek | SS | Mills 1983 |
| Howe Creek | Atwell Creek | SS | Mills 1983 |
| | Dinner Creek | FR | Shapovalov 1940 |
| | Jordan Creek | OT | Hallock et al. 1952 |
| Eel River | near Pepperwood | FR | Shapovalov 1940 |
| | Shively Creek | SS | Mills 1983 |
| | Bear Creek | CC | G. Flosi, unpubl. data |
| | Chadd Creek | CC | G. Flosi, unpubl. data |
| | Larabee Creek | SS | Mills 1983 |
| Larabee Creek | Carson Creek | CC | G. Flosi, unpubl. data |
| | Newman Creek | FR | Shapovalov 1940 |
| | Jewett Creek | SS | Mills 1983 |
| | Kekawaka Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Outlet Creek | CC | G. Flosi, unpubl. data |
| Outlet Creek | Bloody Run Creek | SS | W. Jones, pers. comm. |
| Outlet Creek | Long Valley Creek | CC | Brown and Moyle 1991 |
| Outlet Creek | Reeves Canyon Cr. | CC | G. Flosi, unpubl. data |
| Outlet Creek | Ryan Creek | CC | G. Flosi, unpubl. data |
| Outlet Creek | Rowes Creek | SS | W. Jones, pers. comm. |
| Outlet Creek | Mill Creek | SS | W. Jones, pers. comm. |
| Mill Creek | Willits Creek | CC | G. Flosi, unpubl. data |
| Willits Creek | Dutch Henry Creek | SS | W. Jones, pers. comm. |
| Outlet Creek | Brouddus Creek | CC | G. Flosi, unpubl. data |
| Outlet Creek | Haehl Creek | CC | G. Flosi, unpubl. data |
| Outlet Creek | Baechtel Creek | CC | G. Flosi, unpubl. data |
| | Indian Creek | SS | Mills 1983 |
| Tomki Creek | Rocktree Creek | SS | Mills 1983 |
| Tomki Creek | String Creek | SS | Mills 1983 |
| Tomki Creek | Tarter Creek | SS | Mills 1983 |
| Van Duzen River | Van Duzen River | SS | Brown and Moyle 1991 |
| (trib. to Eel River) | Palmer Creek | OT | Hallock et al. 1952 |
| | Wolverton Gulch | SS | Mills 1983 |
| | Yager Creek | SS | Mills 1983 |
| Yager Creek | Cooper Mill Creek | OT | Hallock et al. 1952 |
| Yager Creek | Wilson Creek | SS | Mills 1983 |
| Yager Creek | Lawrence Creek | CC | G. Flosi, unpubl. data |
| Lawrence Creek | Shaw Creek | CC | G. Flosi, unpubl. data |
| | Cuddeback Creek | FR | Shapovalov 1941 |
| | Fielder Creek | OT | Hallock et al. 1952 |
| | Cummings Creek | SS | Brown and Moyle 1991 |
| | Hely Creek | OT | Hallock et al. 1952 |
| | Root Creek | LIT | Hassler 1988 |
| | Grizzly Creek | OT | Hallock et al. 1952 |
| Grizzly Creek | Stevens Creek | LIT | Hassler 1988 |
| | Hoaglund Creek | LIT | Hassler 1988 |
| | Little Larabee Cr. | LIT | Hassler 1988 |
| South Fork Eel River | SF Eel River | SS | Nielsen et al. 1991 |
| (trib. to Eel River) | Bull Creek | JT | S. Downie, unpubl. data |
| Bull Creek | Squaw Creek | CC | G. Flosi, unpubl. data |
| Bull Creek | Albee Creek | LIT | Hassler 1988 |
| Bull Creek | Mill Creek | LIT | Hassler 1988 |
| | Canoe Creek | SS | Brown and Moyle 1991 |
| | Bridges Creek | FR | Shapovalov 1941 |
| | Elk Creek | FR | Shapovalov 1940 |
| | Salmon Creek | FR | Shapovalov 1940 |
| | Bear Butte Creek | FR | Shapovalov 1940 |
| | Fish Creek | FR | Shapovalov 1940 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Anderson Creek | CC | G. Flosi, unpubl. data |
| | Dean Creek | FR | Shapovalov 1940 |
| | Redwood Creek | JT | S. Downie, unpubl. data |
| Redwood Cr. | Seely Creek | SS | Mills 1983 |
| Redwood Cr. | Miller Creek | SS | Mills 1983 |
| Redwood Cr. | China Creek | SS | Mills 1983 |
| Redwood Cr. | Dinner Creek | SS | Mills 1983 |
| | Sprowel Creek | SS | L. Brown, pers. obs. |
| Sprowel Creek | Warden Creek | LIT | Hassler 1988 |
| Sprowel Creek | Little Sprowel Cr. | LIT | L. Brown, pers. obs. |
| Sprowel Creek | WF Sprowel Creek | LIT | Hassler 1988 |
| | EB SF Eel River | JT | S. Downie, unpubl. data |
| EB SF Eel River | Squaw Creek | SS | Mills 1983 |
| | Durphy Creek | FR | Shapovalov 1941 |
| | Milk Ranch Creek | SS | Mills 1983 |
| | Low Gap Creek | SS | Mills 1983 |
| | Indian Creek | CC | Nielsen et al. 1991 |
| | Piercy Creek | CC | Nielsen et al. 1991 |
| | Standley Creek | SS | Mills 1983 |
| | McCoy Creek | SS | Mills 1983 |
| | Bear Pen Creek | SS | Mills 1983 |
| Bear Pen Cr. | Cub Creek | SS | Mills 1983 |
| | Red Mountain Creek | SS | Mills 1983 |
| | Wildcat Creek | SS | Mills 1983 |
| | Hollowtree Creek | CC | Nielsen et al. 1991 |
| Hollowtree Cr. | Mule Creek | SS | Mills 1983 |
| Hollowtree Cr. | Walters Creek | LIT | Hassler 1988 |
| Hollowtree Cr. | Redwood Creek | CC | Nielsen et al. 1991 |
| Hollowtree Cr. | Bond Creek | LIT | Hassler 1988 |
| Hollowtree Cr. | Michaels Creek | SS | Nielsen et al. 1991 |
| Hollowtree Cr. | Waldron Creek | SS | Mills 1983 |
| Hollowtree Cr. | Huckleberry Creek | SS | Nielsen et al. 1991 |
| Hollowtree Cr. | Butler Creek | SS | Nielsen et al. 1991 |
| | Cedar Creek | LIT | Nielsen et al. 1991 |
| | Rattlesnake Creek | SS | Mills 1983 |
| Rattlesnake Cr. | Cummings Creek | SS | P. Baker, pers. comm.* |
| | Ten Mile Creek | CC | G. Flosi, unpubl. data |
| Ten Mile Creek | Grub Creek | SS | Mills 1983 |
| Ten Mile Creek | Streeter Creek | CC | G. Flosi, unpubl. data |
| Ten Mile Creek | Big Rock Creek | SS | Mills 1983 |
| Ten Mile Creek | Mud Springs Creek | SS | Mills 1983 |
| Ten Mile Creek | Mill Creek | SS | Mills 1983 |
| Ten Mile Creek | Cahto Creek | SS | Mills 1983 |
| | Fox Creek | SS | Mills 1983 |
| | Elder Creek | SS | Brown and Moyle 1991 |
| | Jack of Hearts Cr. | CC | Nielsen et al. 1991 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Deer Creek | SS | Mills 1983 |
| | Little Charlie Cr. | LIT | Hassler 1988 |
| | Dutch Charlie Creek | CC | G. Flosi, unpubl. data |
| | Redwood Creek | CC | Nielsen et al. 1991 |
| | Kenny Creek | SS | Mills 1983 |
| | Haun Creek | LIT | Hassler 1988 |
| | Rock Creek | SS | Mills 1983 |
| | Bear Creek | SS | Mills 1983 |
| | Taylor Creek | SS | Mills 1983 |
| Middle Fork Eel River (trib. to Eel River) | MF Eel River | LIT | Hassler 1988 |
| | Mill Creek | SS | Mills 1983 |
| Mill Creek | Grist Creek | SS | Mills 1983 |
| | Rattlesnake Creek | SS | Mills 1983 |
| NF of MF Eel River | Rock Creek | SS | Mills 1983 |
| North Fork Eel River (trib. to Eel River) | Bluff Creek | SS | Mills 1983 |
| Coastal | Guthrie Creek | LIT | Hassler 1988 |
| Bear River | Bear River | LIT | Hassler 1988 |
| | Bonanza Gulch | LIT | Hassler 1988 |
| | SF Bear Creek | LIT | Hassler 1988 |
| SF Bear Creek | Hollister Creek | LIT | Hassler 1988 |
| Coastal | McNut Gulch | LIT | Hassler 1988 |
| Mattole River | Mattole River | LIT | G. Petersen pers. comm. |
| | NF Mattole River | LIT | Hassler 1988 |
| | Mill Cr. (Petrolia) | LIT | Hassler 1988 |
| | Clear Creek | LIT | Hassler 1988 |
| | Conklin Creek | LIT | Hassler 1988 |
| | McGinnis Creek | LIT | Hassler 1988 |
| | Indian Creek | LIT | Hassler 1988 |
| | Squaw Creek | LIT | Hassler 1988 |
| | Pritchard Creek | LIT | Hassler 1988 |
| | Granny Creek | LIT | Hassler 1988 |
| | Saunders Creek | LIT | Hassler 1988 |
| | Woods Creek | LIT | Hassler 1988 |
| | Upper NF Mattole R | LIT | Hassler 1988 |
| Upper NF Mattole R | Rattlesnake Creek | LIT | Hassler 1988 |
| Upper NF Mattole R | Oil Creek | LIT | Hassler 1988 |
| Oil Creek | Devils Creek | LIT | Hassler 1988 |
| | Honeydew Creek | LIT | Hassler 1988 |

Table 1. *continued*

| Drainage | Stream | Method | Source |
|---|---|---|---|
| Honeydew Creek | Bear Trap Creek | LIT | Hassler 1988 |
| | Dry Creek | LIT | Hassler 1988 |
| | Middle Creek | LIT | Hassler 1988 |
| | Westlund Creek | LIT | Hassler 1988 |
| | Gilham Creek | LIT | Hassler 1988 |
| | Fourmile Creek | LIT | Hassler 1988 |
| | Sholes Creek | LIT | Hassler 1988 |
| | Harrow Creek | LIT | Hassler 1988 |
| | Grindstone Creek | LIT | Hassler 1988 |
| | Mattole Canyon | LIT | Hassler 1988 |
| | Blue Slide Creek | LIT | Hassler 1988 |
| | Bear Creek | LIT | Hassler 1988 |
| Bear Creek | SF Bear Creek | SS | L. Preston, unpubl. data |
| | Big Finley Creek | LIT | Hassler 1988 |
| | Eubank Creek | LIT | Hassler 1988 |
| | Bridge Creek | LIT | Hassler 1988 |
| | McKee Creek | LIT | Hassler 1988 |
| | Vanankin Creek | LIT | Hassler 1988 |
| | Mill Creek | LIT | Hassler 1988 |
| | Baker Creek | LIT | Hassler 1988 |
| | Thompson Creek | LIT | Hassler 1988 |
| Coastal | Whale Gulch Creek | OT | Sommerstrom 1984 |
| Coastal | Indian Creek | OT | Murphy 1950 |
| Coastal | Jackass Creek | OT | Sommerstrom 1984 |
| Coastal | Usal Creek | FR | Kimsey 1953 |
| Cottoneva Creek | Cottoneva Creek | OT | Sommerstrom 1984 |
| | SF Cottoneva Creek | LIT | Hassler 1988 |
| | NF Cottoneva Creek | LIT | Hassler 1988 |
| Coastal | Hardy Creek | OT | Sommerstrom 1984 |
| Coastal | Juan Creek | OT | Sommerstrom 1984 |
| | Little Juan Creek | LIT | Hassler 1988 |
| Coastal | Howard Creek | SS | T. Taylor, unpubl. data* |
| Coastal | DeHaven Creek | OT | Murphy 1950 |
| Coastal | Wages Creek | OT | Sommerstrom 1984 |
| Ten Mile River | Ten Mile River | OT | Sommerstrom 1984 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | NF Ten Mile River | LIT | Hassler 1988 |
| NF Ten Mile River | Mill Creek | LIT | Hassler 1988 |
| NF Ten Mile River | Little NF Ten Mile | LIT | Hassler 1988 |
| | SF Ten Mile River | LIT | Hassler 1988 |
| SF Ten Mile River | Smith Creek | LIT | Hassler 1988 |
| SF Ten Mile River | Campbell Creek | LIT | Hassler 1988 |
| SF Ten Mile River | Churchman's Creek | LIT | Hassler 1988 |
| SF Ten Mile River | Redwood Creek | CC | Nielsen et al. 1991 |
| | MF Ten Mile River | LIT | Hassler 1988 |
| MF Ten Mile River | Bear Haven Creek | LIT | Hassler 1988 |
| Pudding Creek | Pudding Creek | CC | Nielsen et al. 1991 |
| | Little Valley Creek | LIT | Hassler 1988 |
| Noyo River | Noyo River | CC | Nielsen et al. 1991 |
| | SF Noyo River | LIT | Nielsen et al. 1991 |
| SF Noyo River | Kass Creek | LIT | Nielsen et al. 1991 |
| SF Noyo River | NF SF Noyo River | CC | Nielsen et al. 1991 |
| SF Noyo River | Parlin Creek | CC | Nielsen et al. 1991 |
| | Little NF Noyo R. | SS | Burns 1971 |
| | Duffy Gulch | LIT | Hassler 1988 |
| | NF Noyo River | LIT | Hassler 1988 |
| NF Noyo River | Marble Gulch | LIT | Hassler 1988 |
| NF Noyo River | Haysworth Creek | LIT | Hassler 1988 |
| NF Noyo River | MF NF Noyo River | LIT | Hassler 1988 |
| | Olds Creek | LIT | Hassler 1988 |
| | Redwood Creek | LIT | Hassler 1988 |
| Hare Creek | Hare Creek | | |
| | SF Hare Creek | LIT | Hassler 1988 |
| | Bunker Gulch Creek | LIT | Hassler 1988 |
| Coastal | Jug Handle Creek | SS | T. Taylor, unpubl. data* |
| Caspar Creek | SF Caspar Creek | CC | Nielsen et al. 1991 |
| | NF Caspar Creek | SS | Nielsen et al. 1991 |
| Coastal | Doyle Creek | LIT | Hassler 1988 |
| Coastal | Russian Gulch | OT | Bartley et al. 1991 |
| Big River | Big River | OT | Sommerstrom 1984 |
| | Little NF Big River | LIT | Hassler 1988 |
| Little NF Big River | EB Little NF Big R | LIT | Hassler 1988 |
| Little NF Big River | Berry Gulch | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| | Tramway Gulch | LIT | Hassler 1988 |
| | NF Big River | LIT | Hassler 1988 |
| NF Big River | EB NF Big River | LIT | Hassler 1988 |
| NF Big River | Chamberlain Creek | LIT | Hassler 1988 |
| Chamberlain Creek | Arvola Gulch | LIT | Hassler 1988 |
| NF Big River | James Creek | LIT | Hassler 1988 |
| James Creek | NF James Creek | LIT | Hassler 1988 |
| | SF Big River | LIT | Hassler 1988 |
| SF Big River | Ramon Creek | CC | Nielsen et al. 1991 |
| SF Big River | Daugherty Creek | LIT | Hassler 1988 |
| Daugherty Creek | Johnson Creek | LIT | Hassler 1988 |
| Coastal | Little River | LIT | Hassler 1988 |
| Coastal | Buckhorn Creek | LIT | Hassler 1988 |
| Albion River | Albion River | OT | Sommerstrom 1984 |
| | SF Albion River | LIT | Hassler 1988 |
| | Railroad Gulch | LIT | Hassler 1988 |
| | NF Albion River | LIT | Hassler 1988 |
| | Marsh Creek | LIT | Hassler 1988 |
| Big Salmon Creek | Big Salmon Creek | LIT | Hassler 1988 |
| | Little Salmon Cr. | LIT | Hassler 1988 |
| | Hazel Gulch | LIT | Hassler 1988 |
| Navarro River | Navarro River | LIT | Hassler 1988 |
| | NF Navarro River | LIT | Hassler 1988 |
| NF Navarro River | NF Flynn Creek | LIT | Hassler 1988 |
| NF Navarro River | SB NF Navarro R | LIT | Hassler 1988 |
| SB NF Navarro R | Bridge Creek | LIT | Hassler 1988 |
| NF Navarro River | NB NF Navarro R | LIT | Hassler 1988 |
| NB NF Navarro R | Little NF Navarro | LIT | Hassler 1988 |
| NB NF Navarro R | John Smith Creek | LIT | Hassler 1988 |
| | Mill Creek | LIT | Hassler 1988 |
| | Indian Creek | LIT | Hassler 1988 |
| Indian Creek | NF Indian Creek | LIT | Hassler 1988 |
| Indian Creek | Gut Creek | LIT | Hassler 1988 |
| Indian creek | Dick creek | LIT | Hassler 1988 |
| | Rancheria Creek | FR | Kimsey 1953 |
| Rancheria Creek | Ham Canyon Creek | LIT | Hassler 1988 |
| Rancheria Creek | Horse Creek | LIT | Hassler 1988 |
| Rancheria Creek | Minnie Creek | LIT | Hassler 1988 |
| Rancheria Creek | Camp Creek | LIT | Hassler 1988 |
| Camp Creek | German Creek | LIT | Hassler 1988 |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| Coastal | Greenwood Creek | LIT | Hassler 1988 |
| Coastal | Mallo Pass Creek | LIT | Hassler 1988 |
| Elk Creek | Elk Creek | LIT | Hassler 1988 |
| | Three Springs Cr. | LIT | Hassler 1988 |
| | Soda Fork | LIT | Hassler 1988 |
| | Sulphur Fork | LIT | Hassler 1988 |
| Coastal | Brush Creek | OT | R. Snyder pers. comm. cited in Snider (1985) |
| Coastal | Garcia River | SS | Pister 1965 |
| Schooner Gulch | Schooner Gulch | LIT | Hassler 1988 |
| | NF Schooner Gulch | LIT | Hassler 1988 |
| Coastal | Fish Rock Gulch | LIT | Hassler 1988 |
| Coastal | Gualala | SS | Pister 1965 |
| Gualala River | NF Gualala River | OT | Sommerstrom 1984 |
| NF Gualala River | Doty Creek | LIT | Hassler 1988 |
| Gualala River | SF Gualala River | LIT | Hassler 1988 |
| SF Gualala River | Franchini Creek | LIT | Hassler 1988 |
| SF Gualala River | Sproule Creek | LIT | Hassler 1988 |
| SF Gualala River | Marshall Creek | LIT | Hassler 1988 |
| Gualala River | Wheatfield Fork | LIT | Hassler 1988 |
| Wheatfield Fork | Fuller Creek | SS | P. Baker, pers. comm.* |
| Wheatfield Fork | Haupt Creek | SS | P. Baker, pers. comm.* |
| Wheatfield Fork | House Creek | LIT | Hassler 1988 |
| Coastal | Fort Ross Creek | SS | P. Baker, pers. comm.* |
| Coastal | Russian Gulch | LIT | Hassler 1988 |
| Russian Gulch | Middle Branch | LIT | Hassler 1988 |
| Russian Gulch | East Branch | LIT | Hassler 1988 |
| Russian River | Russian River | LIT | Hassler 1988 |
| | Willow Creek | SS | B. Cox, pers. comm. |
| | Sheephouse Creek | LIT | Hassler 1988 |
| Sheephouse Creek | unnamed trib | LIT | Hassler 1988 |
| | Freezeout Creek | LIT | Hassler 1988 |
| | Austin Creek | LIT | Hassler 1988 |
| Austin Creek | Kidd Creek | LIT | Hassler 1988 |
| Austin Creek | Ward Creek | SS | P. Baker, pers. comm.* |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| East Austin Creek | Gilliam Creek | SS | B. Cox, pers. comm. |
| East Austin Creek | Gray Creek | SS | p. Baker, pers. comm.* |
| | Dutch Bill Creek | FR | Kimsey 1953 |
| | Hulbert Creek | FR | Kimsey 1953 |
| | Mark West Creek | SS | B. Cox, pers. comm.* |
| | Dry Creek | FR | Kimsey 1952 |
| Dry Creek | Mill Creek | FR | Kimsey 1953 |
| Mill Creek | Wallace Creek | FR | Kimsey 1953 |
| Dry Creek | Pena Creek | FR | Kimsey 1953 |
| Dry Creek | Warm Springs Creek | OT | B. Cox, pers. comm. |
| | EF Russian River - | LIT | Hassler 1988 |
| | WF Russian River | LIT | Hassler 1988 |
| WF Russian River | York Creek | LIT | Hassler 1988 |
| WF Russian River | Forsythe Creek | SS | W. Jones, pers. comm. |
| Forsythe Creek | Mill Creek | SS | W. Jones, pers. comm. |
| Forsythe Creek | Seward Creek | SS | W. Jones, pers. comm. |
| Seward Creek | Eldridge Creek | SS | W. Jones, pers. comm. |
| Seward Creek | Jack Smith Creek | SS | W. Jones, pers. comm. |
| WF Russian River | Salt Hollow Creek | LIT | Hassler 1988 |
| WF Russian River | Rocky Creek | LIT | Hassler 1988 |
| WF Russian River | Mariposa Creek | LIT | Hassler 1988 |
| WF Russian River | Fisher Creek | LIT | Hassler 1988 |
| WF Russian River | Corral Creek | LIT | Hassler 1988 |
| Coastal | Scotty Creek | LIT | Hassler 1988 |
| Salmon Creek | Salmon Creek | SS | B. Cox, pers. comm. |
| | Finley Creek | SS | P. Baker, pers. comm.* |
| | Coleman Creek | SS | P. Baker, pers. comm.* |
| | Fay Creek | SS | P. Baker, pers. comm.* |
| | Tannery Creek | LIT | Hassler 1988 |
| Walker Creek | Walker Creek | SS | Emig 1984 |
| | Salmon Creek | LIT | Hassler 1988 |
| | Arroyo Sausal Cr | LIT | Hassler 1988 |
| Lagunitas Creek | Lagunitas Creek | SS | Emig 1985 |
| | Olema Creek | SS | B. Cox, pers. comm. |
| | Nicasio Creek | LIT | Hassler 1988 |
| | Devil's Gulch Cr. | SS | Emig 1985 |
| | San Geronimo Cr. | SS | Emig 1985 |
| Bolinas Lagoon | Pine Gulch Creek | SS | B. Cox, pers. comm. |
| Coastal | Redwood Creek | SS | B. Cox, pers. comm. |

Table 1. continued

| Drainage | Stream | Method | Source |
|---|---|---|---|
| San Francisco Bay tributaries | Alameda Creek | OT | John Hopkirk, pers. comm. cited in Leidy 1984 |
| | San Pablo Creek | OT | letter to Paul Needham from Willis Evans cited in Leidy 1984 |
| | Walnut Creek | OT | Leidy 1983 |
| | San Anselmo Creek | OT | Fry 1936 |
| | Corte Madera Creek | OT | Leidy 1984 |
| | Mill Valley Creek | OT | Leidy 1984 |
| Sacramento River | Sacramento River | OT | Fry 1973 |
| | Feather River | OT | Painter et al. 1977 |
| Coastal | San Gregorio Creek | SS | L. Ulmer, pers. comm.* |
| Coastal | Pescadero Creek | SS | L. Ulmer, pers. comm.* |
| Coastal | Butano Creek | LIT | Hassler 1988 |
| Coastal | Gazos Creek | LIT | Hassler 1988 |
| Coastal | Waddell Creek | SS | L. Ulmer, pers. comm.* |
| Coastal | Scott Creek | AT | D. Strieg, pers. comm. |
| Scott Creek | Big Creek | AT | D. Strieg, pers. comm. |
| Coastal | San Vicente Creek | LIT | Hassler 1988 |
| San Lorenzo River | San Lorenzo River | OT | Johansen 1975 |
| | Hare Creek | LIT | Hassler 1988 |
| Coastal | Soquel Creek | LIT | Hassler 1988 |
| Coastal | Aptos Creek | LIT | Hassler 1988 |
| Coastal | Carmel River | LIT | Hassler 1988 |
| Coastal | Big Sur River | LIT | Hassler 1988 |

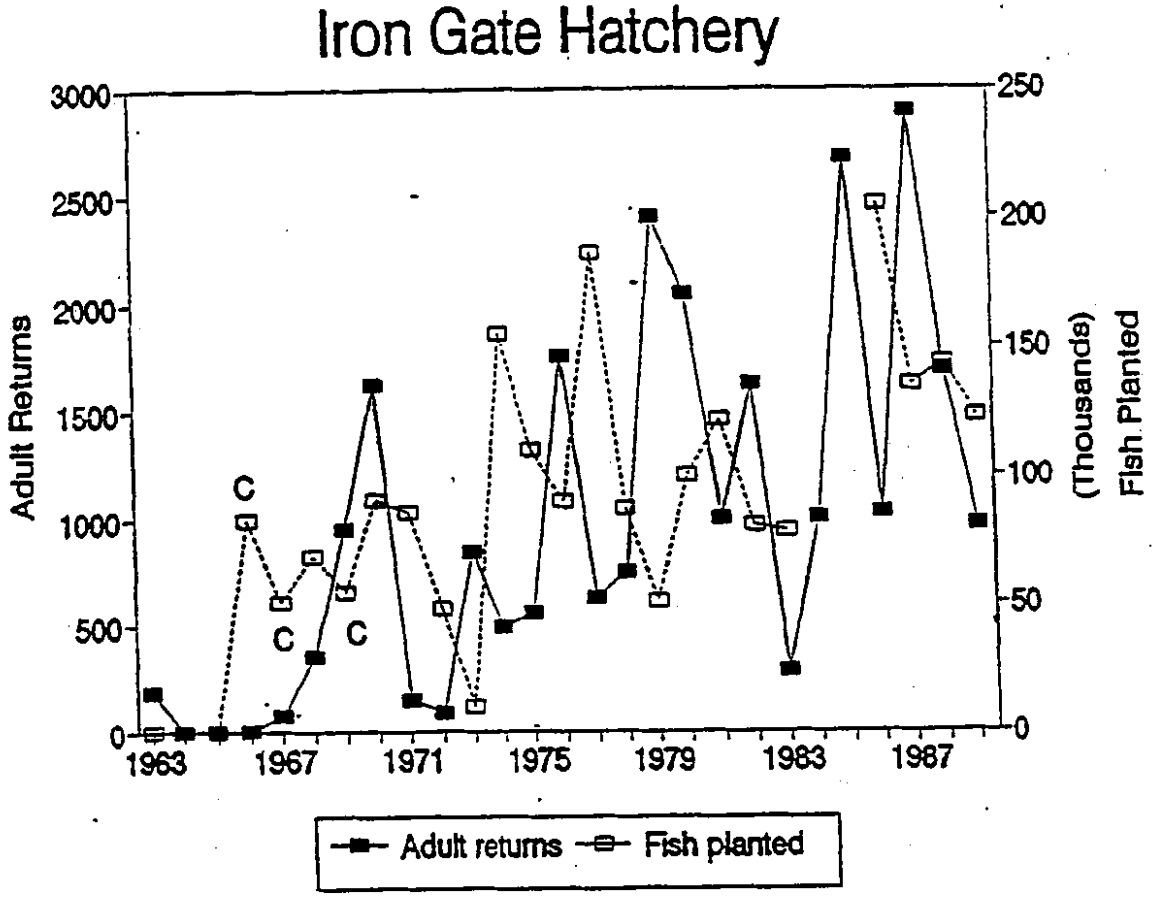


Figure 1. Adult returns to Iron Gate Hatchery (Klamath River) and number of coho salmon planted each year. Data are from published hatchery records. Letters associated with values of fish planted indicate the introduction of exotic stocks (C = Cascade River, Oregon).

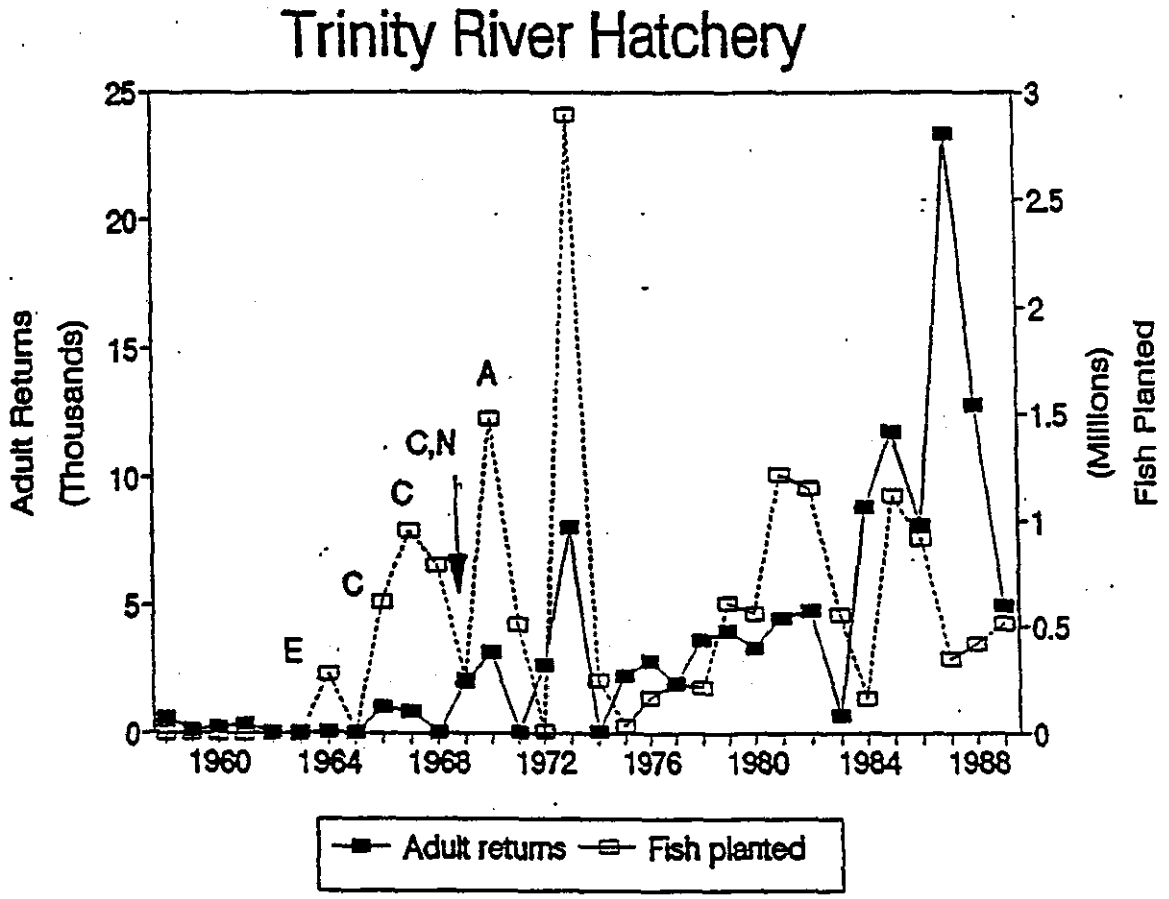


Figure 2. Adult returns to Trinity River Hatchery and number of coho salmon planted each year. Data are from published hatchery records. Letters associated with values of fish planted indicate the introduction of exotic stocks (E = Eel River, California, C = Cascade River, Oregon, N = Noyo River, California, A = Alsea River, Oregon).

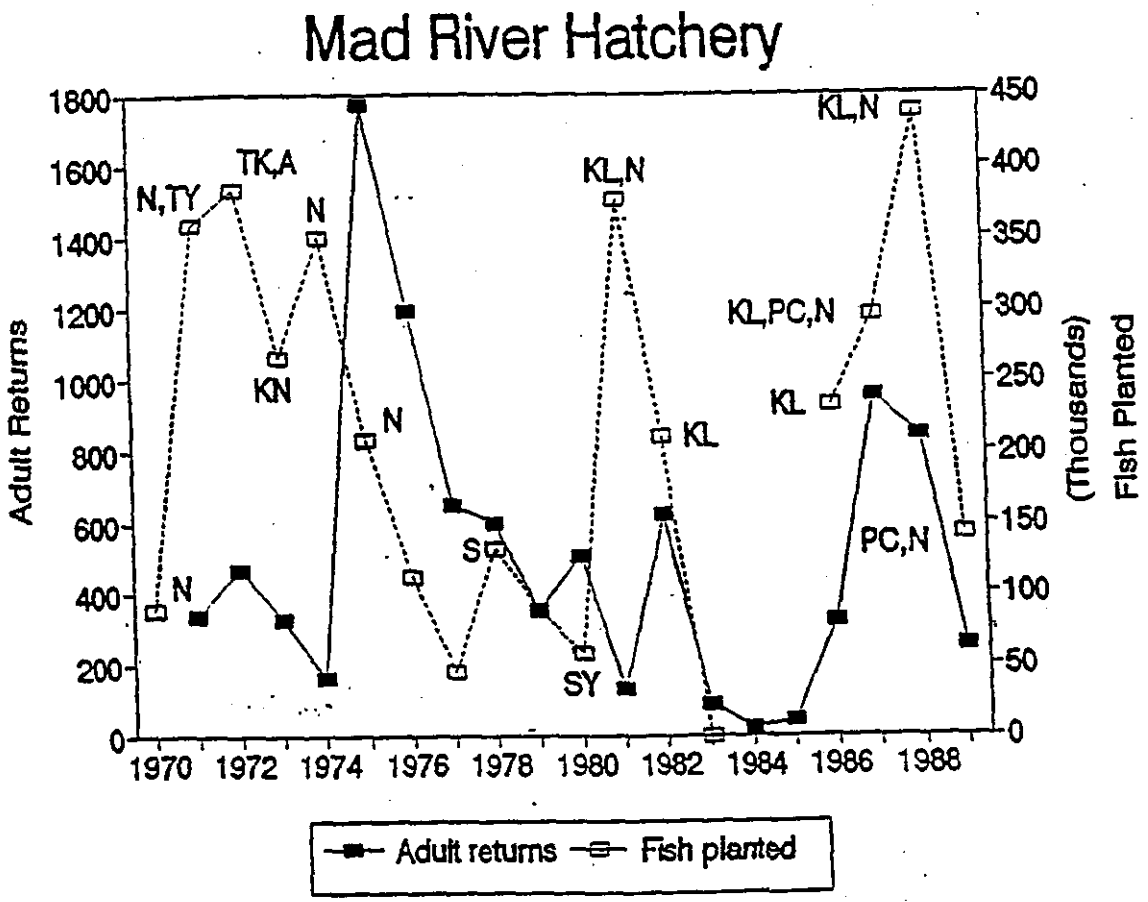


Figure 3. Adult returns to Mad River Hatchery and number of coho salmon planted each year. Data are from published hatchery records. Letters associated with values of fish planted indicate the introduction of exotic stocks (N = Noyo River, California, TY = Trinity River Hatchery, California, TK = Trask River, Oregon, A = Alsea River, Oregon, KN = Klaskanine River, Oregon, S = Soos River, Oregon, SY = Sandy River, Oregon, KL = Iron Gate Hatchery, California, PC = Prairie Creek, California).

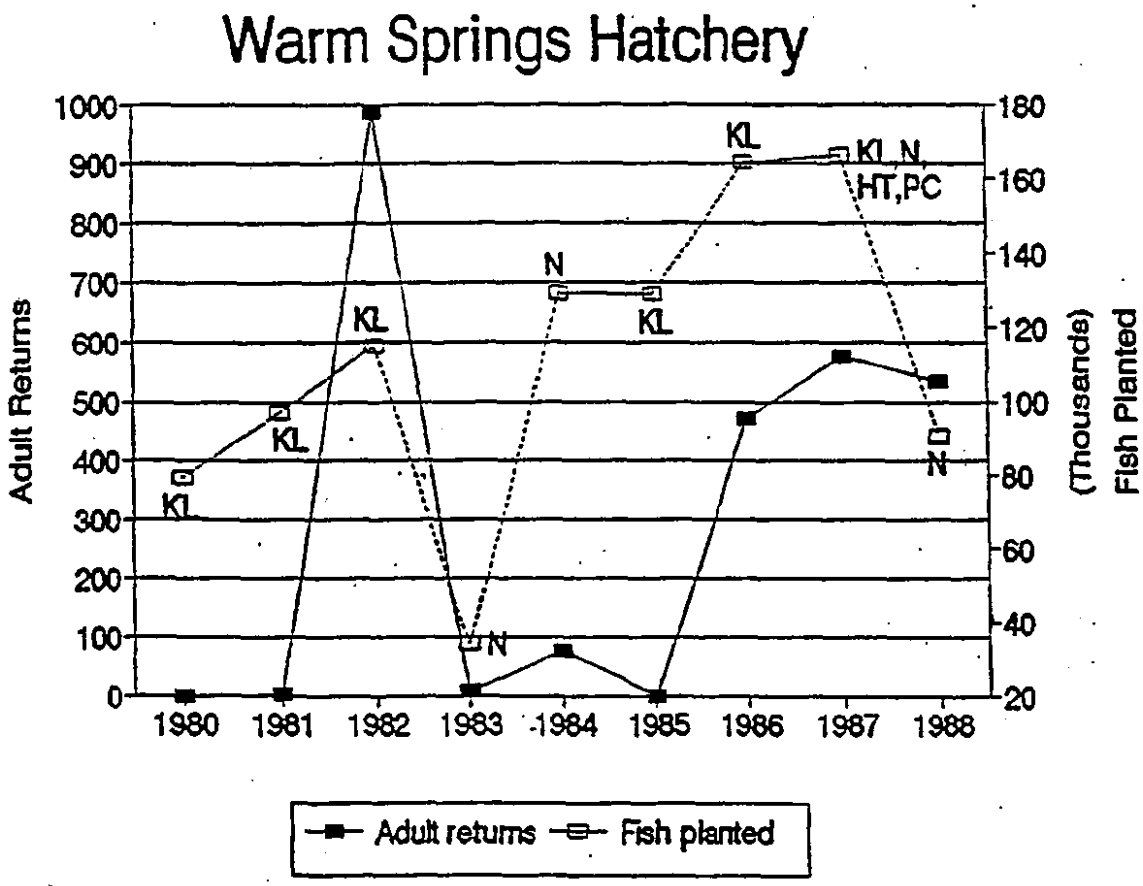


Figure 4. Adult returns to Warm Springs Hatchery (Russian River) and number of coho salmon planted each year. Data are from published hatchery records. Letters associated with values of fish planted indicate the introduction of exotic stocks (KL = Iron Gate Hatchery, California, N = Noyo River, California, HT = Hollowtree Creek, California, PC = Prairie Creek, California).

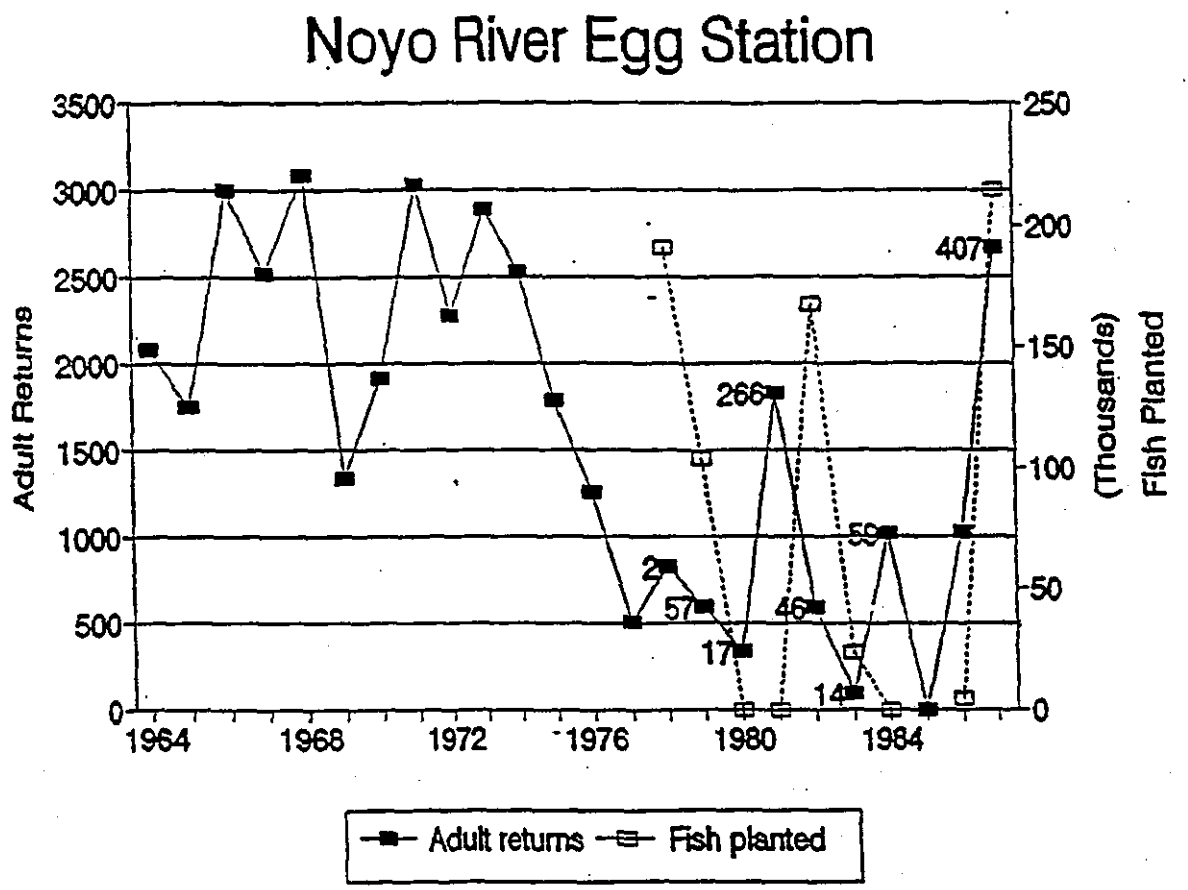


Figure 5. Adult returns to the Noyo River Egg Taking Station (South Fork Noyo River). Number of coho salmon planted are presented for some years. Numbers next to values for adult returns indicate the number of adults passed over the weir to spawn naturally in the upstream area. Data are from published records.

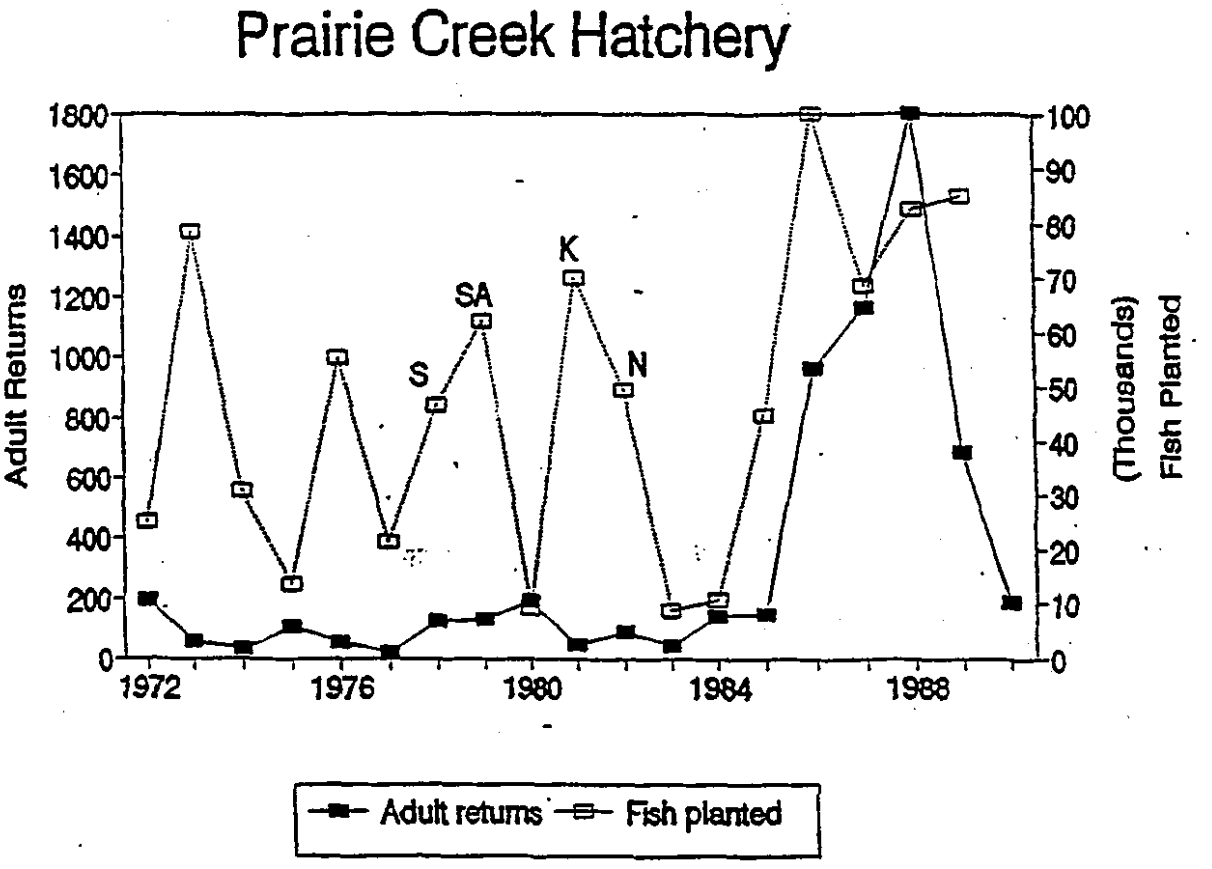


Figure 6. Adult returns to Prairie Creek Hatchery (Prairie Creek is tributary to Redwood Creek) and number of coho salmon planted each year. Data were supplied by S. Sanders. Letters associated with values of fish planted indicate the introduction of exotic stocks (S = Soos, River, Oregon, SY = Sandy River, Oregon, K = Iron Gate Hatchery, California, N = Noyo River, Oregon.

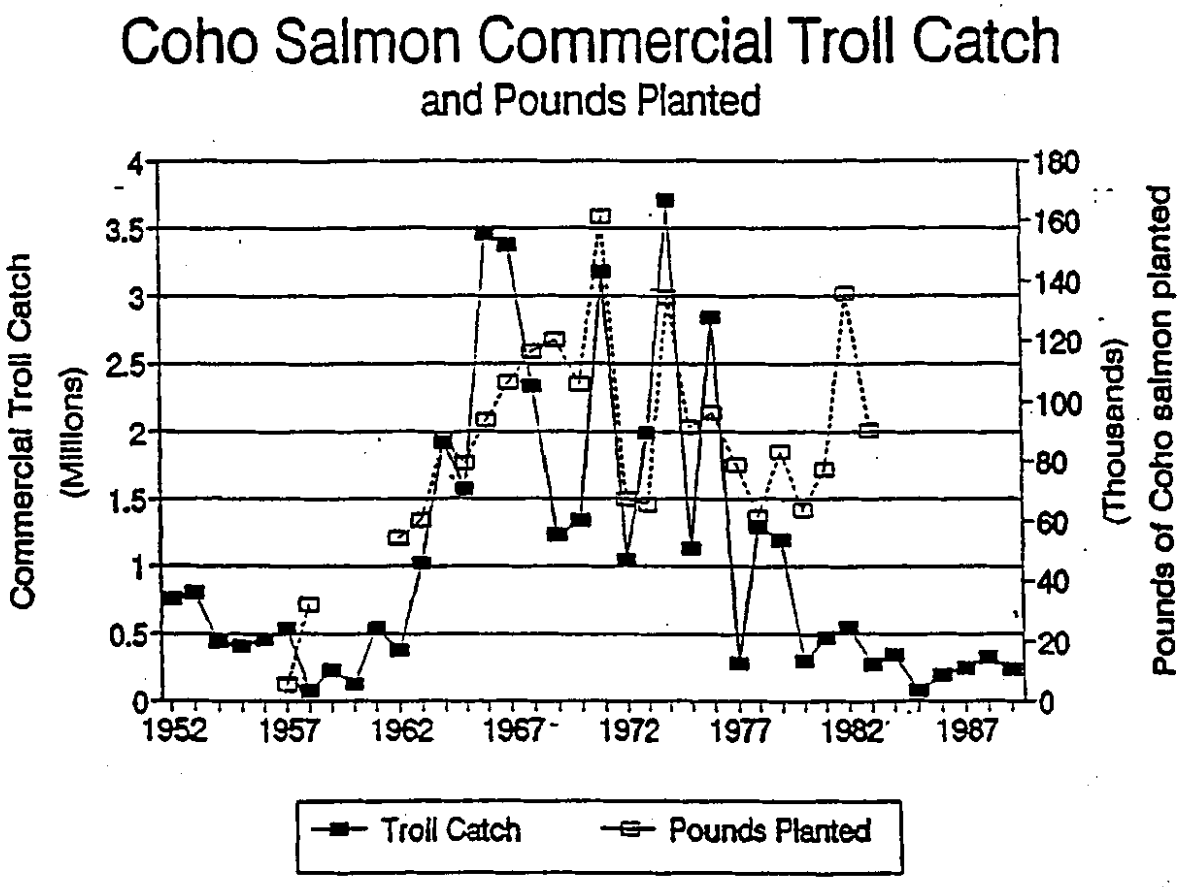


Figure 7. Number of coho salmon caught in the commercial troll catch (published and unpublished records of the California Department of Fish and Game) and pounds of coho salmon planted (data from published hatchery production records) each year.

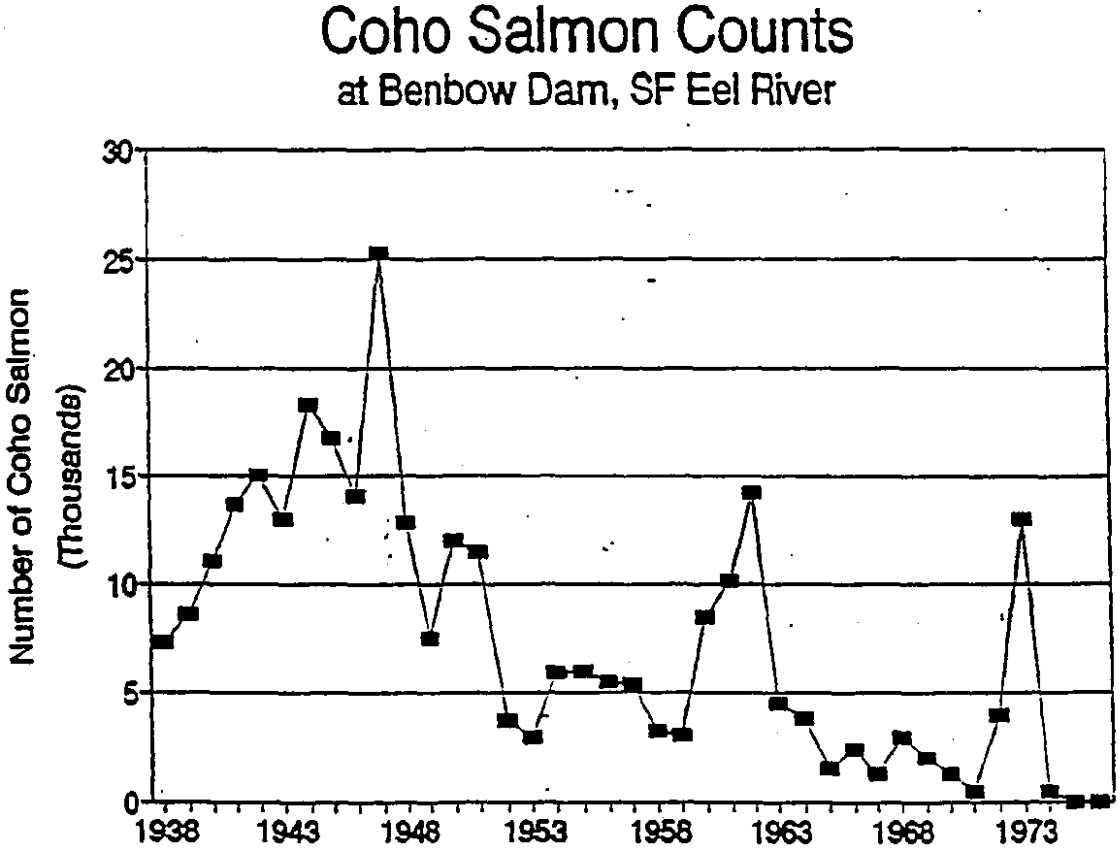


Figure 8. Number of coho salmon passing over Benbow Dam, South Fork Eel River. Data are from Murphy (1952) and unpublished counts by California Department of Fish and Game presented in Frederickson, Kamine and Associates, Inc. (1980).

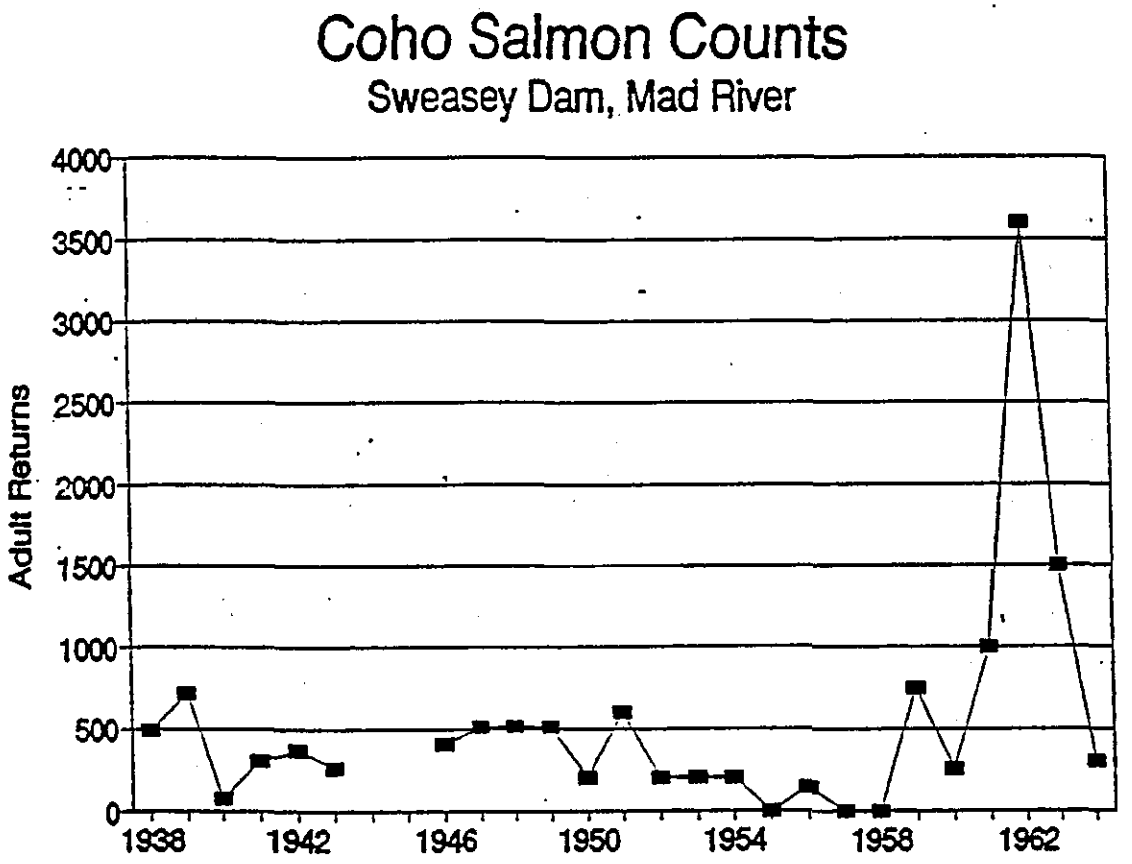


Figure 9. Number of coho salmon passing over Sweasey Dam (Mad River). Data are from Murphy and Shapovalov (1952) and unpublished counts by California Department of Fish and Game presented in Frederickson, Kamine and Associates, Inc. (1980).

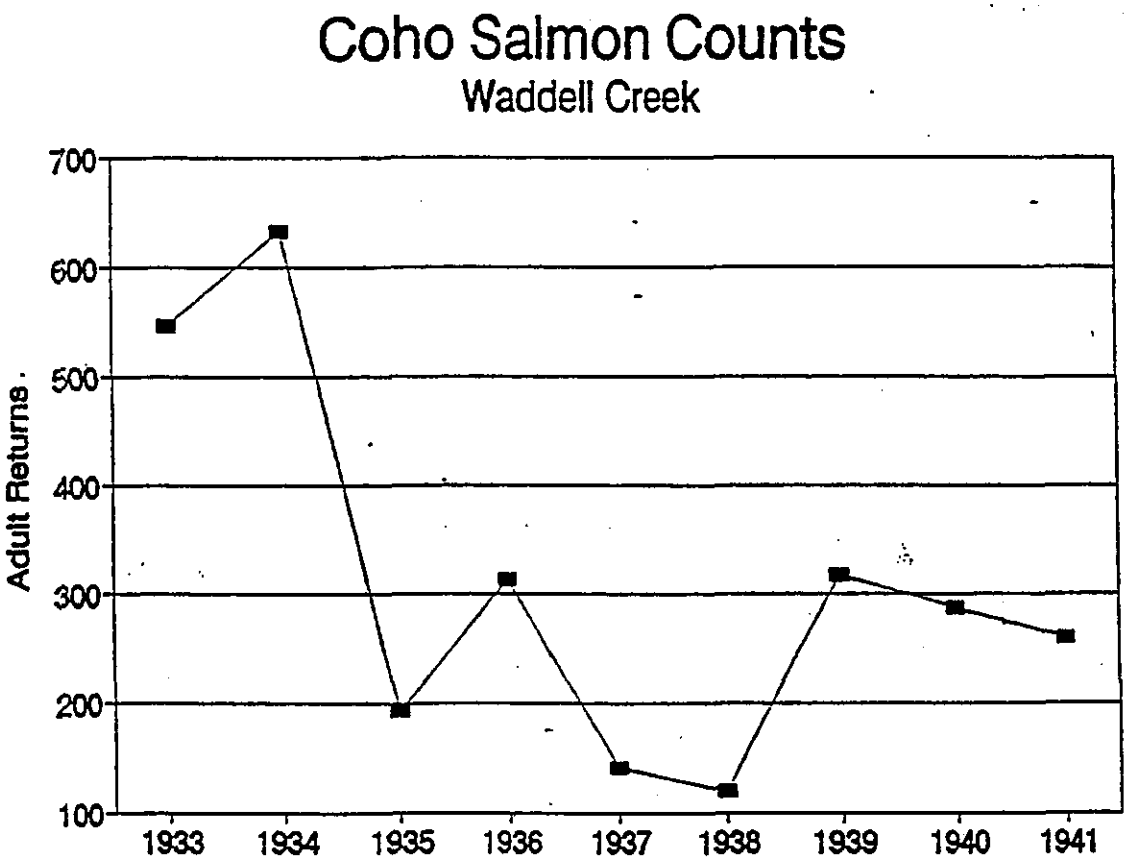


Figure 10. Coho salmon counts in Waddell Creek. Numbers include fish passed through the weir, fish leaping over the weir, and fish spawning downstream of the weir. Data are from Shapovalov and Taft (1954).

Appendix. Number of fish seen during surveys of some of the streams historically known to produce coho salmon, type of evidence (SS = stream survey), and source. Refer to Table 1 for a complete list of streams supporting coho salmon. Numbers of fish seen in other streams are discussed in the text. Negative evidence (lack of fish) was only included when it was known that coho salmon used the stream at some time. Hatchery returns are not included. BR in source column indicates Bureau of Reclamation.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| SF Winchuck River | SF Winchuck River | 11000 juveniles rescues | 1939 | Shapovalov 1940 |
| SF Winchuck River | SF Winchuck River | 3170 juveniles rescued | 1940 | Shapovalov 1941 |
| Smith River | Morrison Creek | 210 juveniles rescued | 1952 | Kinsey 1953 |
| | Rowdy Creek | 56694 juveniles rescued | 1939 | Shapovalov 1940 |
| | Rowdy Creek | 18555 juveniles rescued | 1940 | Shapovalov 1941 |
| | Rowdy Creek | 6645 juveniles rescued | 1941 | Shapovalov 1942 |
| | Rowdy Creek | 20099 juveniles rescued | 1944 | Shapovalov 1945b |
| | Rowdy Creek | 2934 juveniles rescued | 1945 | Shapovalov 1949 |
| | Rowdy Creek | 10358 juvenile rescued | 1950 | Murphy 1951 |
| | Rowdy Creek | 2875 juveniles rescued | 1952 | Kinsey 1953 |
| | Jaqua Creek | 25 juveniles seined | 1951 | Hallock et al. 1952 |
| | Mill Creek | 60602 juveniles seined | 1951 | Hallock et al. 1952 |
| Mill Creek | Bummer Lake Cr. | est. 1.12 kg in 1.5 km | 1967 | Burns 1971 |
| Coastal | Jordan Creek | 200 juveniles seined | 1951 | Hallock et al. 1952 |
| Coastal | Wilson Creek | 3386 juveniles rescued | 1939 | Shapovalov 1940 |
| | Wilson Creek | 41507 juveniles rescued | 1940 | Shapovalov 1941 |
| | Wilson Creek | 1077 juveniles rescued | 1941 | Shapovalov 1942 |
| | Wilson Creek | 7910 juveniles rescued | 1942 | Shapovalov 1944 |
| | Wilson Creek | 4564 juveniles rescued | 1943 | Shapovalov 1945 |
| | Wilson Creek | 5294 juveniles rescued | 1944 | Shapovalov 1945b |
| | Wilson Creek | 8835 juveniles rescued | 1950 | Murphy 1951 |
| | Wilson Creek | 1957 juveniles rescued | 1951 | Kinsey 1952 |
| | Wilson Creek | 11364 juveniles seined | 1951 | Hallock et al. 1952 |
| | Wilson Creek | 28999 juveniles rescued | 1952 | Kinsey 1953 |
| Klamath River | estuary | creel census estimate of 1145 fish in sport catch | 1955 | Gibbs and Kinsey 1955 |
| | estuary | creel census estimate of 4000 fish in sport catch | 1954 | McCormick 1958 |
| | side channel | 690 juveniles rescued | 1941 | Shapovalov 1942 |
| | Hunter Creek | 901 juveniles rescued | 1939 | Shapovalov 1940 |
| | Hunter Creek | 25226 juveniles rescued | 1940 | Shapovalov 1941 |
| | Hunter Creek | 152 juveniles rescued | 1941 | Shapovalov 1942 |
| | Hunter Creek | 7372 juveniles rescued | 1942 | Shapovalov 1944 |
| | Hunter Creek | 5153 juveniles rescued | 1943 | Shapovalov 1945 |
| | Hunter Creek | 7288 juveniles rescued | 1944 | Shapovalov 1945b |
| | Hunter Creek | 4896 juveniles rescued | 1950 | Murphy 1951 |
| | Hunter Creek | 1910 juveniles rescued | 1951 | Kinsey 1952 |
| | Hunter Creek | 535 juveniles seined | 1951 | Hallock et al. 1952 |
| | Hunter Creek | 5641 juveniles rescued | 1952 | Kinsey 1953 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Hunter Creek | High Prairie Creek | 380 juveniles rescued | 1950 | Murphy 1951 |
| Hunter Creek | High Prairie Creek | 3537 juveniles seined | 1951 | Hallock et al. 1952 |
| Hunter Creek | High Prairie Creek | 60 juveniles rescued | 1951 | Kinsey 1952 |
| Hunter Creek | High Prairie Creek | 1123 juveniles rescued | 1952 | Kinsey 1953 |
| Hunter Creek | Hynot Creek | 10000 juveniles rescued | 1940 | Shapovalov 1941 |
| Hunter Creek | Hynot Creek | 1274 juveniles rescued | 1952 | Kinsey 1953 |
| | Hoppaw Creek | 60 juveniles rescued | 1939 | Shapovalov 1940 |
| | Hoppaw creek | 140 juveniles rescued | 1940 | Shapovalov 1941 |
| | Hoppaw Creek | 1153 juveniles rescued | 1950 | Murphy 1951 |
| | Hoppaw Creek | 143 juveniles rescued | 1951 | Kinsey 1952 |
| | Hoppaw Creek | 859 juveniles rescued | 1952 | Kinsey 1953 |
| | Turwar Creek | 4100 juveniles rescued | 1939 | Shapovalov 1940 |
| | Turwar creek | 12109 juveniles rescued | 1940 | Shapovalov 1941 |
| | Turwar Creek | 3045 juveniles rescued | 1941 | Shapovalov 1942 |
| | Turwar Creek | 3212 juveniles rescued | 1942 | Shapovalov 1944 |
| | Turwar Creek | 13685 juveniles rescued | 1943 | Shapovalov 1945 |
| | Turwar Creek | 1705 juveniles rescued | 1944 | Shapovalov 1945b |
| | Turwar Creek | 530 juveniles rescued | 1950 | Murphy 1951 |
| | Turwar Creek | 318 juveniles rescued | 1951 | Kinsey 1952 |
| | Turwar Creek | 3050 juveniles seined | 1951 | Hallock et al. 1952 |
| | Turwar Creek | 9064 juveniles rescued | 1952 | Kinsey 1953 |
| | McGarvey Creek | 220 juveniles seined | 1951 | Hallock et al. 1952 |
| | Shasta River | 310 adults counted at counting station | 1958 | Coots 1958 |
| | Shasta River | no adults counted | 1955 | Coots 1957 |
| | Klamathon racks | many caught but the larger king salmon is selected | 1923 | Bryant 1937 |
| | Klamathon racks | none observed in 1956 | 1958 | Coots 1958 |
| | Fall Creek | a small run of coho salmon noted (method unknown) | 1954 | Coots 1957 |
| Redwood Creek | Redwood Creek | noted as present | 1908 | Snyder 1908 |
| | Redwood Creek | 362 juveniles rescued | 1939 | Shapovalov 1940 |
| | Redwood Creek | 170 juveniles rescued | 1950 | Murphy 1951 |
| | Redwood Creek | 385 juveniles rescued | 1952 | Kinsey 1953 |
| | Redwood Creek | known present | 1966 | Fisk et al. 1966 |
| | Redwood Creek | run estimated at 2000 adults | 1973 | BR 1973 |
| | Prairie Creek | 106 juveniles rescued | 1951 | Kinsey 1952 |
| | Prairie Creek | 956 juveniles seined | 1951 | Hallock et al. 1952 |
| Prairie Creek | Little Lost Man Cr. | 240 juveniles rescued | 1950 | Murphy 1951 |
| Prairie Creek | Little Lost Man Cr. | 189 juveniles seined | 1951 | Hallock et al. 1952 |
| Prairie Creek | Lost Man Creek | 1520 juveniles seined | 1951 | Hallock et al. 1952 |
| Prairie Creek | May Creek | 300 juveniles seined | 1951 | Hallock et al. 1952 |
| Prairie Creek | Godwood Creek | est. 1186 in 1.1 km | 1967 | Burns 1971 |
| | | est. 961 in 1.1 km | 1968 | Burns 1971 |
| | | est. 352 in 1.1 km | 1969 | Burns 1971 |
| Prairie Creek | Boyes Creek | 240 juveniles seined | 1951 | Hallock et al. 1952 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Coastal | McDonald Creek | 70 juveniles rescued | 1952 | Kinsey 1953 |
| Coastal | Little River | 813 juveniles seined | 1951 | Hallock et al. 1952 |
| Mad River | Mad River | 15 juveniles rescued | 1951 | Kinsey 1952 |
| | Lindsay Creek | 10663 juveniles seined | 1951 | Hallock et al. 1952 |
| Lindsay Creek | Squaw Creek | 11672 juveniles rescued | 1950 | Murphy 1951 |
| Lindsay Creek | Squaw Creek | 6810 juveniles seined | 1951 | Hallock et al. 1952 |
| Lindsay Creek | Squaw Creek | 1553 juveniles rescued | 1952 | Kinsey 1953 |
| | Grassy Creek | 11203 juveniles seined | 1951 | Hallock et al. 1952 |
| | Noisy Creek | 500 juveniles seined | 1951 | Hallock et al. 1952 |
| | Camp Bauer Creek | 1020 juveniles rescued | 1950 | Murphy 1951 |
| | Camp Bauer Creek | 200 juveniles seined | 1951 | Hallock et al. 1952 |
| | NF Mad River | 6272 juveniles rescued | 1939 | Shapovalov 1940 |
| Coastal | Jacoby Creek | 14243 juveniles seined | 1951 | Hallock et al. 1952 |
| Coastal | Freshwater Creek | 8642 juveniles seined | 1951 | Hallock et al. 1952 |
| Elk River | Elk River | 17671 juveniles seined | 1951 | Hallock et al. 1952 |
| Eel River | below Van Duzen R. | 4 juveniles seined, uncommon in lower river | 1950 | Murphy and DeWitt 1951 |
| | Eel River | 283 juveniles rescued | 1940 | Shapovalov 1941 |
| | Salt River | SS (CDFG files) | ? | Mills 1983 |
| Salt River | Reas Creek | SS (CDFG files) | ? | Mills 1983 |
| | Rohner Creek | SS (CDFG files) | ? | Mills 1983 |
| | Price Creek | 72 juveniles rescued | 1940 | Shapovalov 1941 |
| | Howe Creek | none observed | 12/87 | Flosi, unpublished data |
| | Howe Creek | SS (CDFG files) | ? | Mills 1983 |
| Howe Creek | Atwell Creek | SS (CDFG files) | ? | Mills 1983 |
| | Dinner Creek | 184 juveniles rescued | 1939 | Shapovalov 1940 |
| | Jordan Creek | 354 juveniles rescued | 1939 | Shapovalov 1940 |
| | Jordan creek | 165 juveniles rescued | 1940 | Shapovalov 1941 |
| | Jordan Creek | 500 juveniles seined | 1951 | Hallock et al. 1952 |
| | Jordan Creek | none observed | 12/87 | Flosi, unpublished data |
| Eel River | near Pepperwood | 65 juveniles rescued | 1939 | Shapovalov 1940 |
| | Shively Creek | SS (CDFG files) | ? | Mills 1983 |
| | Bear Creek | 1 live | 12/87 | Flosi, unpublished data |
| | Bear Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| | Bear Creek | SS (CDFG files) | ? | Mills 1983 |
| | Chadd Creek | 500 juveniles seined | 1951 | Hallock et al. 1952 |
| | Chadd Creek | 1 live and 1 carcass | 12/87, 1/88 | Flosi, unpublished data |
| | Chadd Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| | Chadd Creek | none observed | 1/90 | Flosi, unpublished data |
| | Chadd Creek | SS (CDFG files) | ? | Mills 1983 |
| | Larabee Creek | none observed | 1/88 | Flosi, unpublished data |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| | Larabee Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| | Larabee Creek | none observed | 1/90 | Flosi, unpublished data |
| | Larabee Creek | SS (CDFG files) | ? | Mills 1983 |
| Larabee Creek | Carson Creek | 1 live | 1/88 | Flosi, unpublished data |
| Larabee Creek | Carson Creek | none observed | 12/88, 1/90 | Flosi, unpublished data |
| Larabee Creek | Carson Creek | none observed | 1/90 | Flosi, unpublished data |
| | Newman Creek | 1242 juveniles rescued | 1939 | Shapovalov 1940 |
| | Newman Creek | SS (CDFG files) | ? | Mills 1983 |
| Eel River | at Rio Dell | no juveniles trapped | 1967 | Puckett 1976 |
| Eel River | at Holmes | no juveniles trapped | 1967 | Puckett 1976 |
| Eel River | at McCann | no juveniles trapped | 1967-70 | Puckett 1976 |
| Eel River | at Eel Rock | no juveniles trapped | 1967 | Puckett 1976 |
| Eel River | at Fort Seward | no juveniles trapped | 1968 | Puckett 1976 |
| | Jewett Creek | SS (CDFG files) | ? | Mills 1983 |
| Eel River | at Dos Rios | no juveniles trapped | 1968 | Puckett 1976 |
| | Outlet Creek | 1 live and 41 carcasses | 12/87, 1/88 | Flosi, unpublished data |
| | Outlet Creek | 2 carcasses | 12/88, 1/89 | Flosi, unpublished data |
| Outlet Creek | Long Valley Creek | 175 juveniles rescued | 1952 | Kinsey 1953 |
| Outlet Creek | Long Valley Creek | 2 carcasses | 12/87 | Flosi, unpublished data |
| Outlet Creek | Long Valley Creek | 7 carcasses | 12/88, 1/89 | Flosi, unpublished data |
| Outlet Creek | Reeves Canyon Cr. | 3 live and 48 carcasses | 12/87, 1/88 | Flosi, unpublished data |
| Outlet Creek | Reeves Canyon Cr. | none seen | 12/88, 1/89 | Flosi, unpublished data |
| Outlet Creek | Ryan Creek | 6 live and 10 carcasses | 12/87 | Flosi, unpublished data |
| Outlet Creek | Ryan Creek | 2 carcasses | 12/88, 1/89 | Flosi, unpublished data |
| Outlet Creek | Willits Creek | 1 carcass | 12/87 | Flosi, unpublished data |
| Outlet Creek | Willits Creek | 1 carcass | 12/88, 1/89 | Flosi, unpublished data |
| Outlet Creek | Brouddus Creek | 23 live and 1 carcass | 12/87, 2/88 | Flosi, unpublished data |
| Outlet Creek | Brouddus Creek | none observed | 1/89 | Flosi, unpublished data |
| Outlet Creek | Baehl Creek | 5 carcasses | 1/88 | Flosi, unpublished data |
| Outlet Creek | Baechtel Creek | 3 carcasses | 12/87, 2/88 | Flosi, unpublished data |
| Outlet Creek | Baechtel Creek | 4 carcasses | 12/88, 1/89 | |
| | Indian Creek | SS (CDFG files) | ? | Mills 1983 |
| Tonki Creek | Rocktree Creek | SS (CDFG files) | ? | Mills 1983 |
| Tonki Creek | String Creek | SS (CDFG files) | ? | Mills 1983 |
| Tonki Creek | Tarter Creek | SS (CDFG files) | ? | Mills 1983 |
| Van Duzen River | Van Duzen River | 2046 juveniles rescued | 1940 | Shapovalov 1941 |
| (Eel River trib.) | Van Duzen River | 121 juveniles rescued | 1941 | Shapovalov 1942 |
| | Van Duzen River | 343 juveniles rescued | 1952 | Kinsey 1953 |
| | near Carlotta | no juveniles trapped | 1968 | Puckett 1976 |
| | Palmer Creek | 956 juveniles seined | 1951 | Hallock et al. 1952 |
| | Wolverton Gulch | SS (CDFG files) | ? | Mills 1983 |
| | Yager Creek | SS (CDFG files) | ? | Mills 1983 |
| Yager Creek | Cooper Mill Creek | 500 juveniles seined | 1951 | Hallock et al. 1952 |
| Yager Creek | Cooper Mill Creek | none observed | 1/88 | Flosi, unpublished data |
| Yager creek | Cooper Mill Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| Yager Creek | Cooper Mill creek | none observed | 1/90 | Flosi, unpublished data |
| Yager Creek | Wilson Creek | SS (CDFG files) | ? | Mills 1983 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Yager Creek | Lawrence Creek | 1 carcass | 1/88 | Flosi, unpublished data |
| Yager Creek | Lawrence Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| Yager Creek | Lawrence Creek | none observed | 1/90 | Flosi, unpublished data |
| Yager Creek | Lawrence Creek | SS (CDFG files) | ? | Mills 1983 |
| Lawrence Creek | Shaw Creek | 3 live | 12/87, 1/88 | Flosi, unpublished data |
| Lawrence Creek | Shaw Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| Lawrence Creek | Shaw Creek | none observed | 1/90 | Flosi, unpublished data |
| | Cuddeback Creek | 168 juveniles rescued | 1940 | Shapovalov 1941 |
| | Fielder Creek | 2100 juveniles seined | 1951 | Hallock et al. 1952 |
| | Cummings Creek | 612 juveniles rescued | 1940 | Shapovalov 1941 |
| | Cummings Creek | 5455 juveniles rescued | 1950 | Murphy 1951 |
| | Cummings Creek | 2435 juveniles recued | 1951 | Kinsey 1952 |
| | Cummings Creek | 502 juveniles seined | 1951 | Hallock et al. 1952 |
| | Cummings Creek | 14083 juveniles rescued | 1952 | Kinsey 1953 |
| | Cummings Creek | 1 live | 12/87 | Flosi, unpublished data |
| | Cummings Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| | Cummings Creek | none observed | 1/90 | Flosi, unpublished data |
| | Hely Creek | none observed | 12/87 | Flosi, unpublished data |
| | Hely creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| | Hely Creek | none observed | 1/90 | Flosi, unpublished data |
| | Hely Creek | 200 juveniles seined | 1951 | Hallock et al. 1952 |
| | Grizzly Creek | 500 juveniles seined | 1951 | Hallock et al. 1952 |
| | Grizzly Creek | SS (CDFG files) | ? | Mills 1983 |
| South Fork Eel River | SF Eel River | 90 juveniles rescued | 1939 | Shapovalov 1940 |
| | SF Eel River | 950 juveniles rescued | 1940 | Shapovalov 1941 |
| | SF Eel River | 22 juveniles rescued | 1941 | Shapovalov 1942 |
| | SF Eel River | 7 live and 75 carcasses | 1/88 | Flosi, unpublished data |
| | SF Eel River | 15 carcasses | 12/88, 1/89 | Flosi, unpublished data |
| | Bull Creek | 4844 juveniles rescued | 1939 | Shapovalov 1940 |
| | Bull Creek | 3000 juveniles seined | 1951 | Hallock et al. 1952 |
| | Bull Creek | 2 carcasses | 12/87, 1/88 | Flosi, unpublished data |
| | Bull Creek | 38 juveniles trapped | 1988 | Downie, unpublished data |
| | Bull Creek | none observed | 12/88 | Flosi, unpublished data |
| | Bull Creek | none observed | 1/90 | Flosi, unpublished data |
| | Bull Creek | SS (CDFG files) | ? | Mills 1983 |
| Bull Creek | Squaw Creek | 1 live | 12/87, 1/88 | Flosi, unpublished data |
| Bull Creek | Squaw Creek | none observed | 12/88, 1/89 | Flosi, unpublished data |
| Bull Creek | Squaw Creek | none observed | 1/90 | Flosi, unpublished data |
| | Canoe Creek | none observed | 1/88 | Flosi, unpublished data |
| | Bridges Creek | 200 juveniles rescued | 1940 | Shapovalov 1941 |
| | Elk Creek | 346 juveniles rescued | 1939 | Shapovalov 1940 |
| | Elk Creek | none observed | 12/87 | Flosi, unpublished data |
| | Elk Creek | none observed | 12/88 | Flosi, unpublished data |
| | Elk Creek | none observed | 1/90, 2/90 | Flosi, unpublished data |
| | Salmon Creek | 492 juveniles rescued | 1939 | Shapovalov 1940 |
| | Bear Butte Creek | 196 juveniles rescued | 1939 | Shapovalov 1940 |
| | Bear Butte Creek | SS (CDFG files) | ? | Mills 1983 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| | Fish Creek | 773 juveniles rescued | 1939 | Shapovalov 1940 |
| | Fish Creek | SS (CDFG files) | ? | Mills 1983 |
| | Anderson Creek | 2 carcasses | 1/1988 | Flosi, unpublished data |
| | Anderson Creek | none observed 12/88, 1/89, 1/90 | | Flosi, unpublished data |
| | Dean Creek | 1250 juveniles rescued | 1939 | Shapovalov 1940 |
| | Redwood Creek MG | SS (CDFG files) | ? | Mills 1983 |
| | Redwood Creek | 87 juveniles rescued | 1939 | Shapovalov 1940 |
| | Redwood Creek | 211 juveniles trapped | 1966 | Puckett 1976 |
| | Redwood Creek | 133 juveniles trapped | 1988 | Downie, unpublished data |
| Redwood Cr. | Seely Creek | SS (CDFG files) | ? | Mills 1983 |
| Redwood Cr. | Miller Creek | SS (CDFG files) | ? | Mills 1983 |
| Redwood Cr. | China Creek | SS (CDFG files) | ? | Mills 1983 |
| Redwood Cr. | Dinner Creek | SS (CDFG files) | ? | Mills 1983 |
| | Sprowel Creek | none observed 12/88, 1/89 | | Flosi, unpublished data |
| | Sprowel Creek | SS (CDFG files) | ? | Mills 1983 |
| | EB SF Eel River | 1 juvenile trapped | 1988 | Downie, unpublished data |
| | EB SF Eel River | 14 juveniles trapped | 1966 | Puckett 1976 |
| EB SF Eel River | Squaw Creek | SS (CDFG files) | ? | Mills 1983 |
| | Durphy Creek | 100 juveniles rescued | 1940 | Shapovalov 1941 |
| | Durphy Creek | none observed | 12/87 | Flosi, unpublished data |
| | Durphy Creek | SS (CDFG files) | ? | Mills 1983 |
| | Milk Ranch Creek | SS (CDFG files) | ? | Mills 1983 |
| | Low Gap Creek | none observed 12/88, 1/89 | | Flosi, unpublished data |
| | Low Gap creek | none observed | 1/90 | Flosi, unpublished data |
| | Low Gap Creek | SS (CDFG files) | ? | Mills 1983 |
| | Indian Creek | 3 live and 11 carcasses | 1/88 | Flosi, unpublished data |
| | Indian Creek | 1 carcass 12/88, 1/89 | | Flosi, unpublished data |
| | Indian Creek | none observed | 1/90 | Flosi, unpublished data |
| | Standley Creek | none observed | 1/88 | Flosi, unpublished data |
| | Standley Creek | none observed | 1/90 | Flosi, unpublished data |
| | Standley Creek | SS (CDFG files) | ? | Mills 1983 |
| | McCoy Creek | none observed | 1/88 | Flosi, unpublished data |
| | McCoy Creek | SS (CDFG files) | ? | Mills 1983 |
| | Bear Pen Creek | none observed | 2/88 | Flosi, unpublished data |
| | Bear Pen Creek | none observed | 1/90 | Flosi, unpublished data |
| | Bear Pen Creek | SS (CDFG files) | ? | Mills 1983 |
| Bear Pen Cr. | Cub Creek | SS (CDFG files) | ? | Mills 1983 |
| | Red Mountain Creek | SS (CDFG files) | ? | Mills 1983 |
| | Red Mountain Creek | none observed | 1/88 | Flosi, unpublished data |
| | Wildcat Creek | none observed | 1/88 | Flosi, unpublished data |
| | Wildcat Creek | none observed | 1/90 | Flosi, unpublished data |
| | Wildcat Creek | SS (CDFG files) | ? | Mills 1983 |
| | Hollowtree Creek | 3 live and 16 carcasses | 12/87 | Flosi, unpublished data |
| | Hollowtree Creek | 12 live and 11 carcasses 12/88, 1/89 | | Flosi, unpublished data |
| | Hollowtree Creek | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Mule Creek | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Redwood Creek | 20 live and 5 carcasses 12/87, 1/88 | | Flosi, unpublished data |
| Hollowtree Cr. | Redwood Creek | 1 live and 1 carcass | 12/88 | Flosi, unpublished data |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Hollowtree Cr. | Redwood Creek[NP] | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Michaels Creek | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Waldron Creek | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Huckleberry Creek | SS (CDFG files) | ? | Mills 1983 |
| Hollowtree Cr. | Butler Creek | SS (CDFG files) | ? | Mills 1983 |
| | Rattlesnake Creek | none observed | 12/87 | Plosi, unpublished data |
| | Rattlesnake Creek | SS (CDFG files) | ? | Mills 1983 |
| Rattlesnake Cr. | Cummings Creek | SS (CDFG files) | ? | Mills 1983 |
| | Ten Mile Creek | 3475 juveniles rescued | 1951 | Kimsey 1952 |
| | Ten Mile Creek | 4369 juveniles rescued | 1952 | Kimsey 1953 |
| | Ten Mile Creek | 1 live and 3 carcasses | 12/87 | Plosi, unpublished data |
| | Ten Mile Creek | non observed | 12/88, 1/89 | Plosi, unpublished data |
| | Ten Mile Creek | SS (CDFG files) | ? | Mills 1983 |
| | Ten Mile Creek | 21 juveniles trapped | 1966 | Puckett 1976 |
| Ten Mile Creek | Grub Creek | SS (CDFG files) | ? | Mills 1983 |
| Ten Mile Creek | Streeter Creek | 1 carcass | 1/88 | Plosi, unpublished data |
| Ten mile Creek | Streeter Creek | none observed | 12/88, 1/89 | Plosi, unpublished data |
| Ten Mile Creek | Streeter Creek | SS (CDFG files) | ? | Mills 1983 |
| Ten Mile Creek | Big Rock Creek | SS (CDFG files) | ? | Mills 1983 |
| Ten Mile Creek | Mud Springs Creek | SS (CDFG files) | ? | Mills 1983 |
| Ten Mile Creek | Mill Creek | SS (CDFG files) | ? | Mills 1983 |
| Ten Mile Creek | Cahto Creek | SS (CDFG files) | ? | Mills 1983 |
| | Fox Creek | SS (CDFG files) | ? | Mills 1983 |
| | Jack of Hearts Cr. | 2 carcasses | 1/88 | Plosi, unpublished data |
| | Jack of Hearts Cr. | SS (CDFG files) | ? | Mills 1983 |
| | Deer Creek | SS (CDFG files) | ? | Mills 1983 |
| | Dutch Charlie Creek | 6 carcasses | 1/88 | Plosi, unpublished data |
| | Dutch Charlie Creek | SS (CDFG files) | ? | Mills 1983 |
| | Redwood Creek | 70 carcasses | 1/88 | Plosi, unpublished data |
| | Redwood Creek | 1 live and 2 carcasses | 12/88 | Plosi, unpublished data |
| | Redwood Creek[NL] | SS (CDFG files) | ? | Mills 1983 |
| | Kenny Creek | SS (CDFG files) | ? | Mills 1983 |
| | Rock Creek | SS (CDFG files) | ? | Mills 1983 |
| | Bear Creek | SS (CDFG files) | ? | Mills 1983 |
| | Taylor Creek | SS (CDFG files) | ? | Mills 1983 |
| Middle Fork Eel River at Etsel Flat | | no juveniles trapped | 1959 | Puckett 1976 |
| | Hill Creek | none observed | 1/88 | Plosi, unpublished data |
| | Hill Creek | SS (CDFG files) | ? | Mills 1983 |
| Hill Creek | Grist Creek | none observed | 2/88 | Plosi, unpublished data |
| | Grist Creek | SS (CDFG files) | ? | Mills 1983 |
| | Rattlesnake Creek | SS (CDFG files) | ? | Mills 1983 |
| MF of MF Eel River | Rock Creek | SS (CDFG files) | ? | Mills 1983 |
| North Fork Eel River | Bluff Creek | SS (CDFG files) | ? | Mills 1983 |
| Coastal | Whale Gulch Creek | present | 1984 | Sommerstrom 1984 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Coastal | Indian Creek | 1 juvenile captured | 1948 | Murphy 1950 |
| Coastal | Jackass Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | Usal creek | 3963 fish rescued | 1940 | Shapovalov 1941 |
| | Usal Creek | 60510 fish rescued | 1944 | Shapovalov 1945b |
| | Usal Creek | 61133 fish rescued | 1945 | Shapovalov 1949 |
| | Usal Creek | 11455 juveniles rescued | 1951 | Kimsey 1952 |
| | Usal Creek | 13865 juveniles rescued | 1952 | Kimsey 1953 |
| Coastal | Cottoneva Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | Hardy Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | Juan Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | Howard Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | DeHaven Creek | present | 1948 | Murphy 1950 |
| Coastal | Wages Creek | present | 1984 | Sommerstrom 1984 |
| Coastal | Ten Mile River | run estimated at 6000 adults | 1973 | BR 1973 |
| | Ten Mile River | present | 1984 | Sommerstrom 1984 |
| Coastal | Pudding Creek | present | 1957 | Allen 1958 |
| Noyo River | Noyo River | run estimated at 6000 adults | 1973 | BR 1973 |
| | Noyo River | 1,000's present | 1958 | Holman and Evans 1964 |
| | Little NF Noyo R. | est. 1.26 kg in .4 km | 1967 | Burns 1971 |
| Caspar Creek | SF Caspar Creek | 613 juveniles trapped 1964 | 1964 | Graves and Burns 1970 |
| | | 1770 in 1968 | 1968 | |
| | SF Caspar Creek | est 9.59 kg in 3.1 km | 1967 | Burns 1971 |
| | NF Caspar Creek | est. 313-122 in 2.4 km | 1967 | Burns 1971 |
| | | est. 359-194 in 2.4 km | 1968 | |
| | | est. 1105-2724 in 2.4 km | 1969 | |
| Coastal | Big River | present | 1984 | Sommerstrom 1984 |
| | Big River | run estimated at 6000 adults | 1973 | BR 1973 |
| Coastal | Albion River | present | 1984 | Sommerstrom 1984 |
| Navarro River | Rancheria Creek | 5045 juveniles rescued | 1950 | Murphy 1951 |
| | Rancheria Creek | 51466 juveniles rescued | 1951 | Kimsey 1952 |
| | Rancheria Creek | 1684 juveniles rescued | 1952 | Kimsey 1953 |
| Coastal | Brush Creek | 80 juveniles captured | 1948 | Murphy 1950 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| Coastal | Brush Creek | coho salmon not recorded since 1976 | 1985 | R. Snyder pers. comm. cited in Snider (1985) |
| Coastal | Garcia River | 18 juveniles shocked in 5 sta. | 1966 | Pister 1965 |
| Coastal | Garcia River | known present | 1966 | Fisk et al. 1966 |
| Coastal | Gualala River | 5 juveniles shocked in 3 sta. | 1965 | Pister 1965 |
| | Gualala River | run estimated at 4000 adults | 1973 | BR 1973 |
| Russian River | Dutch Bill Creek | 734 juveniles rescued | 1951 | Kinsey 1952 |
| | Dutch Bill Creek | 16776 juveniles rescued | 1952 | Kinsey 1953 |
| | Hulbert Creek | 1500 juveniles rescued | 1952 | Kinsey 1953 |
| | Dry Creek | 82 juveniles rescued | 1951 | Kinsey 1952 |
| Dry Creek | Mill Creek | 2936 juveniles rescued | 1951 | Kinsey 1952 |
| Dry Creek | Mill Creek | 560 juveniles rescued | 1952 | Kinsey 1953 |
| Mill Creek | Wallace Creek | 290 juveniles rescued | 1953 | Kinsey 1953 |
| Dry Creek | Pena Creek | 6516 juveniles rescued | 1951 | Kinsey 1952 |
| Dry Creek | Pena Creek | 3125 juveniles rescued | 1952 | Kinsey 1953 |
| Coastal | Walker Creek | 5 juveniles shocked in 6 sta. | 1981 | Baig 1984 |
| Coastal | Lagunitas Creek | coho salmon escapements significantly reduced fora historic levels | 1986 | Smith 1986 |
| | Lagunitas Creek | 7 juv. shocked in 12 sta. | 1982 | Baig 1985 |
| | Lagunitas Creek | State record salmon caught | 1959 | Giddings 1959 |
| Lagunitas Creek | Devil's Gulch Cr. | 15 juveniles shocked in 3 sta. | 1982 | Baig 1985 |
| Lagunitas Creek | San Geronimo Cr. | 8 juveniles shocked in 3 sta. | 1982 | Baig 1985 |
| Lagunitas Creek | Olema Creek | none collected | 1982 | Baig 1985 |
| Coastal | Redwood Creek | unknown # juveniles rescued | 1953 | Pintler 1954 |
| San Francisco Bay tributaries | Alameda Creek | known to occur in the late 1930's | 1930's | John Hopkirk, pers. comm. cited in Leidy 1984 |
| | San Pablo Creek | formerly had spawning runs | 1957 | letter to Paul Needham from Willis Evans cited in Leidy 1984 |
| | Walnut Creek | adults sighted during spawning runs (CDFG files) | 1950's-1960's | Leidy 1983 |
| | Walnut Creek | none observed | 1980 | Leidy 1983 |
| | San Anselmo Creek | recorded as present | 1936 | Fry 1936 |
| | Corte Madera Creek | juveniles collected | 1981 | Leidy 1984 |
| | Mill Valley Creek | juveniles collected | 1981 | Leidy 1984 |
| Sacramento River | Sacramento River | museum specimen | 1881 | Jordan and Jouy 1881 |

Appendix. continued.

| Drainage | Stream | Type of evidence | Date | Source |
|---|---|---|---|---|
| | Sacramento River | described as occuring from Sacramento River to Puget Sound and northward, very abundant in summer and fall | 1881 | Jordan and Gilbert 1881 |
| | Sacramento River | seems to be absent from Sacramento-San Joaquin system | 1947 | Shapovalov 1947 |
| | Sacramento River | before 1956 absent except as rare strays | 1973 | Fry 1973 |
| | Fremont weir | 629 adults trapped | 1957 | Van Woert 1958 |
| | Fremont weir | 437 grilse trapped | 1956 | Van Woert 1957 |
| | Feather River | present but may not form a reproducing population | 1956-1975 | Painter et al. 1977 |
| Coastal | Pescadero Creek | 1 juvenile in lagoon | 1985 | Smith 1987 |
| Coastal | Waddell Creek | adult and juvenile counts | 1930-1940 | Shapovalov and Taft 1954 |
| | Waddell Creek | 20% as abundant as steelhead | 1984 | Smith 1987 |
| Coastal | Scott Creek | adult counts | 1936-1939 | Shapovalov and Taft 1954 |
| Coastal | San Lorenzo River | present in electro stations | 1954-1955 | Pintler 1956 |
| | San Lorenzo River | 370 adults estimated caught<br>342 adults estimated caught | 1971<br>1972 | Johansen 1975 |

Table 2. Coho salmon returns and stocking records for Big Creek, Scott Creek and San Lorenzo River. Data are from the unpublished records of the Monterey Bay Salmon and Trout Project.

| Year | Male | Female | Grilse | Total | Number Planted | Strain |
|---|---|---|---|---|---|---|
| Big Creek | | | | | | |
| 1984 | 4 | 0 | 0 | 4 | 428 | Scott/Big Creek |
| 1985 | 1 | 0 | 8 | 9 | none | |
| 1986 | 11 | 22 | 0 | 33 | none | |
| 1987 | 4 | 6 | 0 | 10 | none | |
| 1988 | 10 | 0 | 0 | 10 | none | |
| 1989 | 63 | 35 | 0 | 98 | none | |
| Scott Creek | | | | | | |
| 1987 | - | - | - | - | 2,450 | Scott/Big Creek |
| 1988 | - | - | - | - | 2,756 | Scott/Big Creek |
| 1989 | - | - | - | - | 6,552 | Scott/Big Creek |
| San Lorenzo River | | | | | | |
| 1985 | 0 | 0 | 0 | 0 | 15,860 | Noyo River |
| 1986 | 36 | 11 | 0 | 47 | none | |
| 1987 | 19 | 36 | 0 | 55 | 20,822 | Noyo River |
| | | | | | 5,997 | Scott/Big Creek |
| 1988 | 26 | 4 | 0 | 30 | 20,242 | San Lorenzo R (Noyo) |
| | | | | | 5,120 | Noyo River |
| 1989 | 115 | 68 | 0 | 183 | 34,500 | Prairie Creek |

Table 3. Summary of presence/absence data. Streams were characterized as streams having coho salmon based on recent data, streams where coho salmon are very rare or absent, and streams with insufficient data to be defined. Results are presented by county. County classifications are based on the location of the mouth of the system. Streams where coho salmon are present some years and not others are classified as having coho salmon. Streams receiving hatchery plants were not counted as having coho salmon unless adult returns were documented. Numbers in parentheses represent percentage of total streams in category.

| System | Number of streams | Coho present | Coho absent | No data |
|---|---|---|---|---|
| Del Norte County | | | | |
| Coastal | 9 | 1 (11) | - | 8 (89) |
| Smith River | 41 | 2 (5) | - | 39 (95) |
| Klamath River | 113 | 21 (18) | 20 (18) | 72 (64) |
| Humboldt County | | | | |
| Coastal | 34 | 7 (21) | - | 27 (79) |
| Redwood Creek | 14 | 3 (21) | - | 11 (79) |
| Mad River | 23 | 2 (9) | - | 21 (91) |
| Eel River | 124 | 34 (27) | 22 (18) | 68 (55) |
| Mattole River | 38 | 3 (8) | - | 35 (92) |
| Mendocino County | | | | |
| Coastal | 44 | 13 (30) | 22 (50) | 9 (20) |
| Ten Mile River | 11 | 7 (64) | 3 (27) | 1 (9) |
| Noyo River | 13 | 11 (84) | 1 (8) | 1 (8) |
| Big River | 16 | 11 (69) | 2 (13) | 3 (18) |
| Navarro River | 19 | 4 (21) | 4 (21) | 11 (58) |
| Sonoma County | | | | |
| Coastal | 10 | 1 (10) | 1 (10) | 8 (80) |
| Gualala River | 11 | 1 (9) | 1 (9) | 9 (82) |

Table 3. continued.

| System | Number of streams | Coho present | Coho absent | No data |
|---|---|---|---|---|
| Russian River | 32 | 2 (6) | 22 (69) | 8 (25) |
| Marin County | | | | |
| Coastal | 10 | 7 (70) | - | 3 (30) |
| Tributaries to San Francisco Bay including Sacramento River | | | | |
| Coastal | 7 | 0 (0) | 7 (100) | 0 (0) |
| Streams South of San Francisco Bay | | | | |
| Coastal | 13 | 5 (38) | 8 (62) | - |
| Total | 582 | 135 (23) | 113 (19) | 334 (58) |

Table 4. Estimates of coho salmon abundance in California. All streams that supported coho salmon or for which there was no data on presence/absence were assumed to support 20 spawners unless data indicated a larger population. Numbers for hatchery populations are the average population from the 1981-1982 season to the latest season for which data were available. For streams where hatcheries are located both hatchery and wild fish are included. An asterisk indicates a high probability that much of the natural production is by wild rather than natural fish. An S indicates streams where it was difficult to classify fish as natural or hatchery. Supplementation occurs in these streams but in the Noyo River most of the production is probably natural and in Scott Creek only returning natural fish are spawned.

| System | Number of streams with coho salmon | Natural | Hatchery | Total |
|---|---|---|---|---|
| Del Norte County | | | | |
| Coastal | 9 | 180* | 0 | 180 |
| Smith River | 41 | 820* | 0 | 820 |
| Klamath River | 93 | 1,860 | 16,265[1] | 18,125 |
| Humboldt County | | | | |
| Coastal | 34 | 680* | 0 | 680 |
| Redwood Creek | 14 | 280 | 525 | 805 |
| Mad River | 23 | 460 | 366 | 826 |
| Eel River | 102 | 2,040* | 0 | 2,040 |
| Mattole River | 38 | 760* | 0 | 760 |
| Mendocino County | | | | |
| Coastal | 22 | 470 | 0 | 470 |
| Ten Mile River | 8 | 160* | 0 | 160 |
| Noyo River | 12 | 3,740 | S | 3,740 |
| Big River | 14 | 280 | 0 | 280 |
| Navarro River | 15 | 300 | 0 | 300 |
| Sonoma County | | | | |

Table 4. continued.

| System | Number of streams with coho salmon | Natural | Hatchery | Total |
|---|---|---|---|---|
| Coastal | 9 | 180 | 0 | 180 |
| Gualala River | 10 | 200 | 0 | 200 |
| Russian River | 10 | 255 | 332 | 587 |
| Marin County | | | | |
| Coastal | 10 | 435 | 0 | 435 |
| Tributaries to San Francisco Bay including Sacramento River | | | | |
| Coastal | 7 | 0 | 0 | 0 |
| Streams South of San Francisco Bay | | | | |
| Coastal | 5 | 140 | S | 140 |
| Total | 469 | 13,240 (43%) | 17,488 (57%) | 30,728 |

[1]Number includes fish from Iron Gate Hatchery and Trinity Hatchery. Also included are hatchery fish spawning below Trinity hatchery based on the assumption that only 60% of returning hatchery fish actually enter the hatchery (Rogers 1973).

Liter

Individual Reports

Allen, J.T. 1958. Report of first season's operations, 1957-58, Pudding Creek silver salmon egg collecting station, Mendocino County. CDFG In. Fish. Admin. Rept. 58-12.

Baker, P. and F. Reynolds. 1986. Life history, habitat requirements, and status of coho salmon in California. Report to the California Fish and Game Commission.

Bartley, D.M., B. Bentley, and P.G. Olin. 1991. Population genetic structure of coho salmon, Oncorhynchus kisutch, in California. Draft report to California Department of Fish and Game.

Botsford, L.W., R.D. Methot, Jr., and J.E. Wilen. 1982. Cycle covariation in the California king salmon, Oncorhynchus tshawytscha, silver salmon, O. kisutch, and Dungeness crab, Cancer magister, fisheries. Fishery Bulletin 80:791-802.

Briggs, J.C. 1949. The salmonid fishes of Prairie Creek, Humboldt County, California. Unpublished report to Calif. Dept. of Fish and Game.

Brown, L.R. and P.B. Moyle. 1991. Eel River survey: final report. Report to Calif. Dept. of Fish and Game, Contract: F-46-R-2.

Bryant, H.C. 1923. Salmon fishcultural operations on the Klamath River. Calif. Fish and Game 9:19-23.

Bureau of Reclamation. 1973. Fishery improvement study, Eureka Division North Coast Project California. Dept. of the Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA. 44 pp. + appendix.

Burns, J.W. 1971. The carrying capacity for juvenile salmonids in some northern California streams. Calif. Fish and Game 57:44-57.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101:1-17.

Calhoun, A. and C. Seeley. 1963. Logging damage to California streams in 1962. CDFG In. Fish. Br. Admin. Rept. 63-2.

California Advisory Committee on Salmon and Steelhead Trout. 1988. Restoring the balance, 1988 annual report. Annual report to Calif. Dept. of Fish and Game and Calif. Legislature.

Coots, M. 1957a. Spawning efficiency of king salmon (Oncorhynchus tshawytscha) in Fall Creek, Siskiyou County. 1954-55 investigations. CDFG In. Fish. Admin. Rept. 57-1.

Coots, M. 1957b. Shasta River, Siskiyou County, 1955 king salmon count, and some notes on the 1956 run. CDFG In. Fish. Admin. Rept. 57-5.

Coots, M. 1958a. Shasta River salmon count, 1957. CDFG In. Fish. Admin. Rept. 58-4.

Coots, M. 1958b. Klamath River 1956 king salmon count, Klamathon Racks, Siskiyou County. CDFG In. Fish. Admin. Rept. 58-9.

Coots, M. 1973. A study of juvenile steelhead, Salmo gairdnerii gairdnerii Richardson, in San Gregorio Creek and lagoon, San Mateo County, March through August, 1971. CDFG Anad. Fish. Br. Admin. Rept. 73-4.

Dill, L.M. and A.H.G. Fraser. 1984. Risk of predation and the feeding behavior of juvenile coho salmon (Oncorhynchus kisutch). Behav. Ecol. Sociobiol. 16:65-71.

Eigenmann, C,H. 1890. The food fishes of California. in, Routier, J. and J.D. Harvey, Biennial report of the State Board of Fish Commissioners of the State of California for the years 1888-1890, Sacramento, California.

Emig, J. 1984. Fish population survey, Walker Creek, Marin County, 1981. CDFG Anad. Fish. Br. Admin. Rept. 84-02. 14 pp.

Emig, J. 1985. Fish population survey, Lagunitas Creek drainage, Marin County, 1982. CDFG Anad. Fish. Br. Admin. Rept. 85-5. 26 pp.

Fisk, L., E. Gerstung, and J. Thomas. 1966. Stream damage surveys - 1966. CDFG In. Fish. Admin. Rept. 66-10. 15 pp.

Fraser, F.J. 1969. Population density effects on survival and growth of juvenile coho salmon and steelhead trout in experimental stream channels. pp. 253-268, in, T.G. Northcote (editor), Symposium on trout and steelhead in streams. Institute of Fisheries, The University of British Columbia, Vancouver.

Fredericksen, Kamine and Associates. 1980. Proposed Trinity River basin fish and wildlife management program, Appendix C, Final, Volume 1. Fredericksen, Kamine and Associates, Sacramento, California.

Fry, D.H., Jr. 1936. Life history of Hesperoleucus venustus. Calif. Fish and Game 22:65-98.

Fry, D.H., Jr. 1973. Anadromous fishes of California. Calif. Dept. of Fish and Game.

Gibbs, E.D. and J.B. Kimsey. 1955. The 1951 creel census on the boat fishery of the Klamath River estuary, Del Norte County. CDFG In. Fish. Admin. Rept. 55-16.

Giddings, A.E. 1959. Record silver salmon taken in Papermill Creek, Marin County. Calif. Fish and Game 45:353.

Grass, A. 1990. Annual report Van Arsdale fisheries station, 1987-88. CDFG In. Fish. Admin. Rept. 90-5.

Graves, D.S. and J.W. Burns. 1970. Comparison of yields of downstream migrant salmonids before and after logging road construction on the South Fork Caspar Creek, Mendocino County. CDFG In. Fish. Admin. Rept. 70-3. 12 pp.

Hallock, R.J., G.H. Warner, and D.H. Fry, Jr. 1952. California's part in a three-state salmon fingerling marking program. Calif. Fish and Game 38:301-332.

Hallock, R.J., D.H. Fry, Jr., and D. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. Calif. Fish and Game 43:271-298.

Hallock, R.J. and D.H. Fry, Jr. 1967. Five species of salmon, Oncorhynchus, in the Sacramento River, California. Calif. Fish and Game 53:5-22.

Hashagen, K., C. Toole, B. Wyatt, S. Sommarstrom, S. Taylor. 1984. Report of the 2nd California salmon and steelhead restoration conference. California Sea Grant College Program.

Hassler, T.J. 1987. Species profiles; life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)—coho salmon. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.70). U.S. Army Corps of Engineers, TR EL-82-4. 19 pp.

Hassler, T.J., C.M. Sullivan, and G.R. Stern. 1988. Distribution of coho salmon in California. Annual Report to Calif. Dept. of Fish and Game, Contract No. FG7292.

Healey, T.P., Jr. 1973. Studies of steelhead and salmon emigration in the Trinity River. CDFG Anad. Fish. Br. Admin. Rept. 73-1.

Helle, J.H. 1981. Significance of the stock concept in artificial propagation of salmonids in Alaska. Can. J. Fish. Aquat. Sci. 38:1665-1671.

Holman, G. and W.A. Evans. 1964. Stream clearance project - completion report Noyo River, Mendocino County. CDFG In. Fish. Admin. Rept. 64-10. 10 pp.

Hull, D. 1987. Salmon restoration in Humboldt Bay: a model of citizen and government participation. Coastal Zone 87:1821-1835.

Hull, D., J. Ellinwood, C. Toole, and T. Flannigan. 1989. Humboldt Fish Action Council, final report project number C-1538, October 1986 through August 1988. Report to Harvey Reading, California Department of Fish and Game.

Jensen, P.T. 1971. Fishery contribution and escapement of hatchery-produced silver salmon in California. CDFG Anad. Fish. Br. Admin. Rept. 71-10.

Jensen, P.T. and P.G. Swartzell. 1967. California salmon landings 1952 through 1965. Calif. Dept. Fish and Game, Fish Bull. 135:43-57.

Johansen, R.R. 1975. San Lorenzo River (Santa Cruz County) winter steelhead and salmon fishery, 1971-72 and 1972-73 seasons. CDFG Anad. Fish. Br. Admin. Rept. 75-6. 14 pp.

Jordan, D.S. and P.L. Jouy. 1881. Checklist of duplicates of fishes from the Pacific Coast of North America, distributed by the Smithsonian Institution in behalf of the United States National Museum, 1881. Proceedings of the United States National Museum 1881:1-18.

Jordan, D.S. and C.H. Gilbert. 1881. Notes on the fishes of the Pacific Coast of the United States. Proceedings of the United States National Museum 1881:29-70.

Kisanuki, T., J. Polos, and D. Wills. 1991. Annual report Klamath River fisheries assessment program 1989. U.S. Fish and Wildlife Service, Rept. No. AFFI-FRO-91-14.

Larkin, P.A. 1979. Maybe you can't get there from here: a foreshortened history of research in relation to management of Pacific Salmon. J. Fish. Res. Board Can. 36:98-106.

Klamath River Fishery Management Council. 1990. The Klamath Fishery Management Council strategic plan for management of harvest of anadromous fish populations of the Klamath River basin. Public review draft prepared by the Klamath River Fishery Management Council.

Larkin, P.A. 1981. A perspective on population genetics and salmon management. Can. J. Fish. Aquat. Sci. 38:1469-1475.

Leidy, R.A. 1983. Distribution of fishes in streams of the Walnut Creek basin, California. Calif. Fish and Game 69:23-32.

Leidy, R.A. 1984. Distribution and ecology of stream fishes in the San Francisco Bay drainage. Hilgardia 52:1-175.

Lockington, W.N. 1881. Report upon the edible fishes of the Pacific Coast, U.S.A. in, Report of the commissioners of fisheries of the Sate of California, for the year 1880, Sacramento, California.

Lufkin, A. (ed.). 1991. California's salmon and steelhead. The struggle to restore an imperiled resource. University of California Press, Berkeley.

McCormick, R.B. 1958. Observations of the sport fishery for salmon in tidewater of the Klamath River, 1954. CDFG In. Fish. Admin. Rept. 58-25.

Miller, W.E., T.C. Coley, H.L. Burge, and T.T. Kisanuki. 1990. Analysis of salmon and steelhead supplementation: emphasis on unpublished reports and present programs. U.S. Department of Energy, Bonneville Power Administration, Project No. 88-100.

Mills, T. 1983. Appendix H, Utilization of Eel River tributary streams by anadromous salmonids. in, F.L. Reynolds, author. 1983 status report of California wild and scenic river salmon and steelhead fisheries. California Dept. of Fish and Game.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Final report to California Dept. of Fish and Game, Contract No. 7337. 222 pp.

Murphy, G.I. 1950. Returns from marked fall spawning rainbow trout planted in several Mendocino County coastal streams in 1948. Unpublished report to Bureau of Fish Conservation, Calif. Div. of Fish and Game.

Murphy, G.I. 1952. An analysis of silver salmon counts at Benbow Dam, South Fork Eel River, California. Calif. Fish and Game 38:105-112.

Murphy, G.I. and J.W. De Witt Jr. 1951. Notes on the fishes and fishery of the lower Eel River, Humboldt County, California. Unpublished report to Bureau of Fish Conservation, Calif. Div. of Fish and Game.

Murphy, G.I. and L. Shapovalov. 1952. A preliminary analysis of northern California salmon and steelhead runs. Calif, Fish and Game 37:497-507.

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

Nielsen, J.L., M. Maas, and G. Balding. 1991. Anadromous salmonid resources of Mendocino coastal and inland rivers 1989-1990. An evaluation of rehabilitation efforts based on carcass recovery and spawning activity. Draft Report to California Department of Fish and Game, Inland Habitat Surveys, Standard Agreement No. FG9364.

Painter, R.E., L.H. Wixom, and S.N. Taylor (anadromous fish. br.). 1977. An evaluation of fish populations and fisheries in the post-Oroville project Feather River. CDFG, report submitted to the Dept. of Water Res.

Pintler, H.E. 1956. The results of a fish population sampling program on the San Lorenzo River, Santa Cruz County, California. CDFG In. Fish. Admin. Rept. 56-26. 19 pp.

Pister, E.P. 1965. Population sampling of three north coastal streams closed to summer trout fishing - 1955 season. CDFG In. Fish. Admin. Rept. 65-12. 8 pp.

Puckett, K.J. and L.M. Dill. 1985. The energetics of feeding territoriality in juvenile coho salmon (Oncorhynchus kisutch). Behavior 92:97-111.

Puckett, L.K. 1976. Observations on the downstream migrations of anadromous fishes within the Eel River system. CDFG Memorandum Report.

Puckett, L.K. 1977. The Eel River estuary - observations on morphometry, fishes, water quality, and invertebrates. CDFG Memorandum Report. 52 pp.

Quinn, W.W. and J.T. Allen. 1969a. Downstream migrant fish trapping operations, 1964, Nicasio Creek, Marin County. Anadromous Fisheries Admin, Report No. 69-2.

Quinn, W.W. and J.T. Allen. 1969b. Downstream migrant fish trapping operations, 1964, Nicasio Creek, Marin County. Anadromous Fisheries Admin, Report No. 69-3.

Reeves, G.H. and T.D. Roelofs. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America. Rehabilitating and enhancing stream habitat: field applications. Gen. Tech. Rep. PNW-140. Portland OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Field Station. 39 pp.

Reeves, G.H., F.H. Everest, and T.E. Nichelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. Gen. Tech. Rep. PNW-GTR-245. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 pp.

Rogers, D.W. 1973. King salmon (Oncorhynchus tshawytscha) and silver salmon (Oncorhynchus kisutch) spawning escapement and spawning habitat in the upper Trinity River, 1970. CDFG Anad. Fish. Br. Admin. Rept. 73-10.

Scarnecchia, D.L. and H.H. Wagner. 1980. Contribution of wild and hatchery reared coho salmon, Oncorhynchus kisutch, to the Oregon ocean sport fishery. Fishery Bulletin 77:617-624.

Scofield, W.L. 1937. A silver salmon at Los Coronados Islands. Calif. Fish and Game 23:245.

Shapovalov, L. 1947. Distinctive characters of the species of anadromous trout and salmon found in California. Calif. Fish and Game 33:185-190.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. CDFG Fish Bulletin No. 98. 375 pp.

Sheehan, J. 1991. Snags and twists abound in managing sport fish. Outdoor California 52:15-25.

Smith, G.E. 1986. Instream flow requirements, anadromous salmonids spawning and rearing, Lagunitas Creek, Marin County. CDFG, Env. Ser. Br., Stream Evaluation Report 86-2.

Smith, J.J. 1987. Aquatic habitat and fish utilization of Pescadero, San Gregorio, Waddell and Pomponio Creek estuary/lagoon systems. Report to Calif. Dept. Parks and Rec. Interagency Agreement 4-823-6004. 35 pp.

Snider, W.M. 1985. Instream flow requirements of anadromous salmonids, Brush Creek, Mendocino County, California. CDFG, Env. Ser. Br., Stream Evaluation Report 85-1.

Snyder, J.O. 1908. The fishes of the coastal streams of Oregon and northern California. Bull of the Bureau of Fisheries 27:153-189.

Snyder, J.O. 1931. Salmon of the Klamath River, California. Div. of Fish and Game of Calif., Fish Bulletin No. 34.

Sommerstrom, S. 1984. Mendocino County salmon and steelhead plan. Mendocino County Fish and Game Advisory Committee, Ukiah, California. 103 pp.

Steiner Environmental Consultants. Potter Valley project monitoring program (FERC No. 77, Article 39): effects of operations on upper Eel River anadromous salmonids, 1988-1989 progress report. Steiner Environmental Consulting, Potter Valley, California.

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. U.S. Department of Energy, Bonneville Power Administration, Technical Report 90-1.

Toole, C., B. Wyatt, S. Sommerstrom, K. Hashagen. 1983. Report of the 1st salmon and steelhead restoration conference. California Sea Grant College Program.

Tschaplinski, P.J. 1982. Aspects of the population biology of estuary-reared and stream-reared juvenile coho salmon in Carnation Creek: a summary of current research. pp. 289-305, in, G.F. Hartman (editor). Proceedings of the Carnation Creek workshop: a ten-year review. Malaspina College, Nanaimo, B.C.

Tschaplinski, P.J. and G.F. Hartman. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Can. J. Fish. Aquat. Sci. 40:452-461.

Tuss, C. J. Larson, T. Kisanuki, J. Polos, and J. Craig. 1989. Annual report Klamath River fisheries assessment program. U.S. Fish and Wildlife Service, Rept. No. AFF/FAO-89-13.

U.S. Heritage Conservation and Recreation Service. 1980. Final Environmental impact statement. Proposed designation of five California rivers in the national wild and scenic rivers system. Vol. 1. 322 pp.

Van Woert, W. 1957. Time pattern of migration of adult salmon and steelhead into the upper Sacramento River during the 1956-57 season, and length-frequency relationship of Sacramento River steelhead. CDFG In. Fish. Admin. Rept. 57-19.

Van Woert, W. 1958. Time pattern of migration of salmon and steelhead into the upper Sacramento River during the 1957-58 season. CDFG In. Fish. Admin. Rept. 58-7.

Waldvogel, J. 1988. Fall chinook salmon spawning escapement estimate for a tributary of the Smith River, California. Second interim report (1980-1987). University of California Sea Grant Extension Program 88-5.

Waples, R.S. In press. Definition of "species" under the endangered species act: application to Pacific salmon. NOAA Technical Memo.

Waples, R.S. 1990a. Conservation genetics of Pacific Salmon. II. Effective population size and the rate of loss of genetic variability. Journal of Heredity 81:267-276.

Waples, R.S. 1990b. Conservation genetics of Pacific salmon. III. Estimating effective population size. Journal of Heredity 81:277-289.

Waples, R.S. and D.J. Teel. 1990. Conservation genetics of Pacific salmon I. Temporal changes in allele frequency. Conservation Biology 4:144-156.

White, R. and P.B. Moyle. 1989. Preserve design database. Final Report to Betsy Bolster, California Department of Fish and Game.

Wright, S. 1981. Contemporary Pacific Salmon fisheries management. North American Journal of Fisheries Management 1:29-40.

Iron Gate Hatchery

Riley, J.O., Jr. 1967. Annual report, Iron Gate salmon and steelhead hatchery, first year of operation 1965-1966. CDFG Anad. Fish. Br. Admin. Rept. 67-8.

Riley, J.O., Jr. 1967. Annual report, Iron Gate salmon and steelhead hatchery, 1966-1967. CDFG Anad. Fish. Br. Admin. Rept. 67-15.

Riley, J.O., Jr. 1968. Annual report, Iron Gate salmon and steelhead hatchery, 1967-1968. CDFG Anad. Fish. Br. Admin. Rept. 68-10.

Riley, J.O., Jr. 1970. Annual report, Iron Gate salmon and steelhead hatchery, fourth year of operation 1968-1969. CDFG Anad. Fish. Br. Admin. Rept. 70-2.

Marshall, L.E. 1970. Annual report, Iron Gate salmon and steelhead hatchery, fifth year of operation 1969-1970. CDFG Anad. Fish. Br. Admin. Rept. 74-17.

Arnold E.A. 1972. Annual report, Iron Gate salmon and steelhead hatchery, sixth year of operation, 1970-1971. CDFG Anad. Fish. Br. Admin. Rept. 72-10.

Arnold E.A. 1972. Annual report, Iron Gate salmon and steelhead hatchery, seventh year of operation, 1971-1972. CDFG Anad. Fish. Br. Admin. Rept. 72-11.

Arnold E.A. 1974. Annual report, Iron Gate salmon and steelhead hatchery, 1972-1973. CDFG Anad. Fish. Br. Admin. Rept. 74-3.

Arnold E.A. 1975. Annual report, Iron Gate salmon and steelhead hatchery, 1973-1974. CDFG Anad. Fish. Br. Admin. Rept. 75-2.

Arnold E.A. 1977. Annual report, Iron Gate salmon and steelhead hatchery, 1974-1975. CDFG Anad. Fish. Br. Admin. Rept. 77-9.

Arnold E.A. 1977. Annual report, Iron Gate salmon and steelhead hatchery, 1975-1976. CDFG Anad. Fish. Br. Admin. Rept. 77-10.

Arnold E.A. 1977. Annual report, Iron Gate salmon and steelhead hatchery, 1976-1977. CDFG Anad. Fish. Br. Admin. Rept. 77-11.

Hiser, C.A. 1979. Annual report, Iron Gate salmon and steelhead hatchery and Bogus rearing ponds, 1977-1978. CDFG Anad. Fish. Br. Admin. Rept. 79-8.

Hiser, C.A. 1982. Annual report, Iron Gate salmon and steelhead hatchery, 1978-1979. CDFG Anad. Fish. Br. Admin. Rept. 82-22.

Hiser, C.A. 1982. Annual report, Iron Gate salmon and steelhead hatchery, 1979-1980. CDFG Anad. Fish. Br. Admin. Rept. 82-28.

Hiser, C.A. 1982. Annual report, Iron Gate salmon and steelhead hatchery, 1980-1981. CDFG Anad. Fish. Br. Admin. Rept. 82-20.

Hiser, C.A. 1984. Annual report, Iron Gate salmon and steelhead hatchery, 1981-1982. CDFG Anad. Fish. Br. Admin. Rept. 84-1.

Hiser, C.A. 1985. Annual report, Iron Gate salmon and steelhead hatchery, 1982-1983. CDFG Anad. Fish. Br. Admin. Rept. 85-2.

Hiser, C.A. 1985. Annual report, Iron Gate salmon and steelhead hatchery, 1983-1984. CDFG Anad. Fish. Br. Admin. Rept. 85-1.

Hiser, C.A. 1990. Annual report, Iron Gate salmon and steelhead hatchery, 1986-1987. CDFG Anad. Fish. Br. Admin. Rept. 90-16.

Hiser, C.A. 1991. Annual report, Iron Gate salmon and steelhead hatchery, 1987-1988. CDFG Anad. Fish. Br. Admin. Rept. 91-5.

Hiser, C.A. 1991. Annual report, Iron Gate salmon and steelhead hatchery, 1988-1989. CDFG Anad. Fish. Br. Admin. Rept. 91-6.

Hiser, C.A. 1991. Annual report, Iron Gate salmon and steelhead hatchery, 1989-1990. CDFG Anad. Fish. Br. Admin. Rept. 91-7.

Trinity River Hatchery

Murray, R. 1964. Annual report, Trinity River salmon and steelhead hatchery, seventh year of operation 1962-1963. CDFG In. Fish. Admin. Rept. No. 64-1.

Murray, R. 1965. Annual report, Trinity River salmon and steelhead hatchery, seventh year of operation 1963-1964. CDFG In. Fish. Admin. Rept. No. 65-5.

Murray, R. 1966. Annual report, Trinity River salmon and steelhead hatchery, seventh year of operation 1964-1965. CDFG In. Fish. Admin. Rept. No. 66-1.

Murray, R. 1966. Annual report, Trinity River salmon and steelhead hatchery, eighth year of operation 1965-1966. CDFG In. Fish. Admin. Rept. No. 66-13.

Murray, R. 1967. Annual report, Trinity River salmon and steelhead hatchery, ninth year of operation 1966-1967. CDFG In. Fish. Admin. Rept. No. 67-11.

Murray, R. 1968. Annual report, Trinity River salmon and steelhead hatchery, tenth year of operation 1967-1968. CDFG In. Fish. Admin. Rept. No. 68-9.

Bedell, G.W. 1970. Annual report, Trinity River salmon and steelhead hatchery, eleventh year of operation 1968-1969. CDFG In. Fish. Admin. Rept. No. 70-5.

Bedell, G.W. 1970. Annual report, Trinity River salmon and steelhead hatchery, twelfth year of operation 1969-1970. CDFG In. Fish. Admin. Rept. No. 70-19.

Bedell, G.W. 1972. Annual report, Trinity River salmon and steelhead hatchery, thirteenth year of operation 1970-1971. CDFG In. Fish. Admin. Rept. No. 72-4.

Bedell, G.W. 1972. Annual report, Trinity River salmon and steelhead hatchery, fourteenth year of operation 1971-1972. CDFG In. Fish. Admin. Rept. No. 72-14.

Bedell, G.W. 1974. Annual report, Trinity River salmon and steelhead hatchery, 1972-1973. CDFG Anad. Fish. Admin. Rept. No. 74-4.

Bedell, G.W. 1975. Annual report, Trinity River salmon and steelhead hatchery, 1973-1974. CDFG Anad. Fish. Admin. Rept. No. 75-4.

Bedell, G.W. 1976. Annual report, Trinity River salmon and steelhead hatchery, 1974-1975. CDFG Anad. Fish. Admin. Rept. No. 76-6.

Bedell, G.W. 1978. Annual report, Trinity River salmon and steelhead hatchery, 1975-1976. CDFG Anad. Fish. Admin. Rept. No. 78-1.

Bedell, G.W. 1978. Annual report, Trinity River salmon and steelhead hatchery, 1976-1977. CDFG Anad. Fish. Admin. Rept. No. 78-2.

Bedell, G.W. 1979. Annual report, Trinity River salmon and steelhead hatchery, 1977-1978. CDFG Anad. Fish. Admin. Rept. No. 79-2.

Bedell, G.W. 1980. Annual report, Trinity River salmon and steelhead hatchery, 1978-1979. CDFG Anad. Fish. Admin. Rept. No. 80-14.

Bedell, G.W. 1982. Annual report, Trinity River salmon and steelhead hatchery, 1979-1980. CDFG Anad. Fish. Admin. Rept. No. 82-3.

Bedell, G.W. 1983. Annual report, Trinity River salmon and steelhead hatchery, 1980-1981. CDFG Anad. Fish. Admin. Rept. No. 83-3.

Bedell, G.W. 1982. Annual report, Trinity River salmon and steelhead hatchery, 1981-1982. CDFG Anad. Fish. Admin. Rept. No. 82-39.

Bedell, G.W. 1983. Annual report, Trinity River salmon and steelhead hatchery, 1982-1983. CDFG Anad. Fish. Admin. Rept. No. 83-11.

Bedell, G.W. 1984. Annual report, Trinity River salmon and steelhead hatchery, 1983-1984. CDFG Anad. Fish. Admin. Rept. No. 84-5.

Bedell, G.W. 1987. Annual report, Trinity River salmon and steelhead hatchery, 1984-1985. CDFG In. Fish. Admin. Rept. No. 87-5.

Bedell, G.W. 1987. Annual report, Trinity River salmon and steelhead hatchery, 1985-1986. CDFG In. Fish. Admin. Rept. No. 87-13.

Bedell, G.W. 1990. Annual report, Trinity River salmon and steelhead hatchery, 1986-1987. CDFG In. Fish. Admin. Rept. No. 87-17.

Bedell, G.W. 1990. Annual report, Trinity River salmon and steelhead hatchery, 1987-1988. CDFG In. Fish. Admin. Rept. No. 90-11.

Bedell, G.W. 1990. Annual report, Trinity River salmon and steelhead hatchery, 1988-1989. CDFG In. Fish. Admin. Rept. No. 90-12.

Bedell, G.W. 1991. Annual report, Trinity River salmon and steelhead hatchery, 1989-1990. CDFG In. Fish. Admin. Rept. No. 91-8.

Mad River Hatchery

Will R.D. 1968. Mad River test hatchery results. CDFG In. Fish. Admin. Rept. 68-6.

Will, R.D. 1973. Annual report, Mad River salmon and steelhead hatchery, first year of operation 1970-1971. CDFG Anad. Fish. Br. Admin. Rept. 73-12.

Will, R.D. 1974. Annual report, Mad River salmon and steelhead hatchery, second year of operation 1971-1972. CDFG Anad. Fish. Br. Admin. Rept. 74-1.

Will, R.D. 1974. Annual report, Mad River salmon and steelhead hatchery, third year of operation 1972-1973. CDFG Anad. Fish. Br. Admin. Rept. 74-2.

Will, R.D. 1975. Annual report, Mad River salmon and steelhead hatchery, 1973-1974. CDFG Anad. Fish. Br. Admin. Rept. 75-1.

Will, R.D. 1976. Annual report, Mad River salmon and steelhead hatchery, 1974-1975. CDFG Anad. Fish. Br. Admin. Rept. 76-7.

Will, R.D. 1978. Annual report, Mad River salmon and steelhead hatchery, 1975-1976. CDFG Anad. Fish. Br. Admin. Rept. 78-16.

Will, R.D. 1978. Annual report, Mad River salmon and steelhead hatchery, 1976-1977. CDFG Anad. Fish. Br. Admin. Rept. 78-17.

Will, R.D. 1979. Annual report, Mad River salmon and steelhead hatchery, 1977-1978. CDFG Anad. Fish. Br. Admin. Rept. 79-3.

Will, R.D. 1980. Annual report, Mad River salmon and steelhead hatchery, 1978-1979. CDFG Anad. Fish. Br. Admin. Rept. 80-10.

Ducey, R.D. 1982. Annual report, Mad River salmon and steelhead hatchery, 1979-1980. CDFG In. Fish. Admin. Rept. 82-1.

Ducey, R.D. 1982. Annual report, Mad River salmon and steelhead hatchery, 1980-1981. CDFG In. Fish. Admin. Rept. 82-4.

Ducey, R.D. 1982. Annual report, Mad River salmon and steelhead hatchery, 1981-1982. CDFG In. Fish. Admin. Rept. 82-27.

Barngrover, B.G. 1983. Annual report, Mad River salmon and steelhead hatchery, 1982-1983. CDFG In. Fish. Admin. Rept. 83-13.

Barngrover, B.G. 1986. Annual report, Mad River salmon and steelhead hatchery, 1983-1984. CDFG In. Fish. Admin. Rept. 86-2.

Barngrover, B.G. 1988. Annual report, Mad River salmon and steelhead hatchery, 1986-1987. CDFG In. Fish. Admin. Rept. 88-3.

Barngrover, B.G. 1990. Annual report, Mad River salmon and steelhead hatchery, 1987-1988. CDFG In. Fish. Admin. Rept. 90-2.

Barngrover, B.G. 1990. Annual report, Mad River salmon and steelhead hatchery, 1988-1989. CDFG In. Fish. Admin. Rept. 90-14.

Barngrover, B.G. 1991. Annual report, Mad River salmon and steelhead hatchery, 1989-1990. CDFG In. Fish. Admin. Rept. 91-9.

Warm Springs Hatchery

Estey, D.F. 1982. Annual report, Warm Springs salmon and steelhead hatchery, 1980-81 (first year). CDFG In. Fish. Admin. Rept. 82-14.

Estey, D.F. 1982. Annual report, Warm Springs salmon and steelhead hatchery, 1981-82. CDFG In. Fish. Admin. Rept. 82-30.

Estey, D.F. 1983. Annual report, Warm Springs salmon and steelhead hatchery, 1982-83. CDFG In. Fish. Admin. Rept. 83-15.

Estey, D.F. 1984. Annual report, Warm Springs salmon and steelhead hatchery, 1983-84. CDFG In. Fish. Admin. Rept. 84-4.

Estey, D.F. 1986. Annual report, Warm Springs salmon and steelhead hatchery, 1984-85. CDFG In. Fish. Admin. Rept. 86-3.

Gunter, E.R. Jr. 1988. Annual report, Warm Springs salmon and steelhead hatchery, 1985-86. CDFG In. Fish. Admin. Rept. 88-4.

Gunter, E.R. Jr. 1988. Annual report, Warm Springs salmon and steelhead hatchery, 1986-87. CDFG In. Fish. Admin. Rept. 88-5.

Gunter, E.R. Jr. 1990. Annual report, Warm Springs salmon and steelhead hatchery, 1987-88. CDFG In. Fish. Admin. Rept. 90-4.

Gunter, E.R. Jr. 1990. Annual report, Warm Springs salmon and steelhead hatchery, 1988-89. CDFG In. Fish. Admin. Rept. 90-8.

Noyo Egg Collecting Station

Snyder, R.U. and S.W. Sanders. 1979. Summary of operations Noyo River egg collecting station 1964-65 through 1977-78. CDFG Anad. Fish. Br. Admin. Rept. 79-7.

Sanders, S.W. 1980. Annual report, Noyo River egg collecting station, 1978-79. CDFG Anad. Fish. Br. Admin. Rept. 80-8.

Sanders, S.W. 1982. Annual report, Noyo River egg collecting station, 1979-80. CDFG In. Fish. Admin. Rept. 82-12.

Grass, A. 1982. Annual report, Noyo River egg collecting station, 1980-81. CDFG In. Fish. Admin. Rept. 82-19.

Sanders, S.W. 1982. Annual report, Noyo River egg collecting station, 1981-82. CDFG In. Fish. Admin. Rept. 82-21.

Sanders, S.W. 1983. Annual report, Noyo River egg collecting station, 1982-83. CDFG In. Fish. Admin. Rept. 83-6.

Poe, S.D. 1984. Annual report, Noyo River egg collecting station, 1983-84. CDFG In. Fish. Admin. Rept. 84-6.

Poe, S.D. 1986. Annual report, Noyo River egg collecting station, 1984-85. CDFG In. Fish. Admin. Rept. 86-4.

Poe, S.D. 1988. Annual report, Noyo River egg collecting station, 1986-87. CDFG In. Fish. Admin. Rept. 88-2.

Grass, A. 1990. Annual report, Noyo River egg collecting station, 1987-1988. CDFG In. Fish. Admin. Rept. 90-3.

Hollowtree Creek Egg Collecting Station

Sanders, S.W. 1982. Annual report, Hollow Tree Creek egg taking station, 1979-1980 first year). CDFG In. Fish. Admin. Rept. 82-7.

Sanders, S.W. 1982. Annual report, Hollow Tree Creek egg taking station, 1980-1981. CDFG In. Fish. Admin. Rept. 82-15.

Sanders, S.W. 1982. Annual report, Hollow Tree Creek egg taking station, 1981-1982. CDFG In. Fish. Admin. Rept. 82-38.

Sanders, S.W. 1983. Annual report, Hollow Tree Creek egg taking station, 1982-1983. CDFG In. Fish. Admin. Rept. 83-7.

Nimbus Hatchery

Hinze, J.A. 1961. Annual report Nimbus salmon and steelhead hatchery fiscal year of 1958-59. CDFG In. Fish. Admin. Rept. 61-1.

Jochimsen, W.H. 1971. Annual report, Nimbus salmon and steelhead hatchery (15th year) 1969-1970 fiscal year. CDFG Anad. Fish. Admin. Rept. 71-6.

Jochimsen, W.H. 1973. Annual report, Nimbus salmon and steelhead hatchery 1970-1971 fiscal year. CDFG Anad. Fish. Admin. Rept. 73-6.

Jochimsen, W.H. 1973. Annual report, Nimbus salmon and steelhead hatchery 1971-1972 fiscal year. CDFG Anad. Fish. Admin. Rept. 73-8.

Jochimsen, W.H. 1974. Annual report, Nimbus salmon and steelhead hatchery 1972-1973 fiscal year. CDFG Anad. Fish. Admin. Rept. 74-8.

Jochimsen, W.H. 1976. Annual report, Nimbus salmon and steelhead hatchery 1973-1974 fiscal year. CDFG Anad. Fish. Admin. Rept. 76-4.

Jochimsen, W.H. 1978. Annual report, Nimbus salmon and steelhead hatchery 1974-1975 fiscal year. CDFG Anad. Fish. Admin. Rept. 78-9.

Jochimsen, W.H. 1978. Annual report, Nimbus salmon and steelhead hatchery 1975-1976 fiscal year. CDFG Anad. Fish. Admin. Rept. 78-10.

Jochimsen, W.H. 1978. Annual report, Nimbus salmon and steelhead hatchery 1976-1977 fiscal year. CDFG Anad. Fish. Admin. Rept. 78-11.

Feather River Hatchery

Groh, F. 1972. Annual report, Feather River salmon and steelhead hatchery, second year of operation 1968-1969. CDFG Anad. Fish. Br. Admin. Rept. 72-5.

Groh, F. 1970. Annual report, Feather River salmon and steelhead hatchery, first year of operation 1967-1968. CDFG Anad. Fish. Br. Admin. Rept. 70-9.

Schlichting, D. 1974. Annual report, Feather River salmon and steelhead hatchery, 1970-1971. CDFG Anad. Fish. Br. Admin. Rept. 74-11.

## Merced River Fish Facility

Chase, C.O. 1978. Merced River fish facility annual report, 1973-74. CDFG Anad. Fish. Br. Admin. Rept. 78-3.

Poe, S.D. 1978. Merced River fish facility annual report, 1974-75. CDFG Anad. Fish. Br. Admin. Rept. 78-4.

Poe, S.D. 1978. Merced River fish facility annual report, 1975-76. CDFG Anad. Fish. Br. Admin. Rept. 78-5.

Poe, S.D. 1978. Merced River fish facility annual report, 1976-77. CDFG Anad. Fish. Br. Admin. Rept. 78-6.

## Production Reports

Macklin, R. and R. Tharratt. 1958. California trout production and costs 1957-1958. CDFG In. Fish. Admin. Rept. 58-15.

Ward, D. and W. Kier. 1959. California trout fish production and costs, 1958-1959. CDFG In. Fish. Admin. Rept. 59-16.

Macklin, R. and D.L. Ward. 1963. California trout, salmon, and warmwater fish production and costs, 1962-63. CDFG In. Fish. Admin. Rept. 63-13.

Ward, D.L. 1965. California trout, salmon, and warmwater fish production and costs, 1963-64. CDFG In. Fish. Admin. Rept. 65-4.

Ward, D.L. 1966. California trout, salmon, and warmwater fish production and costs, 1964-65. CDFG In. Fish. Admin. Rept. 66-2

Ward, D.L. 1967. California trout, salmon, and warmwater fish production and costs, 1965-66. CDFG In. Fish. Admin. Rept. 67-1.

Ward, D.L. 1976. California trout, salmon, and warmwater fish production and costs, 1966-67. CDFG In. Fish. Admin. Rept. 68-1.

Ward, D.L. 1969. California trout, salmon, and warmwater fish production and costs, 1967-68. CDFG In. Fish. Admin. Rept. 69-2.

Schafer, W.E. 1970. California trout, salmon, and warmwater fish production and costs, 1968-69. CDFG In. Fish. Admin. Rept. 70-1.

Bruley, G.K. 1971. California trout, salmon, and warmwater fish production and costs, 1969-70. CDFG In. Fish. Admin. Rept. 71-8.

Bruley, G.K. 1972. California trout, salmon, and warmwater fish production and costs, 1970-71. CDFG In. Fish. Admin. Rept. 72-5.

Bruley, G.K. and E. McClendon. 1973. California trout, salmon, and warmwater fish production and costs, 1971-72. CDFG In. Fish. Admin. Rept. 73-5.

Bruley, G.K. and E. McClendon. 1974. California trout, salmon, and warmwater fish production and costs, 1972-73. CDFG In. Fish. Admin. Rept. 74-2.

Bruley, G.K. 1975. California trout, salmon, and warmwater fish production and costs, 1973-74. CDFG In. Fish. Admin. Rept. 75-2.

Bruley, G.K. 1975. California trout, salmon, and warmwater fish production and costs, 1974-75. CDFG In. Fish. Admin. Rept. 75-4.

Bruley, G.K. 1976. California trout, salmon, and warmwater fish production and costs, 1975-76. CDFG In. Fish. Admin. Rept. 76-5.

Bruley, G.K. and R.V. Pollard. 1977. California trout, salmon, and warmwater fish production and costs, 1976-77. CDFG In. Fish. Admin. Rept. 77-3.

Bruley, G.K. and J.L. Horton. 1978. California trout, salmon, and warmwater fish production and costs, 1977-78. CDFG In. Fish. Admin. Rept. 78-3.

Bruley, G.K. and J.L. Horton. 1980. California trout, salmon, and warmwater fish production and costs, 1978-79. CDFG In. Fish. Admin. Rept. 80-1.

McCormack, M.L. and R.M. Carpenter. 1982. California trout, salmon, and warmwater fish production and costs, 1979-80. CDFG In. Fish. Admin. Rept. 82-5.

McCormack, M.L., R.M. Carpenter and M. Yamashita. 1984. California trout, salmon, and warmwater fish production and costs, 1980-81. CDFG In. Fish. Admin. Rept. 84-1.

Yamashita, M. and R.M. Carpenter. 1984. California trout, salmon, and warmwater fish production and costs, 1982-83. CDFG In. Fish. Admin. Rept. 84-3.

Yamashita, M. and R.M. Carpenter. 1984. California trout, salmon, and warmwater fish production and costs, 1982-83. CDFG In. Fish. Admin. Rept. 84-4.

Yamashita, M. and R.M. Carpenter. 1985. California trout, salmon, and warmwater fish production and costs, 1983-84. CDFG In. Fish. Admin. Rept. 85-1.

Fish Rescue Reports

Shapovalov, L. 1940. Fish rescue work in the North Coast district in 1939. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1941. Fish rescue work in the North Coast district in 1940. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1942. Fish rescue work in the North Coast district in 1941. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1944. Fish rescue and stream improvement work in the North Coast area in 1942. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1945. Fish rescue and stream improvement work in the North Coast area in 1943. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1945. Fish rescue and stream improvement work in the North Coast area in 1944. CDFG Bureau of Fish Conservation Admin. Rept.

Shapovalov, L. 1949. Fish rescue and stream improvement work in the North Coast area in 1945. CDFG Bureau of Fish Conservation Admin. Rept.

Murphy, G.I. 1951. Fish rescue and stream improvement work in the North Coast area in 1950. CDFG Bureau of Fish Conservation Admin. Rept.

Kimsey, J.B. 1952. Fish rescue and stream improvement work in the North Coast area in 1951. CDFG Bureau of Fish Conservation Admin. Rept.

Kimsey, J.B. 1953. Fish rescue and stream improvement work in the North Coast area in 1952. CDFG In. Fish. Admin. Rept. 53-9.

Pintler, H.E. 1954. The results of fish rescue work in Region III for 1953. CDFG In. Fish. Admin. Rept. 54-16.

## Sources of Unpublished Data

Anderson, Dave. Redwood National Park.

Brown, Larry. Postgraduate Researcher, University of California, Davis, California.

Cox, Bill. California Department of Fish and Game.

Cronin, Leo. Corte Madera Lagunitas Creek Restoration, Trout Unlimited, Fairfax, California.

Downie, Scott. Results of downstream migrant trapping on streams of the South Fork Eel River 1986-1988. Pacific Coast Federation of Fisherman's Associations, Inc. Eel River Salmon Restoration Project.

Flosi, Gary. Results of carcass count surveys in the Eel River drainage 1987-1990. California Department of Fish and Game.

Hull, David. City of Arcata, Department of Public Works.

Jones, Weldon. California Department of Fish and Game.

Kisanuki, Tom. U.S. Fish and Wildlife Service.

McCleod, Dave. California Department of Fish and Game.

Moyle, Peter. Professor, University of California, Davis, California. Unpublished data and California Fish Diversity Database.

Nielsen, Jennifer. Graduate student/Consultant, University of California, Berkeley.

Preston, Larry. California Department of Fish and Game.

Olson, Alan. U.S. Forest Service, Happy Camp Ranger District.

Sanders, Steven. Prairie Creek Fish Hatchery, Orick, California.

Smith, Jerry. Assistant Professor, California State University, San Jose, California.

Strieg, Dave. Monterey Bay Salmon and Trout Project, Davenport, California.

Taylor, Tom. California Department of Parks and Recreation.

West, Jack. U.S. Forest Service.