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

DEC 11 2003

In Response Refer To:
151422SWR02SR8288:BLS

Colonel Michael J. Conrad, Jr.
United States Department of the Army
Sacramento District, Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Conrad:

Enclosed is the National Marine Fisheries Service's (NOAA Fisheries) biological opinion (Enclosure 1) for the United States Army Corps of Engineers' (Corps) proposed construction of the San Lorenzo River bank stabilization project, located along the San Lorenzo River, in the City of Santa Cruz, Santa Cruz County, California. This biological opinion concludes the Corps' action is not likely to jeopardize the continued existence of threatened Central California Coast (CCC) Evolutionarily Significant Unit (ESU) steelhead (*Oncorhynchus mykiss*) and is not likely to adversely modify designated critical habitat for threatened CCC ESU coho salmon (*O. kisutch*). NOAA Fisheries expects the action will result in take of CCC ESU steelhead and therefore an incidental take statement is included with the biological opinion. The incidental take statement includes reasonable and prudent measures necessary and appropriate to minimize incidental take of CCC ESU steelhead.

In addition to the biological opinion, an Essential Fish Habitat (EFH) consultation is enclosed (Enclosure 2). The EFH consultation for Pacific coast salmon has determined that EFH will be only temporarily adversely affected, and in this case EFH recommendations are not necessary.

If you have any questions regarding this consultation please contact Mr. Bill Stevens of my staff at (707) 575-6016.

Sincerely,

Rodney R. McInnis
Acting Regional Administrator

Enclosures (2)

cc: Jim Lecky, NOAA Fisheries
Don Lash, Corps, Sacramento
Siobhan O'Neill, City of Santa Cruz Public Works Department
Joe Hall, City of Santa Cruz Redevelopment Agency

Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	Department of the Army, Corps of Engineers, Sacramento District
ACTION:	Construction of a Bank Stabilization Wall and Restoration of Wildlife Habitat Conditions Along the San Lorenzo River, Santa Cruz County, California.
CONSULTATION CONDUCTED BY:	National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR02SR8288
DATE ISSUED:	DEC 11 2003

I. CONSULTATION HISTORY

On April 12, 2002, the National Marine Fisheries Service (NOAA Fisheries) met with the City of Santa Cruz and the United States Army Corps of Engineers (Corps) to discuss the proposed project and conduct a site review. Another meeting occurred on December 10, 2002, to discuss information necessary to initiate consultation pursuant to section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*) and how to minimize potential adverse impacts to listed salmonids and their habitat from the proposed action. Communications, including telephone calls and electronic mail, between NOAA Fisheries, the City of Santa Cruz, and the Corps resulted in identification of potential impacts to Central California Coast (CCC) Evolutionarily Significant Unit (ESU) steelhead (*Oncorhynchus mykiss*), CCC ESU coho salmon (*O. kisutch*), and designated critical habitat for threatened CCC ESU coho salmon from the proposed project. Impact minimization and conservation measures were developed to ensure the project was constructed in the manner considered least damaging to the environment and to minimize the effects to threatened CCC steelhead, CCC coho salmon, and designated critical habitat for CCC ESU coho salmon. Many of these measures were incorporated into the Corps' proposal and are referred to below in the *Description of the Proposed Action* section of this biological opinion.

On March 25, 2003, NOAA Fisheries received the Corps' March 20, 2003, draft Environmental Assessment (EA) and request for formal consultation pursuant to section 7(a)(2) of the ESA. The Corps determined the project may affect CCC ESU steelhead, CCC ESU coho salmon, and designated critical habitat for threatened CCC ESU coho salmon. On April 15, 2003, NOAA Fisheries informed the Corps that all of the information necessary to initiate formal consultation as outlined in the regulations governing interagency consultations (50 CFR 402.14) had not been

received. On June 11, 2003, NOAA Fisheries received the additional information and formal section 7 consultation was initiated. The Corps' August 22, 2003, second and final draft EA was received in our office on August 26, 2003.

During consultation, NOAA Fisheries determined that coho salmon were not likely to be adversely affected by the proposed project. This biological opinion analyzes the effects of the bank stabilization and habitat restoration project on threatened CCC steelhead and designated critical habitat for threatened CCC coho salmon. This biological opinion is based on the best scientific and commercial data available including information contained in the EA, the Corps' Project Description, other letters and electronic mails, field investigations, telephone conversations, and other sources of information. A complete administrative record of this consultation is on file at the NOAA Fisheries Santa Rosa Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

The Corps proposes to design and construct a bank stabilization wall and restore wildlife habitat along 900 feet of eroding river bank on the lower San Lorenzo River, in the City of Santa Cruz, Santa Cruz County, California. In addition, the existing maintenance road at the top of the bank would be rebuilt and restored for pedestrian, and emergency access. The street adjacent to the maintenance road will be replaced and improved. Construction is estimated to take approximately nine months and is scheduled to begin in April 2004. This action will enhance instream habitat conditions in the lower San Lorenzo River, stabilize the river bank, reduce erosion, and allow for the repairs to the maintenance road at the top of the riverbank.

A. Background

In response to severe flooding in 1938, 1941, and 1955, a Corps flood control project was completed in 1960 and designed to provide 100-year flood protection. Sediment deposition has reduced the capacity to about the 25-year level. Congressional authorization in 1986 and 1995 allowed for the modification of levees and habitat improvements to the San Lorenzo River, including: raising existing levees to the Federal Emergency Management Agency 100-year flood protection level, retrofitting and raising existing bridges, installing floodwalls, and revegetating the outer levee slopes with native riparian species to improve habitat. Construction on the San Lorenzo River Flood Control and Habitat Restoration Project began in 1999 and is scheduled for completion by 2003. On July 9, 1998, NOAA Fisheries provided its biological opinion on the Corps' San Lorenzo River Flood Control and Habitat Restoration Project that involved: (1) levee work, involving construction of levee crowns and land side levee slopes, and; (2) sediment removal from the active channel and reconfiguration of the fish passage low flow channel (NOAA Fisheries 1998). Bank erosion and scouring problems were not addressed as part of the flood control project. The City of Santa Cruz obtained Congressional authorization in 1999 which allowed for the design and construction of bank protection features (the proposed project) along a heavily scoured section of river.

B. Project Actions

The project site is along the west bank of the San Lorenzo River at the final bend of the river before the ocean. This reach extends from the Soquel Avenue Bridge to the Riverside Avenue Bridge. The Corps proposes to construct the wall away from the existing slope of the Purisima Shelf formation (a sandstone sedimentary sequence in the river bank), set back far enough to allow establishment of a natural slope and increase the area for in-channel vegetation. The height of the wall would range from approximately nine feet to 20 feet. Specifically, the Corps proposes to construct a soil-nail wall, which is a wall that relies on mechanical anchors and shot-crete to provide the force required to retain the riverbank.

The project also contains habitat enhancement components. At the base of the wall, the Corps will install the following habitat features: a log crib wall, root wad vanes, boulders, and in-stream vegetation. The main functions of these features are to enhance the formation of pools for fish habitat. The Corps will install the following habitat enhancement features: 1) approximately 119 linear feet (LF) of a one-tiered log crib structure and 261 LF of a two-tiered log crib structure along the base of the bank protection wall; 2) 50 LF of footer logs; 3) 76 LF of root wads; 4) 90 LF of log vanes, which will deflect and reduce flow velocities during high flow events; and 5) approximately 24 cubic yards of boulders that will anchor the log vanes and provide substrate for plant establishment. The Corps will use approximately 450 tons of river stone and sandy loam material to fill in the voids of the log crib structure to establish in-channel vegetation. In-channel planting includes species native to the San Lorenzo River watershed (most likely tree pole cuttings from the watershed and seedlings grown from local nurseries). The City of Santa Cruz, the non-Federal sponsor of this project, will be responsible for maintenance of the habitat and landscape features after the Corps completes construction[1].

In-channel construction would commence on May 1, 2004, with installation of a temporary water diversion structure that would be used to dewater the river adjacent to the site in order to facilitate in-channel work. In-channel work will be finished on October 31, 2004. Water diversion would be done at low tide to minimize the quantity of water to be diverted. The preliminary construction specifications call for use of a portable frame diversion system with an impermeable membrane such as a PortaDam™, with removal of water and relocation of fish conducted by a qualified fisheries biologist.

The PortaDam™ will be installed starting at the upstream end of the project site; allowing most water to flow out of the portion of the river to be enclosed. An approximate 30-foot wide swath of channel will be dewatered along 1,000 feet of river bank. Pumps will be used to incrementally draw down the water leaving only the deeper areas with standing water (pools). The pumps will be screened to exclude fish. Groundwater encountered during project activities will be filtered

[1]Maintenance needs cannot be accurately anticipated at this time and were not analyzed in this consultation.

before being pumped back into the river. A fisheries biologist will be on-site to capture any fish that may become stranded in the pools. Stranded fish will be captured with dip nets or seines, placed in a container with river water, and transferred into the flowing water of the San Lorenzo River. Nets may be used to guide fish into a specific location in order to capture the fish. This process should take approximately one to two days depending on the river flow at the time of construction.

Construction of a maintenance road and the improvement of a street are proposed as part of the bank stabilization project. At the top of the bank stabilization wall, the Corps will construct an eight- to ten-foot wide maintenance road and connect it to a downstream river maintenance road. The proposed maintenance road will parallel the Laurel Street Extension and continue along Third Street toward Riverside Avenue Bridge. The maintenance road project includes the construction of an overlook at the intersection of Laurel Street Extension and Third Street, protective railings, and overhead street lighting. Adjacent to the maintenance access road, the Corps will install a continuous three-foot wide vegetated strip consisting of native trees and shrubs along the entire length of the project. The trees will provide shade cover for the river and separate the street from the maintenance road. Finally, the Corps will replace and improve the Laurel Street Extension and Third Street, maintaining Laurel Street Extension's 13-foot one-way direction and Third Street's two-way (12-foot wide) lane direction.

Equipment to be used includes standard construction equipment such as graders, compactors, and haul trucks. Two areas have been designated as equipment and construction staging areas: the existing City of Santa Cruz permit parking lot on the northern end of the Laurel Street Extension and one lane of Third Street between Riverside Avenue and Laurel Street Extension.

C. Minimization and Conservation Measures

The following minimization and conservation measures for CCC steelhead were compiled by NOAA Fisheries from the draft EA developed for the project (Corps 2003) and discussions with the Corps. It is NOAA Fisheries' understanding the following general conditions will be applied to this project to minimize impacts to listed salmonids:

- In-channel construction will be restricted to May 1 through October 31.
- The initial diversion of water will be done during low tide and with incremental drawdowns.
- River flow in the main channel will not be disrupted at anytime during construction activities.
- Relocation of all trapped fish will be conducted by a qualified fisheries biologist.

- Pumps used to draw water out of the secured area will be installed with fish screens.

- The use of best management practices (*e.g.*, filtering groundwater before it is pumped back into the river, and prohibiting fueling, cleaning, or maintenance of equipment in or near the bed and banks of the river) will be implemented to reduce the probability of sediment and/or contaminated material from entering the river.

- No construction will be conducted within the wetted channel (aside from the containment barrier installation).

- Following in-stream operations, all equipment and materials will be removed from the San Lorenzo River.

- Erosion control methods (*e.g.*, a stormwater pollution prevention plan and revegetation upon completion of project construction) will be implemented during and after operations.

D. Action Area

The action area is defined by regulation as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR 402.02). As such, the action area of this biological opinion includes the immediate area of the project site, beginning with the active stream bed and banks within the containment barrier (*e.g.*, PortaDam™), the bank up to the road, including planting areas, and effects downstream of the containment barrier. The action area for this project is further defined as the 30-foot wide swath of channel that will be dewatered along 1,000 feet of river bank (30,000 square feet). The ultimate distance downstream of the project site where effects (*i.e.*, sedimentation and turbidity) may occur cannot be quantified. However, based on sedimentation and turbidity from similar projects in similar streams, NOAA Fisheries expects these effects will be minor.

III. DESCRIPTION AND STATUS OF THE SPECIES

This biological opinion analyzes the adverse effects of the proposed project on the following species and designated critical habitat:

- Threatened CCC ESU steelhead (62 FR 43937).
- Designated Critical Habitat for CCC ESU coho salmon (64 FR 24049).

Threatened CCC ESU coho salmon (61 FR 56138) are believed to be extirpated from the San Lorenzo River watershed at this time. This species therefore will not be considered in the effects analysis of this biological opinion.

A. Species Description

Because juvenile steelhead are expected to be rearing in the action area at the time of project activities, life history requirements during this life stage is discussed below in detail.

Spawning by adult steelhead may occur between December and June, but specific timing of spawning may vary a month or more among streams within a region. Shapovalov and Taft (1954) estimated hatching time of steelhead in Waddell Creek, Santa Cruz County, was from 25 to 35 days, emergence from the gravel began two to three weeks after hatching, and another two to three weeks was required to complete emergence. After emergence, steelhead fry utilize habitats with swift currents, moving gradually into deeper water as they grow. Older fry establish territories which they defend.

Juvenile steelhead require living space (different combinations of water depth and velocity), shelter from predators and harsh environmental conditions, food resources, and suitable water quality and quantity, for development and survival during summer and winter (Bjornn and Reiser 1991). Young-of-the-year (0+) and yearling steelhead generally use riffles and runs (*e.g.*, Roper *et al.* 1994) during much of a given year where these habitats exist. However, 0+ and older juveniles may seek cover and cool water in pools during the summer (Nielsen *et al.* 1994). Juvenile steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles.

Streamside vegetation and cover are essential (Bjornn and Reiser 1991). Steelhead juveniles are usually associated with the bottom of the stream. In smaller California streams, the water levels may drop so low during the summer that pools become isolated and are the only viable rearing habitat. Daytime temperatures in summer rearing pools also may be near lethal levels; riparian shading and the presence of sub-surface, cold water seeps are often essential to maintain pool temperatures at tolerable levels. Because rearing juvenile steelhead reside in freshwater all year, adequate flow and temperature are important to the population at all times (California Department of Fish and Game (CDFG) 1997). In winter, juvenile steelhead become inactive and hide in any available cover, including gravel or woody debris.

Juvenile steelhead are affected by water temperature and dissolved oxygen (DO) levels. Water temperatures influence the growth rate, population density, swimming ability, ability to capture and metabolize food, and ability to withstand disease of these rearing juveniles. Dissolved oxygen levels of 6.5 to 7.0 milligrams per liter (mg/L) affected the migration and swimming performance of steelhead juveniles at all temperatures (Davis *et al.* 1963). Low DO levels decrease the rate of metabolism, swimming speed, growth rate, food consumption rate, efficiency of food utilization, affect normal behaviors, and ultimately reduce the survival rate of the

juveniles.

During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Larger juvenile salmon and trout appear to be little affected by ephemerally high concentrations of suspended sediments that occur during most storms (Cordone and Kelly 1961, Sorenson *et al.* 1977) but juvenile salmonids tend to avoid streams that are chronically turbid, such as those disturbed by human activities (Lloyd *et al.* 1987).

B. ESU Status and Trends

Steelhead abundance in the CCC ESU is low. Increases in stream water temperature and other habitat alterations over large areas in the ESU have led to shifts in fish communities favoring warm water species. Steelhead north of the Russian River (the largest river in the ESU located in Sonoma and Mendocino Counties, California) are still fairly abundant. However, streams impacted by urban development, typically support few, if any, steelhead. Nonetheless, this species remains more common than Chinook salmon (*O. tshawytscha*) and coho salmon in Northern California.

While there are no specific estimates of abundance at the population scale, steelhead numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this ESU in the mid-1960s, including 50,000 fish in the Russian River and 19,000 fish in the San Lorenzo River (Busby *et al.* 1996). The San Lorenzo River is the second largest river in the ESU. Based on the best data available NOAA Fisheries has estimated Russian River steelhead currently number about 7,000 fish, including hatchery fish which are currently not considered part of the listed population (Busby *et al.* 1996, NOAA Fisheries 1997a). San Lorenzo River steelhead are thought to number approximately 1,000 to 2,500 fish (Alley 2000), including hatchery fish, which are considered part of the listed population in this river. Abundance estimates for smaller coastal streams in the ESU indicate low but stable levels (NOAA Fisheries 1997a), with recent estimates for several streams (Lagunitas Creek (San Mateo County), Waddell Creek, Scott Creek, San Vincente Creek, Soquel Creek, and Aptos Creek (all in Santa Cruz County) of individual run sizes of 500 fish or less (62 FR 43937).

A positive indicator for the ESU is CCC steelhead have maintained a wide distribution throughout the area (62 FR 43937). Species with broad distributions are more likely to survive environmental fluctuations and stochastic events, even if they suffer local extirpation (Pimm *et al.* 1988). However, the West Coast Biological Review Team analyzed juvenile data that were collected at numerous sites in the ESU using a variety of methods. The data suggest an overall decline in juvenile abundance and the hypothesis that the ESU is stable or increasing can be statistically rejected, dependent on sampling conditions (NOAA Fisheries 2003).

In 1997 NOAA Fisheries identified past and present hatchery operations as the major threat to genetic integrity for steelhead in this ESU in (NOAA Fisheries 1997a). Hatcheries can cause adverse genetic impacts on wild fish populations, disease transmission, predation on wild fish, replacement rather than supplementation of wild stocks, and depletion of wild stocks to increase brood stocks (61 FR 56138). The two hatchery operations in the ESU are: (1) Don Clausen Fish Hatchery, which includes the hatchery and collection site on Dry Creek, tributary to the Russian River, Sonoma County, and the Coyote Valley Fish Facility, located on the East Fork of the Russian River, Mendocino County; and (2) Kingfisher Flat Hatchery (Monterey Bay Salmon and Trout Project), located on Big Creek, tributary to Scott Creek, Santa Cruz County. These hatchery operations have been improved to address genetic concerns. The stock has not had out-of-basin introductions in recent years, and hatchery fish are excluded from the broodstock. The current program goal of each hatchery is the restoration of local steelhead stocks.

C. Factors Responsible for Stock Declines: Changes to Habitat and Other Impacts

Threats to naturally reproducing steelhead are numerous and varied. Habitat degradation and destruction (CDFG 1998), natural stochastic events (*e.g.*, droughts, landslides and floods), ocean conditions (Beamish and Bouillion 1993, Beamish *et al.* 1997, Johnson 1988), alteration of stream flows (Chapman and Bjornn 1969, Berggren and Filardo 1993, 61 FR 56138), artificial propagation (Waples 1991, 1999, 61 FR 56138), predation by marine mammals (NOAA Fisheries 1999, Hanson 1993), and reduced marine-derived nutrient transport (Bilby *et al.* 1996, Bilby *et al.* 1998, Gresh *et al.* 2000) have played a role to varying degrees in the decline of steelhead populations. Among the most serious and ongoing threats to steelhead survival in this ESU are changes in hydrology and freshwater habitat degradation and loss (NOAA Fisheries 1996).

D. Coho Salmon Critical Habitat

The proposed project occurs in the San Lorenzo River, which contains designated critical habitat for threatened CCC ESU coho salmon. In designating critical habitat, NOAA Fisheries considers the following requirements of the species: (1) space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, (5) in general, habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species (50 CFR 424.12(b)). In addition to these factors, NOAA Fisheries also focuses on known physical and biological features (primary constituent elements) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

The condition of CCC ESU coho salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid

populations. NOAA Fisheries has determined present depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat: Logging, agricultural and mining activities, urbanization, stream channelization, dams, wetland loss, water withdrawals and unscreened diversions for irrigation.

Numerous studies have demonstrated land use activities associated with logging, road construction, urban development, mining, agriculture, and recreation have significantly degraded coho salmon critical habitat quantity and quality in the CCC coho salmon ESU. Impacts of concern include alteration of stream bank and channel morphology, alteration of water temperatures, loss of spawning and rearing habitat, fragmentation of habitat, loss of downstream recruitment of spawning gravels and large woody debris, degradation of water quality, removal of riparian vegetation resulting in increased stream bank erosion, increases in erosion entry to streams from upland areas, loss of shade (resulting in higher water temperatures) and loss of nutrient inputs (64 FR 50394, NOAA Fisheries 1996, 61 FR 56138).

E. Status of the Species in the San Lorenzo River

1. Overview

The San Lorenzo River is the primary municipal water source of the greater Santa Cruz area, with approximately 85,000 customers (60-80 percent of the City of Santa Cruz's supply; County of Santa Cruz 2000). Approximately 75,000 people live within the watershed and obtain water supply from smaller streams and groundwater basins within the watershed (County of Santa Cruz 2000). The San Lorenzo River watershed includes 80 miles of streams and is currently subject to numerous deleterious impacts including water diversions, summer dams, timber harvest, and urbanization.

Watersheds within the San Lorenzo River are sinuous and incised with many ridges and deep ravines. Slow downward soil movement and landslides are the natural erosional processes chiefly responsible for forming the topography of this area. Numerous faults cross the San Lorenzo Valley and pose a potential geologic hazard and contribute overall to sediment loading in the Santa Cruz Mountains (Balance Hydrologics, Inc. 1998).

2. Steelhead in the San Lorenzo River

Recent data for the San Lorenzo River watershed suggested this basin has a steelhead population smaller than 15 percent of the size it had 30 years previously. This basin was thought to have originally contained one of the two largest steelhead populations in the ESU (NOAA Fisheries 2003).

Since 1994, the County of Santa Cruz, the City of Santa Cruz, and the San Lorenzo Valley Water District have collaboratively funded surveys in the San Lorenzo River and its tributaries to ascertain population levels of steelhead. These surveys have been more rigorous than past efforts

and provide the best available estimate of year-to-year status of steelhead in the San Lorenzo River watershed. In 2002, estimated juvenile steelhead abundance extrapolated to the mainstem of the San Lorenzo River and all sampled tributaries was 168,278, the highest since 1998, which had similar abundance estimates (H.T. Harvey & Associates 2003).

In the summer of 2002, two sites (0a and 0b) in the San Lorenzo River nearest the project site (site 0a was approximately at the Water Street Bridge; 3,700 feet upstream of the upstream portion of the project site) were sampled and juvenile steelhead abundances were estimated (H.T. Harvey & Associates 2003). Total juvenile density at sampling sites 0a and 0b was 3.9/100 feet and 3.0/100 feet, respectively. All steelhead captured were ≥85 millimeters (mm) in length. Each summer a sandbar builds up at the mouth of the river, creating a lagoon. During late fall or early winter, the sandbar naturally breaches due to high river flows and storm-induced wave action. Two surveys conducted in the fall of 2002 from the mouth of the San Lorenzo River to the Water Street Bridge resulted in 51 steelhead (pre-beach seining) and 11 steelhead (post-breach seining). All steelhead captured were ≥85 mm in length. The trap nets failed to capture steelhead during either of the two sampling periods.

3. Anthropogenic Factors Affecting Species in the San Lorenzo River

A variety of factors, both anthropogenic and natural, have played a role in the decline of steelhead in the San Lorenzo River. Natural events, such as floods, droughts, and ocean productivity cycles, have depressed population numbers when these events occur. However, the more recent anthropogenic destruction and degradation of essential freshwater habitats have reduced the resiliency of steelhead populations to natural disturbances.

Excessive erosion, sedimentation, and turbidity (SCCPD 1979), diminished streamflows (SCCPD 1979, NOAA Fisheries 2001a, Denise Duffy & Associates, Inc. 1999) channelization (Mount 1995), and summer dams (NOAA Fisheries 2001b) have degraded steelhead spawning and rearing habitats and designated critical habitat for CCC coho salmon in the San Lorenzo River watershed. These effects caused by on-going activities such as urbanization and water diversions are expected to continue to occur in the San Lorenzo River.

The San Lorenzo River is located near the southern boundary of the CCC coho salmon ESU and the southernmost range of coho salmon in the western United States. Coho salmon used the San Lorenzo River for spawning and rearing. In 1954-55, the estimated adult coho salmon run in the San Lorenzo River ranged between 7,000 and 14,000 (State Water Resources Control Board 1982). This watershed's value as critical habitat is high for coho salmon, given its location near the southernmost extent of their range and the relatively large coho population it supported historically. Recovering coho salmon to the full extent of their former range will likely require restoring important components of critical habitat in the San Lorenzo River, such as spawning and rearing areas.

IV. ENVIRONMENTAL BASELINE

1. Aquatic Habitat Conditions in the Action Area

The project site is located along the west bank within the estuarine reach of the San Lorenzo River. This reach of the river consists of a single slack-water channel that has been heavily modified by encroachment, filling, fragmentation, levee construction, and rock lining of the lower estuary. The project area is located along a heavily scoured bank. At the bottom of the bank, a sandstone Purisima Shelf protrudes a few feet into the river channel. This rock formation was exposed as a result of river scouring. Several small resting pools of slow-moving water are below the shelf, but they have no cover elements for fish. Vegetation along the levee toe is maintained in a 10-foot buffer. A narrow one-way road adjacent to a vertical sandstone bluff is at the top of the river bank. This street is used by pedestrians, cyclists, and vehicular traffic. Part of the asphalt from this road overhangs the bank due to severe undercutting during high flow events.

The action area is influenced by the sandbar conditions at the mouth of the San Lorenzo River, approximately 3,700 feet downstream. During most summer and fall months, deep-water conditions occur due to development of a sandbar at the river mouth that allows the estuary to convert to freshwater. The sandbar closes the mouth of the river and forms a seasonal summer lagoon; in wetter years it appears that the sandbar self-breaches when the lagoon fills and spills over the sandbar. The sandbar across the mouth of the river forms naturally through wave action in late spring and summer. Typically, the sandbar forms during June and holds back water until November. In most years, flow levels in the river are lowest in May because the sandbar has not built up enough to hold back water to create a lagoon setting (Don Lash, Corps, pers. com., October 9, 2003). The City of Santa Cruz does not presently implement a sandbar management or breaching program for the mouth of the San Lorenzo River, but did so prior to 1995. Breaching activities were ceased following issues with public safety and natural resource (*e. g.*, steelhead) management.

2. Status of Steelhead in the Action Area

Steelhead adults and juveniles use the action area as a migration corridor and as rearing habitat, respectively. Adult steelhead are not expected to be present when the project is scheduled to occur based on the timing of adult migration (winter/spring). Although the project will occur in May when smolts are likely to be outmigrating; their presence on the project site is unlikely. Outmigrating smolts are expected to use the main flow area of the River, which does not run through the project area. Based on 14 seining samples each covering 100 feet of stream length (H.T. Harvey & Associates 2003), NOAA Fisheries estimates juvenile steelhead density in the San Lorenzo River between the mouth of the San Lorenzo River to the Water Street Bridge averages 4.4 steelhead per 100 feet of stream. The San Lorenzo River Bank Stabilization Project is situated nearly equidistant between the Water Street Bridge and the mouth of the river (approximately 3,700 feet from either). NOAA Fisheries estimates that no more than 44 juvenile

steelhead are likely to be present in the action area when the project occurs (4.4 steelhead per 100 feet multiplied by 10 for the 1,000-foot action area).

V. EFFECTS OF THE ACTION

The purpose of this section is to identify the direct and indirect effects of the proposed action on threatened CCC steelhead in the action area and designated critical habitat for threatened CCC coho salmon. Generally, the effects of the proposed action on steelhead and aquatic habitat, including designated coho salmon critical habitat, are those associated with temporarily diverting stream flow and dewatering work spaces to conduct in-channel construction activities and construct the containment barrier.

A. Turbidity and Sedimentation

Increased sedimentation and turbidity could result if fine sediment is contributed to the San Lorenzo River, or mobilized, during the proposed action. Substantial sedimentation rates could bury less mobile organisms (Ellis 1936, Cordone and Kelley 1961) that serve as a food source for many fish species, degrade instream habitat conditions (Cordone and Kelly 1961, Eaglin and Hubert 1993), infiltrate redds resulting in progressively lower egg survival (Tappel and Bjornn 1983, McNeil and Ahnell 1964, Reiser and White 1988, Tagart 1984), and cause reductions in fish abundance (Alexander and Hansen 1986, Berkman and Rabeni 1987) and growth (Crouse *et al.* 1991). Turbidity may cause indirect harm, injury or mortality to juvenile steelhead in the action area. High turbidity concentrations can result in fish mortality, reduce feeding efficiency, and decrease food availability (Berg and Northcote 1985, McLeay *et al.* 1983, Gregory and Northcote 1993, Velagic 1995).

The in-channel work proposed will likely cause increased levels of sedimentation and turbidity in the action area because the stream bed and banks will be disturbed. Although specific sedimentation and turbidity rates have not been estimated, NOAA Fisheries expects them to be low and temporary because: the Corps proposes to isolate the work space from flowing water; the in-channel work window will be limited, adequate erosion control measures will be employed at the time of the proposed action, and groundwater encountered during project activities will be filtered before being pumped back into the river. Consequently, sedimentation and turbidity are not expected to have adverse effects on steelhead. Habitat will be only temporarily disturbed, and project clean-up actions and winter flows are expected to return the creek bed and banks to conditions similar to those found in the action area prior to the project.

B. Maintenance Road Lighting

Salmonids are known to avoid high intensity light, and may be attracted to dim lights (Corps 2003). Lights placed along the planned maintenance will be oriented away from the River. Shields will also be placed on the light fixtures to further reduce the amount of light reaching

aquatic habitat. Therefore, NOAA Fisheries does not expect adverse effects to listed salmonids from the proposed lighting.

C. Fish Capture and Relocation

Juvenile steelhead within the project site will be captured following the installation of the containment barrier and relocated to adjacent suitable habitat. As described previously in the *Environmental Baseline* section, NOAA Fisheries does not expect more than 44 steelhead will need to be captured and relocated.

An effect of principal concern is mortality and injury to juvenile steelhead in the work area due to fish capture and relocation activities. Any fish relocation gear, whether passive (Hubert 1983) or active (Hayes 1983) has some associated risk to the fish, including stress, disease transmission, injury, or death.

Dip nets and/or seines will be used to capture and relocate juvenile steelhead. Small steelhead can be gilled in the mesh of a seine and scales and dermal mucus can be abraded by contacting the net. Juvenile steelhead can be suffocated if they are not quickly removed from the net after the net is removed from the water to process steelhead. Steelhead also can be crushed by the handler if the handler steps on the net. The risks to juvenile steelhead can be minimized if the handler carefully, quickly, and thoroughly removes all steelhead from the net and places them in bucket of water.

After juvenile steelhead are relocated, stress from crowding and increased competition for food in the relocation areas may occur. This stress and increased competition in the relocation areas will be minimal and temporary. Upon project completion, steelhead will be able to redistribute in the action area unimpeded.

Based on NOAA Fisheries prior experience with current relocation techniques and protocols to be used to conduct the fish capture and relocation activities, unintentional mortality of listed juvenile CCC steelhead expected from capture and handling procedures is not likely to exceed three percent of the fish subjected to handling, and can be reduced to near one percent with increased skill and experience of the fish relocation personnel. Despite these impacts, fish capture and relocation operations are expected to significantly minimize project impacts to steelhead by removing them from areas where they would have experienced high rates of injury and mortality. Based on the estimate of salmonid numbers given above, and a three percent mortality rate from dip netting and/or seining, NOAA Fisheries expects no more than two steelhead will be killed during fish capture and relocation activities.

D. Dewatering

Stream flow diversion and work space dewatering is expected to cause temporary loss, alteration, and reduction of aquatic habitat within the action area. Stream flow diversions could harm

individual steelhead by concentrating or stranding them in residual wetted areas (Cushman 1985) before they are relocated, or causing them to move to adjacent habitats (Clothier 1953, 1954, Kraft 1972, Campbell and Scott 1984). Steelhead could be killed or injured if crushed beneath the containment barrier during installation, though direct mortality is expected to be minimal because of the small number of steelhead in the action area. During installation of the containment barrier, a fisheries biologist will remain in the river to net and rescue any additional fish that may have become stranded throughout the dewatering process.

Steelhead which avoid capture in work spaces will die during dewatering activities. However, because the affected space is small and the number of steelhead which avoid capture likely few, the number of steelhead subject to mortality via stranding will be few. NOAA Fisheries expects the juvenile steelhead stranding rate associated with dewatering for this project will be less than the unintentional mortality rate from capturing and handling procedures (three percent). Based on the estimates of salmonid numbers given above, NOAA Fisheries expects no more than one steelhead to be killed as a result of stranding during dewatering activities.

Benthic (*i.e.*, bottom dwelling) aquatic macroinvertebrates may be temporarily lost or their abundance reduced when individual organisms are stranded or when creek habitats are dewatered (Cushman 1985). Effects to aquatic macroinvertebrates resulting from stream flow diversions and dewatering will be temporary because construction activities will be relatively short-lived, and rapid recolonization (about one to two months) of disturbed areas by macroinvertebrates (Cushman 1985, Thomas 1985, Harvey 1986) is expected following rewatering. In addition, the effect of macroinvertebrate loss on juvenile steelhead is likely to be negligible because food from upstream sources (via drift) would be available downstream of the dewatered areas since stream flows will be maintained outside of the checkdam. Based on the foregoing, the loss of aquatic macroinvertebrates as a result of dewatering activities is not expected to adversely effect steelhead.

E. In-Channel Habitat Structures

A single-tier crib wall, two-tier crib wall, footer logs, and root wad vanes with boulders will be placed in the dewatered channel and attached to the bank stabilization wall. Vegetation will be planted and the river bank slope will be restored to existing grade. As a result of these activities, emergent and riparian vegetation will be enhanced, local river flow velocities will be reduced, sediment/pool formation will be enhanced, and in-stream cover and habitat diversity will be increased. NOAA Fisheries expects these effects to be beneficial and long-lasting to CCC steelhead and designated critical habitat for CCC coho salmon.

F. Interrelated and Interdependent Actions

An interrelated action is an activity that is part of a larger action and depends on the larger action for its justification. An interdependent action is an activity that has no independent utility apart from the action under consultation (50 CFR 402.02). There are no known interrelated or

interdependent actions associated with the Corps constructing the bank stabilization project.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Other than the on-going activities described above in the *Environmental Baseline* section, NOAA Fisheries is unaware of future State, tribal, local, or private actions reasonably certain to occur that will affect the action area.

VII. INTEGRATION AND SYNTHESIS OF EFFECTS

The San Lorenzo River Bank Stabilization Project will result in the dewatering of approximately 30,000 square feet of the San Lorenzo River. Steelhead present in the area to be dewatered will be subject to capture and relocation. A few juvenile steelhead (no more than three) will likely be killed as a result of relocation and dewatering activities.

Although the population of steelhead in the San Lorenzo River is considerably depressed from historical numbers, NOAA Fisheries does not believe the loss of three juvenile steelhead will appreciably reduce the number, distribution, or reproduction of steelhead in the San Lorenzo River. The project has no long term detrimental impacts on steelhead habitat and will not restrict the amount of juvenile rearing space in future years. Beneficial effects to steelhead habitat are expected. Based on the estimated 1,000 to 2,500 adult steelhead in the San Lorenzo River, a one-time loss of three juvenile steelhead rearing in the action area during project construction is unlikely to have a detectable effect on this population's abundance or viability because the remaining population is large enough to be resilient to this small, one-time, loss. Spawning in subsequent years is expected to produce enough juveniles to repopulate any habitat areas that may become vacant by the loss of three juveniles. As noted, the survival chances of juveniles in these areas in future years are likely to improve. Thus, survival and recovery of this population, or the ESU in general, is not likely to be appreciably reduced.

The effects of the project will result in temporary impacts (*i.e.*, dewatering and loss of macroinvertebrates) to critical coho salmon habitat. These impacts will last no more than a few weeks based on the impact minimization measures and conservation measures proposed. The area of the channel disturbed for the instream work is expected to return to pre-project conditions following project completion. The effects of placing in-channel habitat structures are expected to be beneficial and long-lasting to CCC steelhead and designated critical habitat for CCC coho salmon.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the status of CCC steelhead, the environmental baseline for the action area including the condition of CCC coho salmon critical habitat, the effects of the proposed San Lorenzo River Bank Stabilization Project, and cumulative effects, it is NOAA Fisheries' biological opinion that the proposed project is not likely to jeopardize the continued existence of CCC steelhead, nor is it likely to destroy or adversely modify designated coho salmon critical habitat.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NOAA Fisheries as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require its designees to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the actions and its impact on the species to NOAA Fisheries as specified in the incidental take statement. (50 CFR §402.14(I)(3)).

A. Amount or Extent of Take

NOAA Fisheries anticipates incidental take of CCC steelhead is likely to occur as a result of implementation of the proposed project. The best available information has been used to estimate the number of CCC steelhead likely to be taken is 44.

NOAA Fisheries anticipates the following take is likely to occur:

1. No more than 43 juvenile steelhead will be captured and relocated from the work area.

2. Based on the number of juvenile steelhead captured (43) and a three percent mortality rate from dip netting and/or seining, NOAA Fisheries would expect only two juvenile steelhead to be killed during capture and relocation activities.

3. Based on NOAA Fisheries' best judgement of the number of juvenile steelhead that will remain on site after steelhead relocation activities, NOAA Fisheries would expect only one juvenile steelhead to be killed as a result of stranding during dewatering activities.

B. Effect of the Take

In the accompanying biological opinion, NOAA Fisheries determined this level of anticipated take is not likely to result in jeopardy to CCC steelhead and the project is not likely to result in the destruction nor adverse modification of CCC coho salmon critical habitat.

This incidental take statement is based on implementation of the proposed San Lorenzo River Bank Stabilization Project as described in the Description of the Proposed Action section of this biological opinion, including impact minimization and conservation measures incorporated into the project design. Failure to implement the project as proposed (including relevant conservation measures) or implementation of the project in a manner that causes an effect to listed species, or designated critical habitat not considered in this opinion may cause coverage of section 7(o)(2) to lapse and require reinitiation of consultation to ensure compliance with section 7(a)(2) of the ESA.

C. Reasonable and Prudent Measures

The following reasonable and prudent measures are necessary and appropriate to minimize take of threatened CCC steelhead. The results of the effect analysis in this biological opinion provide the basis for the reasonable and prudent measures.

1. The Corps shall implement measures to reduce and monitor steelhead injury and mortality associated with dewatering and fish relocation activities.

2. The Corps shall implement minimization and conservation measures that will avoid and minimize impacts to CCC steelhead.

3. The Corps shall report to NOAA Fisheries activities associated with minimizing and monitoring effects of the proposed action on steelhead.

D. Terms and Conditions

In order to be exempt from the take prohibitions of the ESA, the Corps must comply with the following non-discretionary Terms and Conditions, which implement the Reasonable and Prudent Measures described above and outline reporting/monitoring conditions.

The following Terms and Conditions implement Reasonable and Prudent Measure No. 1.

1. Captured fish shall be kept in cool, shaded, aerated water (*e.g.*, plastic bucket) protected from noise or jostling any time they are not in the stream and fish shall not be removed from this water except for (1) collection of genetic material (see below) and (2) when released.

2. Fish capture activities shall be conducted by a NOAA Fisheries-approved biologist. Contact NOAA Fisheries (see below) for approval procedures.

3. Fish shall not be overcrowded into buckets, allowing approximately six cubic inches per 0+ individual and more for larger/older fish.

4. Make every effort not to mix 0+ with larger salmonids, or other potential predators, that may consume the smaller salmonids.

5. A copy of this biological opinion shall be kept on-site for the duration of the project.

The following Term and Condition implements Reasonable and Prudent Measure No. 2.

1. Fish screens on pumps shall be implemented according to NOAA Fisheries' *Fish Screening Criteria for Anadromous Salmonids* (NOAA Fisheries 1997b).

The following Terms and Conditions implement Reasonable and Prudent Measure No. 3.

1. Notify NOAA Fisheries one week prior to capture activities in order to provide an opportunity to attend. Call Bill Stevens at (707) 575-6016, or e-mail at William.Stevens@noaa.gov

2. Provide a written monitoring report to NOAA Fisheries within 90 working days following the completion of the proposed action. The report shall include the number of CCC steelhead killed or injured during the proposed action; the number and size (in millimeters) of steelhead captured and removed; any effect of the proposed action on steelhead not previously considered; and, photographs taken before, during, and after the activity from photo reference points. All data relating to steelhead shall be submitted to the Santa Rosa NOAA Fisheries office at 777 Sonoma Avenue, Room 325, Santa Rosa, California, 95404-6528, Attention: Bill Stevens.

3. If more than three listed salmonids are killed, injured, or found dead or injured, the project permitee shall contact NOAA Fisheries Biologist Bill Stevens by phone immediately at (707) 575-6016. If Mr. Stevens cannot be reached, the

Santa Rosa NOAA Fisheries Office will be contacted at (707) 578-8555. The purpose of the contact is to review the activities resulting in take and to determine if additional protective measures are required. All steelhead mortalities must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NOAA Fisheries.

4. For all steelhead captured, genetic tissue data shall be collected. The following information shall be part of the Genetic Tissue Collection Data:

Collection Date
Collection Location (County, River, Exact location on river)
Collector Name
Collector Affiliation/Phone
Sample ID Number
Species Tissue Type
Condition
Fork Length (mm; in order to facilitate measurements, fish may be anesthetized.)
Sex (M, F, Unk.)
Adipose Fin Clip? (Y or N)
Tag? (Y or N)
Notes/Comments

Genetic tissue shall be collected according to the following protocols:

a. Live fish: Cut a three millimeter (mm) square clip from tail fin using clean scissors and place sample in a piece of dry blotter/filter paper (*e.g.*, Whatman brand). Return steelhead to aerated bucket to recover. Fold blotter paper over for temporary storage. Samples must be air-dried as soon as possible (do not wait more than eight hours). Air-drying inside takes about 24 hours; air-drying in the sun is much quicker. When blotter/filter paper is dry to the touch, place it and sample into a clean envelope labeled with Sample ID Number. Seal envelope.

b. Live fish (alternate method): Cut a three mm square clip from tail fin using clean scissors and store the clip in a small (*e.g.*, two milliliter) vial filled with pure ethanol. Return steelhead to aerated bucket to recover. Sample must be fully immersed in ethanol. Ethanol dissolves all

inks, so make sure vials are well sealed and outside is dry. Label with Sample ID Number.

c. Carcasses: Either a three mm square clip from the operculum or tail fin, or alternately, complete scales (20-30) should be removed and placed on a piece of dry blotter/filter paper (*e.g.*, Whatman brand). Fold blotter paper over for temporary storage. Samples must be air-dried as soon as possible (do not wait more than eight hours). When tissue/paper is dry to the touch, place into a clean envelope labeled with Sample ID Number. Seal envelope

d. Additional guidelines:

Never cut adipose fin.
Each sample must be stored in a separate tube or envelope.
Each sample must be clearly labeled with the Sample ID Number.
Samples may be sent surface mail.
Samples are for scientific research. Please take care in their collection.

5. The Genetic Tissue Collection Data shall be provided to the Salmonid Genetic Repository, NOAA Fisheries Science Center, 110 Shaffer Road, Santa Cruz, California, 95060. Please contact Dr. Carlos Garza at (831) 420-3903 with questions or for additional instructions.

6. All non-salmonid aquatic vertebrates will be collected and relocated during electrofishing activities.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. NOAA Fisheries recommends the Corps develop plans to address the impacts of summer dams in the San Lorenzo River watershed on salmonids.

2. NOAA Fisheries recommends the Corps work with the City of Santa Cruz, other agencies, and stakeholders to develop and implement a program for protection and restoration of salmon and steelhead habitat in the San Lorenzo River.

3. NOAA Fisheries recommends the Corps work with the City of Santa Cruz to develop a City-wide plan on how to minimize impacts to riparian habitats on projects permitted by the Corps.

In order for NOAA Fisheries to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NOAA Fisheries requests notification of the implementation of any conservation recommendations.

XI. REINITIATION NOTICE

This concludes formal consultation on the actions outlined in the project proposal. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered in this opinion; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; (4) a new species is listed or critical habitat designated that may be affected by the action; or (5) the measures outlined above and included in the project proposal are not fully implemented. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XII. LITERATURE CITED

Alexander, G.R., and E.A. Hansen. 1986. Sand bed load in a brook trout stream. North American Journal of Fisheries Management. 6:9-23.

Alley, D.W., & Associates. 2000. Comparisons of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for the San Lorenzo River, Santa Cruz County, 1995-99; with an Index of Adult Returns. Unpublished report prepared for City of Santa Cruz Water Department, Santa Cruz County Environmental Planning and the San Lorenzo Valley Water District. June 2000. 256 pages + appendices.

Balance Hydrologics, Inc. 1998. An assessment of streambed conditions and erosion control efforts in the San Lorenzo River watershed, Santa Cruz County, California. Unpublished report prepared for Environmental Health Dept., Santa Cruz Co., California. July 13, 1998.

Beamish, R.J., and D.R. Bouillion. 1993. Pacific salmon production trends in relation to climate. Canadian Journal of Fisheries and Aquatic Sciences 50:1002-1016.

____, C.M. Neville, and A.J. Cass. 1997. Production of Fraser River sockeye salmon (*Oncorhynchus nerka*) in relation to decadal-scale changes in the climate and the ocean. Canadian Journal of Fisheries and Aquatic Sciences 54:543-554.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Fisheries Engineering Research Program, Portland, Oregon.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Berggren, T.J. and M.J. Filardo. 1993. An analysis of variable influencing the migration of juvenile salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13:48-63.

Berkman, H.E., and C.F. Rabeni. 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18:285-294.

Bilby, R.E., B.R. Fransen, P.A. Bisson, and J.K. Walter. 1998. Response of juvenile coho salmon (*Oncorynchus kisutch*) and steelhead (*Oncorynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, USA. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Transactions of the American Fisheries Society 100:423-438.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14:237-261.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. United States Department of Commerce, NOAA Technical Memo NMFS-NWFSC-27. 261 pages. August 1996.

California Department of Fish and Game. 1997. Eel River Salmon and Steelhead Restoration Action Plan, Final Review Draft, January 28, 1997. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California.

____. 1998. Draft strategic plan for restoration of the endangered coho salmon south of San Francisco Bay. September 1998.

Campbell, R.N.B., and D. Scott. 1984. The determination of minimum discharge for 0+ brown trout (*Salmo trutta L.*) using a velocity response. New Zealand Journal of Marine and Freshwater Resources 18:1-11.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding, p. 153-176. In: T. G. Northcote (ed.). Symposium on Salmon and Trout in Streams. H. R. MacMillan Lectures in Fisheries, Institute of Fisheries, Univ. of British Columbia, Vancouver, BC. 388 pages.

Clothier, W.D. 1953. Fish loss and movement in irrigation diversions from the west Gallatin River, Montana. Journal of Wildlife Management 17:144-158.

____. 1954. Effect of water reductions on fish movement in irrigation diversions. Journal of Wildlife Management 18: 150-160.

Cordone, A.J., and D.W. Kelley. 1961. The influences of inorganic sediment of the aquatic life of streams. California Fish and Game pp. 189-228.

County of Santa Cruz. March 2000. San Lorenzo wastewater management plan. Program status report 1996-1998. Unpublished report prepared for Health Services Agency, Environmental Health Service, Santa Cruz, California.

Crouse, M.R., C.A. Callahan, K.W. Malueg, and S.E. Dominguez. 1991. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110:281-286.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5:330-339.

Davis, G.E., J. Foster, C.E. Warren, and P. Doudoroff. 1963. The influence of oxygen concentration on the swimming performance of juvenile Pacific salmon at various temperatures. Transactions of the American Fisheries Society 92(2):111-124.

Denise Duffy & Associates, Inc. December 1999. Draft environmental impact report for the Mount Hermon Christian Conference Center master plan. Unpublished report prepared for County of Santa Cruz Planning Department. Denise Duffy & Associates, Inc., 947 Cass Street, Suite 5, Monterey, California 93940.

Eaglin, G.S., and W.A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13:844-846.

Ellis, M.M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17:29-42.

Gregory, R.S., and T.G. Northcote. 1993. Surface, planktonic, and benthic foraging by juvenile chinook salmon (*Oncorhynchus tshawytscha*) in turbid laboratory conditions. Canadian Journal of Fisheries and Aquatic Sciences 50:233-240.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast pacific ecosystem. Fisheries 15(1):15-21.

Hanson, L.C. 1993. The foraging ecology of Harbor Seals, *Phoca vitulina*, and California Sea Lions, *Zalophus californianus*, at the mouth of the Russian River, California. Master of Science thesis, Sonoma State University, Rohnert Park, California.

Harvey, B.C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. North American Journal of Fisheries Management 6:401-409.

Hayes, M.L. 1983. Active Capture Techniques. Pages 123-146 *In* L.A. Nielsen and D.L. Johnson, eds. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland. 468 pages.

H.T. Harvey & Associates. 2003. Salmonid Monitoring in the San Lorenzo River, 2002. Unpublished report prepared for the City of Santa Cruz Water Department. June 27, 2003. Project No. 2163-01. 58 pages + appendices.

Hubert, W.A. 1983. Passive Capture Techniques. Pages 95-122 *In:* L.A. Nielsen and D.L. Johnson, eds. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland. 468 pages.

Johnson, S.L. 1988. The effects of the 1983 El Niño on Oregon's coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) salmon. Fisheries Research 6:105-123.

Kraft, M.E. 1972. Effects of controlled flow reduction on a trout stream. J. Fish. Res. Board of Canada 29:1405-1411.

Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

McLeay, D.J., A.J. Knox, J.G. Malick, I..K. Birtwell, G. Hartman, and G.L. Ennis. 1983. Effects on Arctic grayling (*Thymallus arcticus*) of short-term exposure to Yukon placer mining sediments: laboratory and field studies. Canadian Technical Report of Fisheries and Aquatic Sciences 1171.

McNeil, W.J., and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish and Wildlife Service Special Scientific Report Fisheries 469.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and life histories. American Fisheries Society Special Publication 19:47-82.

Mount, J.F. 1995. California rivers and streams: the conflict between fluvial process and land use. University of California Press, Berkeley, California.

Nielsen, J.L., T.E. Lisle, and V. Ozaki. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society 123:613-626.

National Oceanic and Atmospheric Administration. 1996. Factors for decline; a supplement to the notice of determination for West Coast steelhead under the Endangered Species Act. Portland, OR. 80 pages.

____. 1997a. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. 67 pages.

____. 1997b. Fish screening criteria for anadromous salmonids. National Marine Fisheries Service, Southwest Region, Santa Rosa Field Office. January 1997.

____. 1998. Biological Opinion. San Lorenzo River Flood Control and Habitat Enhancement. Reference Number 151422SWR985SR9013. 19p. July 9,1998.

____. 1999. Impacts of California sea lions and Pacific harbor seals on salmonids and West Coast ecosystems. Report to Congress. Available from NOAA Fisheries, Protected Resources Division, 777 Sonoma Avenue, Room 325, Santa Rosa, California 95404.

____. 2001a. Biological Opinion. Widening of Branciforte and Carbonera Creek Bridges on U.S. Route 1, Santa Cruz County, California. Reference Number 151422SWR01SR195. 46p. November 14, 2001.

____. 2001b. The effects of summer dams on salmon and steelhead in California coastal watersheds and recommendations for mitigating their impacts. National Marine Fisheries Service, Southwest Region, Santa Rosa, California. July 23, 2001. 49 pages.

____. 2003. Preliminary conclusions regarding status of listed ESUs of West Coast salmon and steelhead (Draft). West Coast Biological Review Team. February 2003.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. W.R. Meehan, editor. U.S. Department of Agriculture Forest Service General Technical Report PNW-96.

____, and R.G. White. 1988. Effects of two sediment size-classes on survival of steelhead and chinook salmon eggs. North American Journal of Fisheries Management 8:432-437.

Santa Cruz County Planning Department. 1979. San Lorenzo River Watershed Management Plan, including Technical Appendices. Unpublished report prepared for Water Resources Management memorandum, County of Santa Cruz, County Administrative Office. 23 pages. January 15, 1999.

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. California Department of Fish and Game, Fish Bulletin 98:1-375.

Sorenson, D.L., M.M. McCarthy, E.J. Middlebrooks, and D.B. Porcella. 1977. Suspended and dissolved solids effects on freshwater biota. U.S. Environmental Protection Agency, EPA-600/3-77-042 *In*: Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

State Water Resources Control Board. 1982. Draft staff report for fact-finding hearing: Zayante Creek/Lower San Lorenzo River and the upper San Lorenzo River instream beneficial use protection program. *Prepared by*: staff of State Water Resources Control Board. September 28, 1982.

Tagart, J.V. 1984. Coho salmon survival from egg deposition to fry emergence. Pages 173-182 *In* J. M. Walton and D. B. Houston, editors. Proceedings of the Olympic Wild Fish Conference. Peninsula College, Port Angeles, Washington.

Tappel, P.D., and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Thelander, C.G., editor. 1994. Life on the Edge; A guide to California's endangered natural resources: Wildlife. 1994. BioSystems Books, Santa Cruz. 550 pages.

Thomas, V.G. 1985. Experimentally determined impacts of a small, suction gold dredge on a Montana stream. North American Journal of Fisheries Management 5:480-488.

United States Army Corps of Engineers. 2003. Draft Environmental Assessment: San Lorenzo River Bank Stabilization Project, City of Santa Cruz, Santa Cruz County, California. August 2003.

Velagic, E. 1995. Turbidity study: a literature review. Prepared for Delta planning branch, California Department of Water Resources by Centers for Water and Wildland Resources, University of California, Davis.

Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48 (supplement 1):124-133.

____. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

A. Federal Register Notices

61 FR 56138: Endangered and Threatened Species: Threatened Status for Central California Coho Salmon Evolutionarily Significant Unit (ESU). National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce. Final Rule. Federal Register, Volume 61, No. 212, October 31, 1996. pp 56138-56149.

62 FR 43937: Endangered and Threatened Species: Listing of Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce. Final Rule. Federal Register, Volume 62, No. 159, August 18, 1997. pp. 43937-43954.

64 FR 24049: Designated Critical Habitat; Central California Coast Coho Salmon and Southern Oregon/Northern California Coasts Coho Salmon. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce. Final Rule and Correction. Federal Register, Volume 64, No. 86, May 5, 1999. pp. 24049-24062

64 FR 50394: Endangered and Threatened Species: Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce. Final Rule. Federal Register, Volume 64, No. 179, September 16, 1999. pp 50934-50415.

Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

I. INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established requirements for Essential Fish Habitat (EFH) descriptions in Federal fishery management plans and to require Federal agencies to consult with the National Marine Fisheries Service (NOAA Fisheries) on activities that may adversely affect EFH. Essential Fish Habitat for Pacific Coast salmon has been described in Appendix A, Amendment 14 to the Pacific Coast Salmon Fishery Management Plan. The San Lorenzo River bank stabilization project constructed by the U.S. Army Corps of Engineers (Corps) affects the San Lorenzo River, which has been designated EFH for salmon.

Only species managed under a Federal fishery management plan are covered under the MSFCMA. Coho salmon and Chinook salmon are managed under Federal fishery management plans, whereas steelhead are not managed. Therefore, these EFH Conservation Recommendations address only coho salmon and do not address steelhead. No recommendations are presented for Chinook salmon EFH because Chinook salmon are not present and do not use the San Lorenzo River watershed.

II. LIFE HISTORY AND HABITAT REQUIREMENTS

The life history of coho salmon in California has been well documented by Shapovalov and Taft (1954) and Hassler (1987). In contrast to the life history patterns of other anadromous salmonids, coho salmon in California generally exhibit a relatively simple 3-year life cycle (Shapovalov and Taft 1954, Hassler 1987). Adult salmon typically begin the freshwater migration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). Delays in river entry of over a month are not unusual (Salo and Bayliff 1958, Eames *et al.* 1981). Migration continues to March, generally peaking in December and January, with spawning occurring shortly after returning to the spawning grounds (Shapovalov and Taft 1954).

Coho salmon are typically associated with small to moderately-sized coastal streams characterized by heavily forested watersheds; perennially-flowing reaches of cool, high-quality water; dense riparian canopy; deep pools with abundant overhead cover; instream cover consisting of large, stable woody debris and undercut banks; and gravel or cobble substrates.

Female coho salmon choose spawning sites usually near the head of a riffle, just below a pool, where water changes from a laminar to a turbulent flow and there is small to medium gravel

substrate. The flow characteristics of the location of the redd usually ensure good aeration of eggs and embryos, and flushing of waste products. The water circulation in these areas also facilitates fry emergence from the gravel. Preferred spawning grounds have nearby overhead and submerged cover for holding adults; water depth of 10-54 centimeters (cm); water velocities of 20-80 cubic meters per second (cm/s); clean, loosely compacted gravel (1.3-12.7 cm diameter) with less than 20 percent fine silt or sand content; cool water (4-10 degrees Celsius [°C]) with high dissolved oxygen (8 milligrams per liter [mg/l]); and an intergravel flow sufficient to aerate the eggs. The lack of suitable gravel often limits successful spawning in many streams.

Each female builds a series of redds (nests), moving upstream as she does so, and deposits a few hundred eggs in each. Fecundity of coho salmon is directly proportional to female size; coho salmon may produce deposit from 1,000-7,600 eggs (reviewed in Sandercock 1991). Briggs (1953) noted a dominant male accompanies a female during spawning, but one or more subordinate males also may engage in spawning. Coho salmon may spawn in more than one redd and with more than one partner (Sandercock 1991). Coho salmon are semelparous (they spawn once and then die). The female may guard a nest for up to two weeks (Briggs 1953).

The eggs generally hatch between four to eight weeks, depending on water temperature. Survival and development rates depend on temperature and dissolved oxygen levels within the redd. According to Baker and Reynolds (1986), under optimum conditions, mortality during this period can be as low as 10 percent; under adverse conditions of high scouring flows or heavy siltation, mortality may be close to 100 percent. McMahon (1983) found that egg and fry survival drops sharply when fines make up 15 percent or more of the substrate. The newly-hatched fry remain in the gravel from two to seven weeks until emergence from the gravels (Shapovalov and Taft 1954). Upon emergence, fry seek out shallow water, usually along stream margins. As they grow, they often occupy habitat at the heads of pools, which generally provide an optimum mix of high food availability and good cover with low swimming cost (Nielsen 1992). Chapman and Bjornn (1969) determined that larger parr tend to occupy the head of pools, with smaller parr found further down the pools. As the fish continue to grow, they move into deeper water and expand their territories until, by July and August, they are in the deep pools. Juvenile coho salmon prefer well shaded pools at least 1 meter deep with dense overhead cover; abundant submerged cover composed of undercut banks, logs, roots, and other woody debris; preferred water temperatures of 12-15°C (Brett 1952, Reiser and Bjornn 1979), but not exceeding 22-25°C (Brungs and Jones 1977) for extended time periods; dissolved oxygen levels of 4-9 mg/l; and water velocities of 9-24 cm/sec in pools and 31-46 cm/sec in riffles. Water temperatures for good survival and growth of juvenile coho salmon range from 10-15°C (Bell 1973, McMahon 1983). Growth is slowed considerably at 18°C and ceases at 20°C (Stein *et al.* 1972, Bell 1973).

Preferred rearing habitat has little or no turbidity and high sustained invertebrate forage production. Juvenile coho salmon feed primarily on drifting terrestrial insects, much of which are produced in the riparian canopy, and on aquatic invertebrates growing in the interstices of the substrate and in the leaf litter in the pools. As water temperatures decrease in the fall and winter

months, fish stop or reduce feeding due to lack of food or in response to the colder water, and growth rates slow down. During December-February, winter rains result in increased stream flows and by March, following peak flows, fish again feed heavily on insects and crustaceans and grow rapidly.

In the spring, as yearlings, juvenile coho salmon undergo a physiological process, or smoltification, which prepares them for living in the marine environment. They begin to migrate downstream to the ocean during late March and early April, and out migration usually peaks in mid-May, if conditions are favorable. Emigration timing is correlated with peak upwelling currents along the coast. Entry into the ocean at this time facilitates more growth and therefore greater marine survival (Holtby *et al.* 1990). At this point, the smolts are about 10-13 cm in length. After entering the ocean, the immature salmon initially remain in nearshore waters close to their parent stream. They gradually move northward, staying over the continental shelf (Brown *et al.* 1994). Although they can range widely in the north Pacific, movements of coho salmon from California are poorly known.

III. PROPOSED ACTION

The Corps proposes to design and construct a bank stabilization wall and restore wildlife habitat along 900 feet of eroding river bank on the lower San Lorenzo River, in the City of Santa Cruz, Santa Cruz County, California. In addition, the existing maintenance road at the top of the bank would be rebuilt and restored for pedestrian, and emergency access. The street adjacent to the maintenance road will be replaced and improved. Construction is estimated to take approximately nine months and is scheduled to begin in April 2004. This action will enhance instream habitat conditions in the lower San Lorenzo River, stabilize the river bank, reduce erosion, and allow for the repairs to the maintenance road at the top of the riverbank.

IV. EFFECTS OF THE PROJECT ACTION

Effects of the proposed project on salmon EFH are those associated with the implementation of a bank stabilization project on the San Lorenzo River as described in the preceding biological opinion. In the action area in the San Lorenzo River (approximately 30,000 square feet), EFH is temporarily adversely affected by this project due to habitat degradation, sedimentation, turbidity, and loss of macroinvertebrates from construction activities. Ultimately, habitat effects of the proposed project are expected to be beneficial to EFH. The Corps will install root wad vanes, boulders, and in-stream vegetation to create pools for fish habitat at the project site.

V. CONCLUSION

After reviewing the effects of the San Lorenzo River bank stabilization project, NOAA Fisheries believes the project action, as proposed, will adversely affect the EFH of coho salmon in the San Lorenzo River. However, these adverse effects will be minor and temporary. NOAA Fisheries has determined that coho salmon have been extirpated from the San Lorenzo River and will not be impacted by adverse effects from this project. If coho salmon are restored to the river, they may benefit from the habitat improvements resulting from this project. Therefore no EFH recommendations are provided.

VIII. LITERATURE CITED

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.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Fisheries Engineering Research Program, Contract No. DACW57-68-C-006, Portland Oregon.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9:265-323.

Briggs, J.C. 1953. The behavior and reproduction of salmonid fishes in a small coastal stream. State of California Department of Fish and Game, Fish Bulletin 94, 63 pages.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14:237-261.

Brungs, W.A., and B.R. Jones. 1977. Temperature criteria for freshwater fish: protocol and procedures. U.S. Environmental Protection Agency, Environmental Research Laboratory, EPA-600/3-77-061, Duluth, Minnesota, USA.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176. *In*: T.G. Northcote editor. Symposium on Salmon and Trout in Streams. H.R. Macmillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, British Columbia.

Eames, M., T. Quinn, K. Reidinger, and D. Haring. 1981. Northern Puget Sound 1976 adult coho and chum tagging studies. Washington Department of Fisheries Technical Report 64:1-136.

Hassler, T.J. 1987. Species Profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - coho salmon. U.S. Fish and Wildlife Service Biological Report 82:1-19.

Holtby, L.B., B.C. Anderson, and R.K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 47(11): 2181-2194.

McMahon, T.E. 1983. Habitat suitability index models: coho salmon. U.S. Fish and Wildlife Service, USFWS/OBS-82/10.49.

Nielsen, J.L. 1992. The role of cold-pool refugia in the freshwater fish assemblage in northern California rivers. Published in proceedings of the Symposium on Biodiversity of Northwestern California, October 28-30, 1991, Santa Rosa, California.

Reiser, D.W., T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. W.R. Meehan, editor. U.S. Department of Agriculture Forest Service General Technical Report PNW-96.

Salo, E., and W.H. Bayliff. 1958. Artificial and natural production of silver salmon, *Oncorhynchus kisutch*, at Minter Creek, Washington. Washington Department of Fisheries Research Bulletin 4, 76 pages, Washington Department of Fish and Wildlife, Olympia, Washington.

Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 395-445 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, British Columbia, 564 pages.

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. California Department of Fish and Game, Fish Bulletin 98:1-375.

Stein, R.A., P.E. Reimers, and J.D. Hall. 1972. Social interaction between juvenile coho (*Oncorhynchus kisutch*) and fall Chinook salmon (*O. tshawytscha*) in Sixes River, Oregon. Journal of the Fisheries Research Board of Canada 29:1737-1748.