UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

Refer to NMFS No: WCR-2017-8390

April 16, 2018

Baker Holden
Deputy Project Leader
Anadromous Fish Restoration Program
850 S. Guild Avenue, Suite 105
Lodi, California 95240-3188

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road

Dear Mr. Holden:

Thank you for your letter of November 20, 2017, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action. NMFS' review concludes that the project would adversely affect the EFH of Pacific Coast Salmon in the action area.

The enclosed biological opinion (BO), based on the biological assessment, and the best available scientific and commercial information, concludes that the project is not likely to jeopardize the continued existence of the federally listed threatened California Central Valley steelhead distinct population segment (DPS) (*Oncorhynchus mykiss*) and is not likely to destroy or adversely modify their designated critical habitats. NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take of listed species associated with the project.

Please contact Monica Gutierrez in the California Central Valley Office at 916-930-3657 or Monica.Gutierrez@noaa.gov, if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

for Maria Rea

Barry A. Thom
Regional Administrator

Enclosure
cc: To the File ARN 151422-WCR-2017-00391

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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response

Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road

National Marine Fisheries Service (NMFS) Consultation Number: WCR-2017-8390

Action Agency: U.S. Fish and Wildlife Service

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
California Central Valley steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

for Barry A. Thom
Regional Administrator

Date: April 16, 2018

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1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document would be available through NMFS' Public Consultation Tracking System https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at the NMFS California Central Valley Office.

1.2 Consultation History

- On November 20, 2017, NMFS received an electronic copy of the initiation letter and BA of the proposed project, via email, from the action agency, U.S. Fish and Wildlife Service (USFWS).
- On November 22, 2017, NMFS received the hard copy in the mail of the initiation letter and BA, which constituted a complete application package.
- On December 19, 2017, NMFS issued a letter to the USFWS notifying them that we've received a complete initiation package and that consultation was initiated on November 22, 2017.
- On April 3, 2018, NMFS received a letter from USFWS, stating that the U.S. Army Corps of Engineers (Corps) has designated USFWS as the lead Federal agency. The permitting actions and impacts for the Corps authorizations under Section 404 of the Clean Water Act, 33 U.S.C. 1344 and Section 14 of the Rivers and Harbors Act, 33 U.S.C. 408 (Section 408), are also included in the biological assessment. However, since USFWS is the lead Federal Agency for this project, consultation with the Corps will not be required.

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). The USFWS proposes to fund the

Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road.

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). In 2009, NMFS issued the Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project and State Water Project (OCAP). This opinion includes Reasonable and Prudent Alternatives (RPAs): III.2.1. Increase and Improve Quality of Spawning Habitat with Addition of 50,000 Cubic Yards of Gravel by 2014 and with a Minimum Addition of 8,000 Cubic Yards per Year for the Duration of the Project Actions, and III.2.2. Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on One- to Three-Year Schedule. The current project supports both of these objectives required by NMFS to avoid jeopardy for California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*) in the Stanislaus River. However, the proposed project is a stand-alone project and doesn't depend on any other projects for its justification, therefore there are no interrelated or interdependent actions associated with the Project.

1.3.1 Project Purpose

The Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road (Proposed Project) is designed to restore and enhance ecosystem processes with a primary focus on improving productive salmonid habitat for spawning, egg incubation, and juvenile rearing to increase natural production of Central Valley (CV) fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and CCV steelhead (*O. mykiss*) in the lower Stanislaus River. The Proposed Project would directly address the doubling goal of the United States Fish and Wildlife Service's Anadromous Fish Restoration Program (USFWS AFRP), the NMFS priority action in the Recovery Plan (NMFS 2014) to increase the quantity and quality of spawning and rearing areas in Central Valley rivers for Endangered Species Act (ESA)-listed Chinook Salmon and CCV steelhead, and test hypotheses regarding a variety of habitat enhancement techniques and subsequent utilization (or lack thereof) of salmonids in spawning, floodplain, and off-channel habitats.

In addition, the USFWS has determined that it is a high priority to improve Stanislaus River watershed management to restore and protect instream and riparian habitat, including restoring and replenishing spawning gravel and rearing habitat (USFWS 2001). The California Department of Fish and Wildlife (CDFW; formerly known as California Department of Fish and Game [CDFG]) has determined that the river reach between Goodwin Dam and the confluence with the San Joaquin River is of considerable importance for maintenance and restoration of Chinook Salmon and CCV steelhead (CDFG 1993).

The AFRP is the funding entity and Federal lead action agency and, with the consultant teams, Cramer Fish Sciences and ESA Associates, support the development of restoration designs, construction and monitoring of the Proposed Project.

1.3.2 Project Location Description

The Proposed Project would take place in the Stanislaus River below Goodwin Dam (the extent of anadromy), located approximately 1 mile upstream from the Highway 120 Bridge (Figure 1).

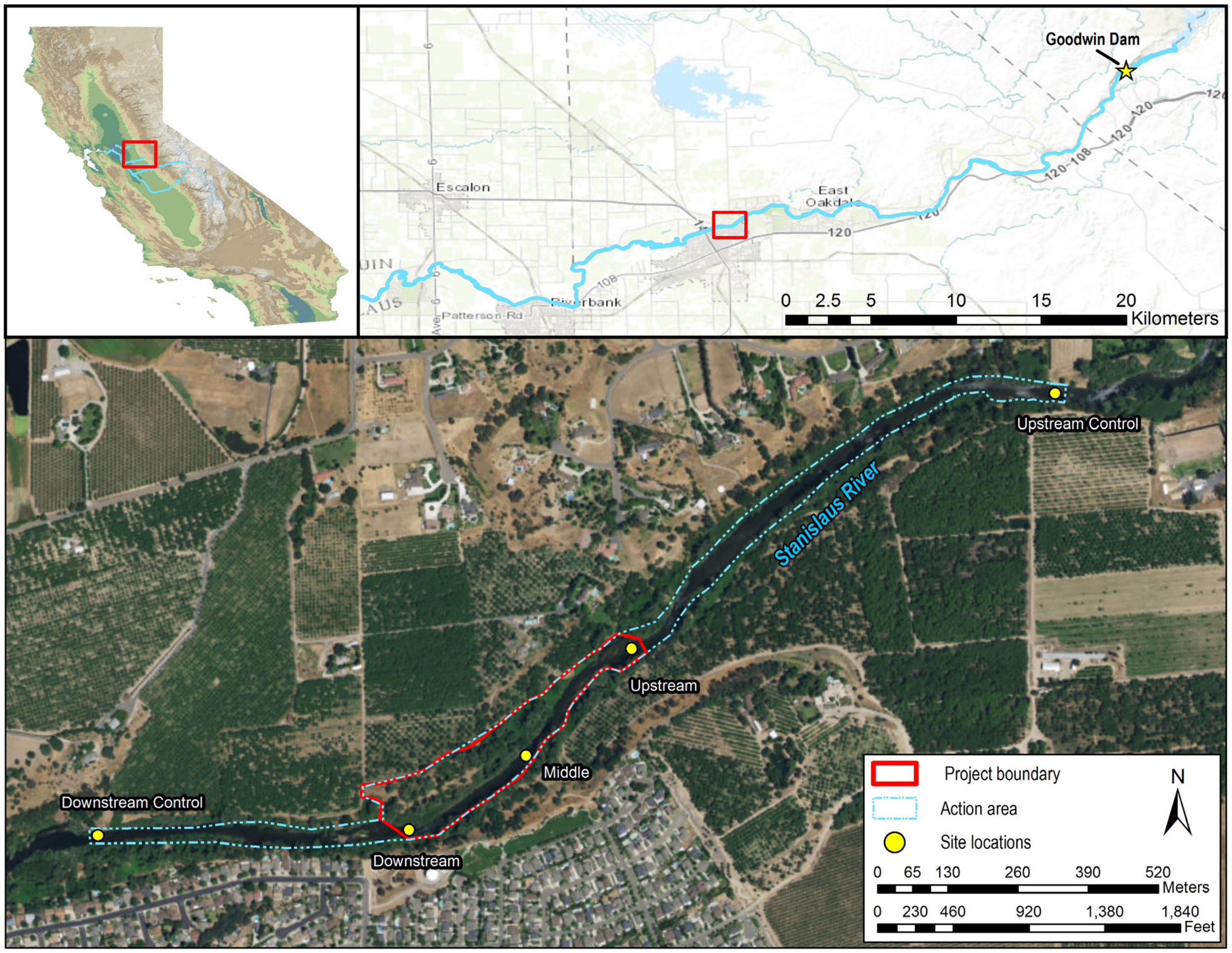

Figure 1. Proposed project location and boundary on the lower Stanislaus River.

The Stanislaus River within the site exhibits an entrenched channel with little habitat complexity. There are pools at the top and bottom of the site with a sequence of riffles and runs between the pools. The north side of the channel contains a remnant vegetated floodplain that is perched and is rarely inundated under the current flow regime. The south side of the channel has a relatively steep, vegetated continuous bank along the majority of the project site with some smaller discontinuous terraces present. The primary aquatic habitat types in the Project Area are riffles, runs, and pools. Many of the juvenile Chinook salmon and CCV steelhead rearing within the Stanislaus River are observed holding in association with submerged vegetation and woody material (Cramer Fish Sciences unpublished data). Various types of fish cover are present within the site, including submerged terrestrial vegetation and roots, instream woody material, and overhead cover provided by low-growing riparian vegetation (Cramer Fish Sciences 2015a). Some locations support aquatic macrophytes that also provide cover for fish. The quality and quantity of salmonid spawning habitat in the lower Stanislaus River has also been reduced by anthropogenic impacts (Kondolf *et al*. 2001, NMFS 2014).

The bed profile in the project area is at a transition from steeper reaches of the river to lowland reaches with a much more gradual slope (Figure 2). The average bed slope in the project reach is approximately 0.0007, while it is closer to 0.001 for the first 50,000 ft below Goodwin Dam and 0.0003 below the Highway 120 bridge (Figure 2).

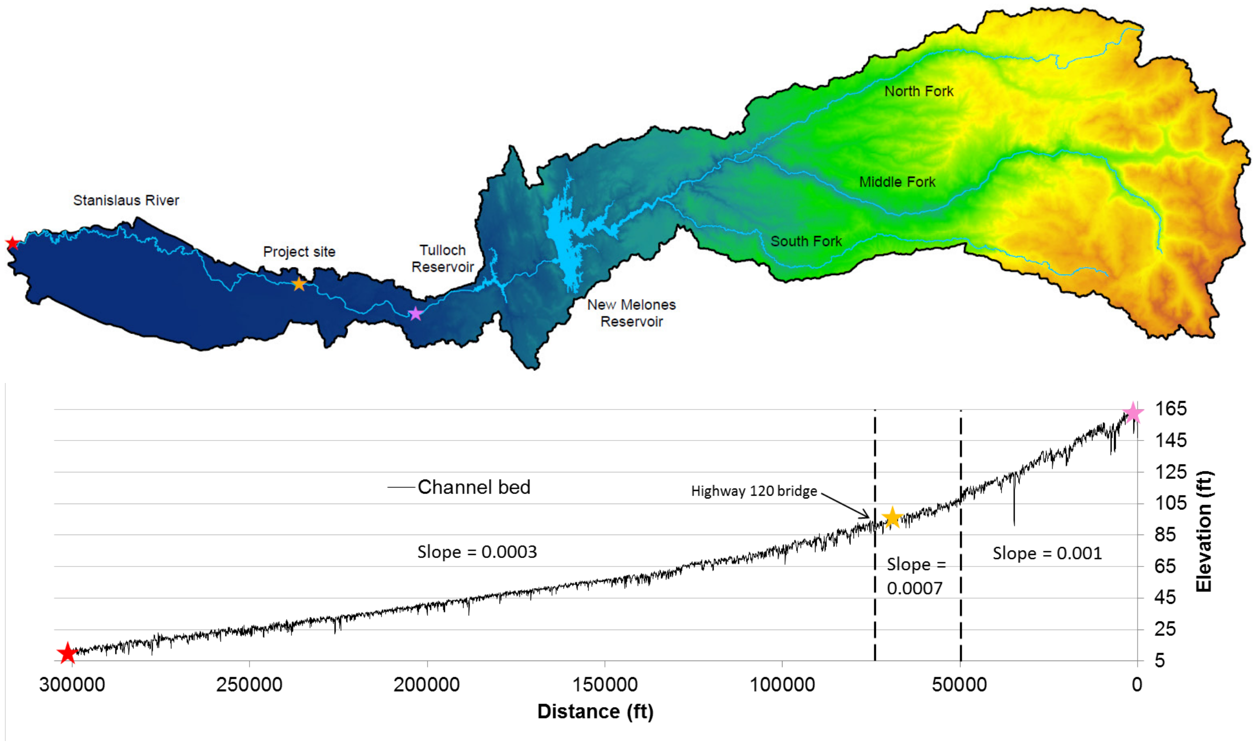

Figure 2. Watershed map of the Stanislaus River (top) and long profile of the Stanislaus River below Goodwin Dam to the confluence with the San Joaquin River (bottom). The Project site is denoted by a yellow star and Goodwin Dam (limit of anadromy) by a pink star.

Native fishes observed at the site or likely present include fall-run Chinook salmon, CCV steelhead, Pacific Lamprey (*Entosphenus tridentatus*), Western Brook Lamprey (*Lampetra richardsoni*), Sacramento Pikeminnow (*Ptychocheilus grandis)*, Sacramento Sucker *(Catostomus occidentalis)*, Threespine Stickleback (*Gasterosteus aculeatus*), Riffle Sculpin (*Cottus gullosus*), Prickly Sculpin *(Cottus asper*), and Tule Perch *(Hysterocarpus traski*). Non-native fishes observed at the site or likely present include Black Bass (*Micropterus* spp.), Striped Bass (*Morone saxatilis*), Sunfish (*Lepomis* spp.), Crappie (*Pomoxis* spp.), and Bullhead (*Ameiurus* spp.)(Moyle 2002).

The riparian vegetation present at the site includes the native tree species; Fremont cottonwood (*Populus fremontii*), Northern California walnut (*Juglans hindsii*), Oregon ash (*Fraxinus latifolia*), valley oak (*Quercus lobata*), Gooding's wouldow (*Salix gooddingii*) and the non-native tree species; cultivated plum (*Prunus* sp.) (Vaghti and Cramer Fish Sciences 2017). The riparian understory is dominated by Himalayan blackberry (*Rubus armeniacus*), a non-native species, with California wild grape (*Vitis californica*), dusky wouldow (*Salix melanopsis*), elderberry (*Sambucus nigra* ssp. *cerulea*), and California button-wouldow (*Cephalanthus occidentalis* var. *californicus*) also being common (Vaghti and Cramer Fish Sciences 2017). The non-native grass, ripgut brome (*Bromus diandrus*), is also common throughout the site (Vaghti and Cramer Fish Sciences 2017).

The Stanislaus River, which drains an approximately 1,100 square mile (mi^2) watershed, has a north, middle, and south fork, which each originate in the Sierra Nevada mountain range. The Middle Fork and North Fork join together to form the main Stanislaus River, which then flows into New Melones Reservoir. The South Fork of the Stanislaus River flows directly into New Melones Reservoir. Elevations in the watershed range from 13,000 ft (4,000 m) at the crest of the Sierra Nevada to 50 ft (15 m) at the confluence with the San Joaquin River.

1.3.3 Project Description

Gravel Augmentation and Channel Modification
The Proposed Project would re-grade and rehabilitate approximately 4.9 acres (1.98 hectares [ha]) of perched floodplain and spawning riffles (Figure 3). Approximately 23,000 cubic yards (yd3) (~17,585 m3) of material would be excavated during floodplain lowering and side channel creation.

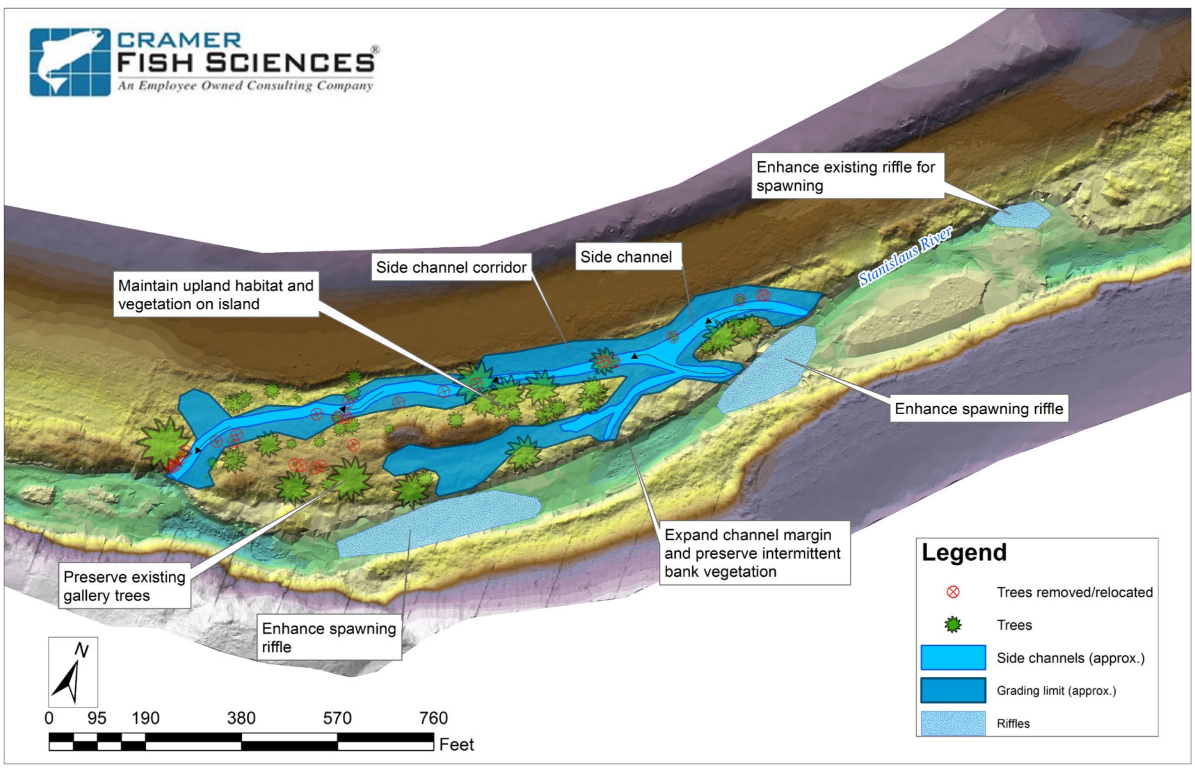

Figure 3. Stanislaus River Salmonid Habitat Restoration Project at Rodden Road conceptual design with floodplain grading (side channels) and gravel augmentation (spawning habitat) areas indicated.

Approximately 1,362 yd^3 (~1041 m^3) of washed, rounded river gravel and cobble would be purchased from a Stanislaus River Watershed quarry and transported to the site to enhance/create spawning riffles within the site. The gravel would already be washed offsite prior to being transported to the project site. The river rock would be placed in the main channel to enhance/create 1.1 acres (0.42 ha) and 769 linear feet (ft) of salmonid spawning habitat and increase water surface elevation to facilitate inundation of the floodplain and side channels (Figure 3). The enhanced/created spawning riffles would consist of 5 to 10 inch diameter (12.7 to 25.4 centimeter [cm]) cobbles used to build up base layer and stabilize the toe of spawning riffles and ¼ – 5 inch diameter (0.6 – 12.7 cm; per AFRP specifications) gravel that would be placed 2 to 3 ft (0.6 – 0.9 m) deep. Gravel would be deposited instream and placed by rubber-tired front-end loaders (Caterpillar 950 Loader).

An approximately 3.8 acre (1.54 ha) perched floodplain area on the north side of the river would be re-graded by 1-10 ft (0.3 – 3.0 m) in elevation, allowing it to inundate at flows greater than 1,000 cubic feet per second (cfs). Side channels, totaling 3.5 acres (1.42 ha) and 2,000 ft (610 m) would be created on the reclaimed floodplain. The floodplain and side channel excavation would require no in-channel work, as construction would occur when flows are lower than the features are designed to inundate.

The strategy for instream gravel replenishment is based on the existing channel bed topography (Cramer Fish Sciences unpublished data), and is intended to re-create channel bedforms to enhance spawning of salmon and steelhead. Gravel would be placed using designs from the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) developed by the University of California at Davis (Wheaton *et al*. 2004 a, b, Pasternack 2008, Sawyer *et al*. 2009), and general rearing habitat components.

Table 2. Estimated area and channel length of habitats and excavation and fill volumes associated with the Stanislaus River Habitat Restoration Project located at Rodden Road on the Stanislaus River, Stanislaus County, California.

Habitat Type	**Excavation Volume (yards^3)**	**Fill Volume (yards^3)**	**Area (Acres)**	**Channel Length (ft)**
Main Channel Riffle (Spawning Habitat)	---	1,362	1.1	769
Side Channel Complex (Floodplain)	23,000	---	3.8	2,000
TOTAL	**23,000**	**1,362**	**4.9**	**2,769**

Riparian Vegetation Enhancement

Native trees, such as Fremont cottonwood, oak, and willow with a diameter at breast height (dbh) of at least 12 in (15.2 cm) would be protected with 30 ft (9.1 m), 10 ft (3 m) and 10 ft (3 m) buffers, respectively. To compensate for the removal of riparian shrubs and trees during project implementation, the plans would identify tree and shrub species that would be planted, how, where, and when they would be planted, and measures taken to ensure a performance criteria of 70 percent survival of planted trees for a period of three consecutive years.

The trees removed during restoration activities would be used within the created side channels as large woody material habitat elements. The trees would be strategically placed in the side channels to provide cover and habitat complexity for rearing juvenile salmonids. Juvenile salmonids use large woody material for cover (Shirvell 1990, Beechie *et al*. 2005, Nagayama *et al*. 2009). Juvenile salmonid abundance has been observed to be greater in reaches that contain large woody material than reaches without (Inoue and Nakano 1998, Miyakoshi *et al*. 2002, Roni and Quinn 2001, Nagayama *et al*. 2009).

After floodplain grading and gravel augmentation activities have been completed, the disturbed areas would be revegetated with native riparian plants. Planting would occur in late November, which is the likely beginning of the winter storm season, to maximize survival rates. Exotic species present in the riparian area, including tree of heaven (*Ailanthus altissima*), Himalayan blackberry (*Rubus discolor*), yellow starthistle (*Centaurea solstitialis*) and milk thistle (*Silybum marianum*), would be eradicated where possible. A detailed monitoring program would document the pre-project conditions, rehabilitation and revegetation, and the effectiveness of the planting in terms of vigor and survival (Cramer Fish Sciences 2017) (Table 2). Additionally, trees that cannot be avoided during implementation of the proposed project would be removed and compensated for the following:

- Oaks having a dbh of three to five inches would be replaced in-kind, at a ratio of 3:1, and planted during the winter dormancy period in the nearest suitable location to the area where they were removed. Oaks with a dbh greater than five inches would be replaced in-kind at a ratio of 5:1.
- Riparian trees (i.e., willow, cottonwood, sycamore, alder, ash, etc.) would be replaced in-kind on site at a ratio of 3:1 and planted in the nearest suitable location to the area where they were removed.

Table 2. List of native trees and shrubs that would be removed and compensated for by replanting at the project site.

Species	Removed	Replanted
Oak (*Quercus* spp.)	3	9
Cottonwood (*Populus fremontii*)	7	21
Willow (*Salix* spp.)	6	18
Elderberry (*Sambucus* spp.)	11	33
Total	**27**	**81**

Timing of Proposed Project

To minimize any potential negative effects on CCV steelhead, instream gravel placement activities would occur during summer/early-fall (July 15 to October 15) when flows are low (approximately 300 cubic-feet-per-seconds (cfs)) and is outside of the salmonid spawning timeframe. Hauling fine sediment from the floodplain to an off-site location may occur through November 30; however, no instream work would be conducted after October 15. Construction would occur over a single season and would require approximately 12 weeks, with instream construction requiring approximately 10 to 20 days. Work would occur Monday through Friday from 7:00 am to 5:00 pm to ensure minimal disturbance to the local landowners.

Habitat Suitability Modeling

To evaluate the change in physical habitat from existing to design conditions, habitat suitability modeling was performed for the target species and life stage for defined ecologically meaningful flows. The focus of this analysis was Chinook salmon juvenile rearing habitat. Using outputs of depth and velocity, physical habitat suitability modeling was performed for 2 scenarios:

- Juvenile Chinook Salmon rearing habitat at 1,000 cfs
- Juvenile Chinook Salmon rearing habitat at 3,000 cfs

The USFWS used a combination of habitat suitability criteria (HSC) for river depths and velocities to evaluate potential habitat changes resulting from the project design. These HSC were obtained from habitat suitability preferences developed for Chinook salmon in the Stanislaus River (Aceituno 1990). For each depth and velocity raster at the target flows, the preferred suitability was evaluated creating depth and velocity habitat suitability rasters. Depth and velocity HSC were combined to create a habitat suitability index (HSI) by calculating the geometric mean of the two HSC at any modeled location. These HSI estimates were used to create hydraulic habitat suitability rasters. For each scenario noted above we then compared increases in useable habitat from existing conditions to the 65 percent design surface. The predicted usable habitat, or weighted usable area (WUA), is calculated as the product of wetted area and the corresponding water depth and velocity HSI at that location. Useable habitat at each location in the project site was summed to estimate the total useable habitat for a given flow, where the percent change in usable habitat after project implementation is assumed to be due to restoration actions. The USFWS coupled the hydraulic conditions in the project site at 1,000 cfs and 3,000 cfs with the Chinook salmon rearing HSI to calculate the total usable rearing habitat in the Proposed Project site at that flow.

The juvenile Chinook salmon rearing habitat WUA increase substantially under the design grade of the Proposed Project at the two modeled rearing flows (Figure 4). For a flow of 1,000 cfs under existing conditions the juvenile Chinook Salmon rearing WUA within the project site is 20,831 ft^2 (1,935 m^2) while under project conditions the area of rearing WUA increased to 48,664 ft^2 (4,521 m^2), a 134% increase (Table 3). Similarly, at 3,000 cfs rearing WUA increased from 36,936 ft^2 (3,431 m^2) under existing conditions to 60,964 ft^2 (5,664 m^2) under project conditions, a 65% increase (Table 3).

Table 3. The weighted useable area (WUA; ft^2 and m^2) for juvenile Chinook Salmon rearing habitat under existing and design conditions for the Proposed Project for two spring rearing flows; 1,000 and 3,000 cfs.

Juvenile Rearing WUA

Flow (cfs)	Existing (ft^2)	Design (ft^2)	Existing (m^2)	Design (m^2)
1,000	20,831	48,664	1,935	4,521
3,000	36,936	60,964	3,431	5,664

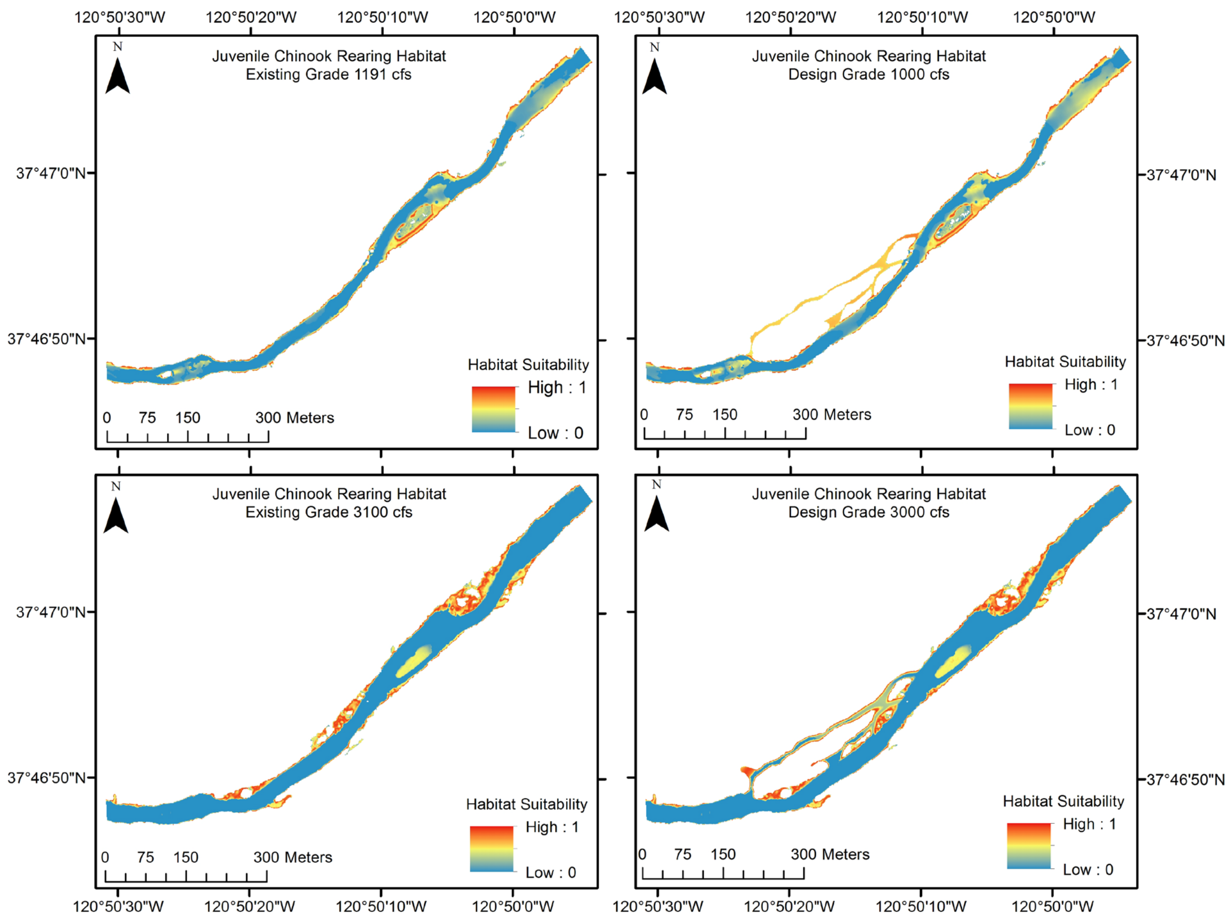

Figure 4. The modeled juvenile Chinook salmon rearing habitat suitability within the Proposed Project site for existing and design grade for two different flow scenarios; 1,000 and 3,000 cfs.

Project Monitoring

A detailed Monitoring Plan has been developed for the Proposed Project, with the primary goal of defining the current state of the system before restoration and determining whether the implemented project had the desired effect on target species and overall system health (Cramer Fish Sciences 2017). The Monitoring Plan follows a before-after-control-impact (BACI) design to account for background variation in success metrics. The Monitoring Plan is intended to be a working document, and would be further refined with input from USFWS AFRP, NMFS, CDFW, and the Stanislaus Operations Group.

The monitoring program consists of four conceptual approaches to monitoring: 1) pre-project site description, 2) implementation, 3) effectiveness, and 4) validation (Table 4). Pre-project monitoring helps identify the baseline for the project including the identification of deficiencies in ecosystem health and for detecting change over time (Roni 2005). Implementation monitoring would determine if the project was constructed according to the design standards. Hydrology, topography and bathymetry, sediment dynamics, and vegetation would be assessed. The effectiveness monitoring would determine if the project was effective in meeting target physical and biological objectives. A range of physical and biological traits would be tracked before and after restoration to assess ecosystem function. Pre-project monitoring is essential for effectiveness monitoring because it establishes an objective baseline of ecosystem function with which to evaluate change caused by the project implementation. Validation monitoring would be conducted to validate the underlying assumptions of the restoration work and determine if restoration projects, like the Proposed Project, recover productive habitat that promotes juvenile salmonid growth and riparian vegetation recruitment. The monitoring efforts described in this plan would improve USFWS' understanding of restored ecosystem function and the potential of restoring off-channel and floodplain rearing habitat to enhance salmonid populations within streams impacted by dam flow regulation and channel modification.

Table 4. Types of monitoring associated with Proposed Project.

Type of monitoring	**Question addressed**	**Time frame**
Pre-project	What is the baseline condition of the site? Does the site contain special-status species?	1-3 years before project implementation
Implementation	Was the project installed as planned?	2+ years
Effectiveness	Was the project effective at meeting restoration objectives?	1 year to decades
Validation	Are the basic assumptions behind the project conceptual model valid?	1-10 years

Fish abundance, habitat use, and community composition would be determined at the project site using field methods described below. The general locations where snorkel surveys and benthic macroinvertebrate sampling occur are depicted on Figure 5.

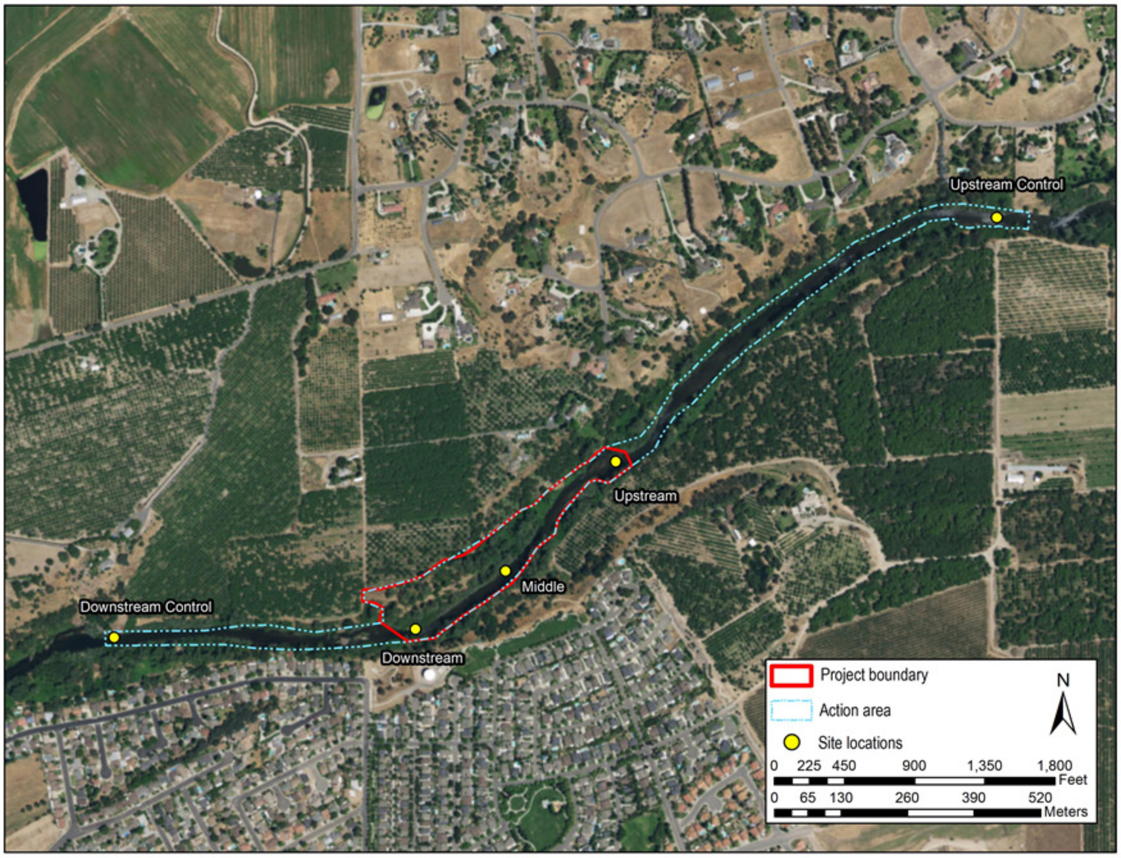

Figure 5. Locations within the Proposed Project action area where snorkel/seine surveys and benthic macroinvertebrate sampling occur.

Spawner Surveys

Information on adult Chinook salmon spawning would be provided by ongoing CDFW escapement surveys in the Stanislaus River and additional coordinated surveys by Cramer Fish Sciences. The CDFW's surveys provide information on abundance and distribution of spawning fall-run Chinook salmon throughout the Stanislaus River. The Cramer Fish Sciences team would conduct more focused redd and spawner surveys within the Proposed Project site, in coordination with CDFW, which would include redd size and depth measurements and ambient conditions. These data would be used to map Chinook salmon spawning density and redd locations within the sampling sites before and after restoration. This information is critical to addressing project hypotheses regarding rehabilitated spawning habitat productivity. Spawner surveys would be conducted every other week during the fall-run Chinook salmon spawning season (mid-October to January). GPS coordinates would be recorded using a GPS unit (Trimble GeoXT) for individual Chinook salmon redds.

Snorkel Surveys

Snorkel surveys would be conducted to assess juvenile and adult salmonid abundance and use of the restored sites. Snorkeling methods would be consistent with other studies (Edmundson et al.

1968, Hankin and Reeves 1988, McCain 1992, Jackson 1992, Dolloff et al. 1996, Cavallo et al. 2004, Sellheim et al. 2016). Sample units would consist of transects that are approximately 35 to 75 meters long and distributed throughout the site to capture the available habitat types within the Proposed Project site and at upstream and downstream control locations. Units would be snorkeled by two or three divers moving upstream adjacent to each other for channel margin habitats and downstream for mid-channel habitats. Fish would be observed, identified, and enumerated as divers proceed through each sampling unit. Counts would be compiled for all divers and recorded as a total for each sample unit. Fish would be categorized by species and fork length size classes: 0 to 50 millimeters (mm), 51 to 80 mm, 81 to 100 mm, 101 to 120 mm, 121 to 150 mm, 151 to 200 mm, 201 to 300 mm, and >301 mm. Juvenile salmonid snorkel surveys would be conducted monthly from February through May. All surveys would be led by a crew member with training and experience conducting snorkel surveys. To minimized fish disturbance, surveyors would attempt to limit fast or sudden movements and would wear mud-brown colored StreamCount drysuits (O.S. Systems, Inc.) to not cause visual distraction.

Additionally, during snorkel surveys, two depth and velocity transects would be recorded along each channel margin at one third and two thirds of the unit length to represent conditions within each sample unit. At all locations where individuals or groups of juvenile salmonids are observed to be rearing, GPS coordinates would be taken using a GPS unit (Trimble GeoExplorer Series) and the average water column velocity would be recorded.

Video Surveys

Video surveys would be used to assess habitat use, abundance, and behavior of juvenile salmonids in shallow water habitats such as side channels and channel margins. GoPro waterproof video cameras on a camera mount would be deployed within the project site and at unrestored control sites. The GoPro would be set to record for a specific amount of time and would then be retrieved. The recorded video would be reviewed in the lab.

Hydrology and Geomorphology

Evaluating the changes in the proposed site's hydrology and geomorphology would be predominantly done using digital elevation models and 2-dimensional hydraulic models. Data needed to parameterize these models include topography and bathymetry surveys, riverbed substrate composition, and water surface elevations. Collecting these data would require in-water wading by staff to conduct survey work with survey-grade GPS equipment. Wading activities would likely be restricted during low-flow periods in late summer (i.e., July through September) when the presence of juvenile and adult salmonids is minimized due to the timing of their life cycles (Table 4). If juvenile or adult salmonids are observed during survey work then all effort would be made to avoid disturbing them by not wading or surveying in their vicinity or impacting their spawning habitat.

Stream Temperature Data

Long-term changes in stream temperature would be evaluated during and after the project is implemented. These evaluations would require the installation of water temperature recorders within the proposed project site. Installation of these temperature recorders may require minimal wading. However, the installation of the water temperature recorders would be in locations and at times of the year when presence of juvenile or adult salmonids are least likely present.

Juvenile Salmonid Prey Base

Changes to juvenile salmonid prey-base would be assessed before and after project implementation. These assessments would require sampling of macroinvertebrates present in the drift and benthos. The total area of benthic substrate disturbed during sampling (using a Hess sampler) is small (< 10 square feet) and time spent wading is short term (minutes). Care would be taken to avoid areas being used by salmonids (e.g., active redds). If juvenile or adult salmonids are observed during macroinvertebrate sampling, all effort would be made to avoid disturbing them by not sampling or wading in their vicinity or impacting their spawning habitat.

Juvenile Salmonid Seine Sampling

Monitoring juvenile salmonid habitat use within the main channel, side-channel, and floodplain in the proposed site may require seine sampling. Up to four locations would be seined within each habitat type (main channel, side channel, and floodplain) with up to three seine hauls per location. Seine sampling may occur monthly from February through May. Seine sampling would be used when water turbidity (i.e. visibility) precludes snorkel surveys. The seine size used would be based on the configuration of the seine location with a larger seine used in the main channel and a smaller seine used in the side channel.

A crew of two to four members would conduct beach seining for juvenile salmonids following the methods of Merz et al. (2015). Typically, three 50-meter long seine hauls would be performed at each sampling location, and up to 12 locations would be seined within the action area. A 4-ft by 50-ft beach seine with 0.125-inch mesh attached to 1 inch by 5 ft wood poles would typically be used; however, seine length and mesh size would vary depending on project objectives and specific site characteristics. Lead weights would be used along the bottom line of the seine to keep in contact with the bottom, and floats would be attached to the top line to keep it near the waters' surface. Once the lead line approaches the shore it would be withdrawn up the shore so that fish are corralled in the bag of the seine and the lead line is on the shore. Fish from each beach seining haul would be stored in separate buckets filled with river water. Water in the buckets would be monitored to ensure that temperature remains within 2 °C of the river water and dissolved oxygen (DO) is above 5 milligrams per liter (mg/l). Water would be replaced and aerators used, as necessary. Fish would be released at the capture location after all seine passes at the location have been performed and the fish have been processed and have recovered from processing. No seining would occur if water temperatures exceed 18°C. All non-target fish would be identified to species, enumerated, and released. All salmonids with a fork length greater than 50 mm would be anesthetized, measured, and weighed, while salmonids with a fork length less than or equal to 50 mm would only be anesthetized and measured. During the anesthesia process, fish would be immersed in a bath of AQUI-S (20-30 milligrams per liter) to sedate the fish during handling procedures. After the fish has been measured and weighed, it would go into a recovery bucket prior to being released back into the river.

++Fyke-Net Sampling

Fyke-net sampling would be used to determine if juvenile salmonids are using and benefitting from the floodplain and side channel areas that were restored. Sampling would only be performed during periods when the floodplain and/or side channels are inundated during the time period when juvenile salmonids would be present. Therefore, fyke nets would be deployed sometime between February and May. Floodplains are typically only inundated for several days to four weeks during flow events on the Stanislaus River. The fyke net would be "fished" continuously during the period of floodplain/side channel inundation and then removed when the floodplain/side channel was no longer inundated. The fyke-net sampling would be used to test hypotheses related to whether floodplains and side channels provide habitat that is utilized by juvenile salmonids and other native fish, whether salmonids rearing on the floodplain experience measureable growth, and whether stomach content is greater in the floodplain relative to the main channel.

A four-foot-tall by five-foot-wide fyke made of 0.25-inch nylon mesh or a three-foot-tall by four-foot-wide fyke made of 0.125-inch nylon mesh, both with 25-ft wings, would be used for trapping. The cod end of the fyke net would be connected to a live box that is 4-ft long, 2.5-ft wide, and 2.5-ft high. A velocity break would be inserted into the live box to ensure that captured fish are not impinged on the back of the live box. The fyke net would be placed in the floodplain spanning an exit channel or in the exit to one of the side channels, and the wings would be extended as necessary by adding additional 0.25 or 0.125-inch nylon mesh to cover the width of the floodplain exit or side channel.

Captured fish would be held in cool, oxygenated freshwater and anesthetized (using AQUI-S, as stated above) prior to handling. Captured salmonids would be weighed and measured and then placed in an aerated recovery bucket. The live boxes would be checked at twice a day, typically in the morning and afternoon to process fish in the live boxes and to clean debris from the traps and live boxes. During each trap check, the fyke trap would be cleaned of debris and all fish in the live box would be netted out using aquarium nets and placed in five gallon buckets of fresh river water. Larger, piscivorous fish would be placed in separate buckets from juvenile salmonids and other smaller fish to prevent predation. Water in the buckets would be monitored to ensure that temperature remains within 2 °C of the river water and DO is above 5 mg/l. Water would be replaced and aerators used, as necessary. All non-target fish would be identified to species, enumerated, and released. All salmonids with a fork length greater than 50 mm would be anesthetized, measured, and weighed, while salmonids with a fork length less than or equal to 50 mm would only be anesthetized and measured. After processing, the fish would be immediately placed in a recovery bucket with a battery powered aerator. Once all fish in the recovery bucket are behaving normally, they would be released immediately downstream of the live box.

<u>1.3.4 Conservation Measures</u>

Informational Measures

The Project proponent would develop informational signage to be posted in visible locations at any work sites where there is known or potential public access. The purpose of the signage would be to ensure that the public is aware of the purpose and goals of the restoration project. It would include an overview of the planned activities and the expected restoration outcomes, as well as a construction timeline. Signage would be posted in English and Spanish and would include a contact name and telephone number for further inquiries or concerns.

General Measures to Protect Water Quality

Subject to requirements of Section 402 of the Federal Clean Water Act, and the National Pollutant Discharge Elimination System permitting process, all construction projects that disturb more than one acre of land are required to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP). The firm selected to prepare detailed restoration plans would also be required to prepare a SWPPP for the Project and include it in Project plans and specifications. The restoration construction contractor(s) would then be required to post a copy of the SWPPP at the Project site, file a notice of intent to discharge stormwater with the Regional Water Quality Control Board, and implement all measures required by the SWPPP. A Qualified SWPPP Practitioner (QSP) would be responsible for monitoring to ensure that the provisions of the SWPPP are effectively enforced.

The SWPPP would include the following information and stipulations:

- A description of site characteristics, including runoff and drainage characteristics and soil erosion hazard.
- A description of proposed construction procedures and construction-site housekeeping practices, including prohibitions on discharging or washing potentially harmful materials into streets, shoulder areas, inlets, catch basins, gutters, or agricultural fields, associated drainage, or irrigation features.
- A description of measures that would be implemented for erosion and sediment control, including requirements to:
    - Conduct major restoration activities involving excavation and spoils haulage during the dry season, to the extent possible.
    - Conduct all restoration work in accordance with site-specific construction plans that minimize the potential for increased sediment inputs to storm drains and surface waters.
    - Grade and stabilize spoils sites to minimize erosion and sediment input to surface waters and generation of airborne particulate matter.
    - Implement erosion control measures as appropriate to prevent sediment from entering surface waters, agricultural water features, and storm drains to the extent feasible, including the use of silt fencing or fiber rolls to trap sediments and erosion control blankets on exposed slopes.
- A Spill Prevention and Response Plan that identifies any hazardous materials to be used during restoration work; describes measures to prevent, control, and minimize the spillage of hazardous substances; describes transport, storage and disposal procedures for these substances; and outlines procedures to be followed in case of a spill of a hazardous material. The Spill Prevention and Response Plan would require that hazardous and

potentially hazardous substances stored onsite be kept in securely closed containers located away from drainage courses, agricultural areas, storm drains, and areas where stormwater is allowed to infiltrate. It would also stipulate procedures, such as the use of spill containment pans, to minimize hazard during onsite fueling and servicing of construction equipment. Finally, the Spill Prevention and Response Plan would require that the County be notified immediately of any substantial spill or release.

- A stipulation that restoration work would be monitored by a QSP to ensure that contractors are adhering to all provisions relevant to state and federal stormwater discharge requirements, and that the QSP would shut down the construction site in the event of noncompliance.

Water Quality Measures for In-Channel Restoration Work

In-channel work, including all channel and bank modifications, would be restricted to the minimum necessary to support restoration success. In-channel work would be limited to the dry season (July 15 to October 15).

- The project would comply with Section 401 of the Clean Water Act and obtain certification for project-related activities to control sediment from entering the main river channel during restoration activities. To minimize risk from additional fine sediments, all trucks and equipment would be cleaned. Gravel would be appropriately screened and cleaned offsite prior to placement in the main channel and side channels to avoid introduction of additional fine material into the Stanislaus River.

- Stream bank impacts would be isolated and minimized to reduce bank sloughing. The banks would be stabilized following project activities.

- All equipment working within the stream corridor would be inspected daily for fuel, lubrication, and coolant leaks; and for leak potentials (e.g., cracked hoses, loose filling caps, stripped drain plugs); and, all equipment must be free of fuel, lubrication, and coolant leaks.

- Vehicles or equipment would be washed/cleaned only at approved off-site areas. In addition, all equipment would be steam cleaned prior to working within the stream channel to remove contaminants that may enter the river and adjacent lands.

- All equipment would be fueled and lubricated in a designated staging area located outside the stream channel and banks.

- Only vehicles serviced with vegetable-based lubricants would work in the active channel to reduce the potential for water quality impacts to the Stanislaus River.

- All equipment entering the river would be steam cleaned before it is used elsewhere to minimize the chance of introducing New Zealand mud snails to other water bodies.

- Staging area would be located on the north bank of the river, approximately 500 feet from the main river channel.

Vegetation Protection Measures

In order to avoid and minimize adverse effects on riparian vegetation slated to remain in place, the following guidelines would be observed:

- Before restoration work begins, the project engineer and a qualified biologist would identify locations for equipment and personnel access and materials staging that would minimize riparian disturbance.
- Existing access points and roads would be used whenever possible in order to avoid disturbance to sensitive locations. Least sensitive areas would be used for parking, stockpiling, and staging areas and these areas would be clearly marked and restored following completion.
- During restoration activities, as much understory brush and as many trees as possible would be retained. The emphasis would be on retaining shade-producing and bank-stabilizing vegetation.
- There would be no impacts on heritage size trees (i.e., greater than 16 inches (40.6 cm) diameter at breast height).
- When chainsaws are used to remove riparian vegetation, saws compatible with vegetable-based bar oil would be used if possible.
- When heavy equipment is required, unintentional soil compaction would be minimized by using equipment with a greater reach, or using low-pressure equipment. Disturbed soils would be decompacted when work is completed.
- Any disturbed and decompacted areas outside the restoration area would be revegetated with locally native stock in an appropriate palette.
- Sensitive vegetation (e.g., elderberry shrubs) in the near vicinity of restoration areas would be flagged or fenced.
- All contractors and equipment operators would be given instructions to avoid impacts and be made aware of the ecological value of the site.

Measures to Protect Salmonids

To reduce the likelihood of adverse impacts on CCV steelhead in the lower Stanislaus River corridor, instream construction activities would be limited to the dry season (July 15 to October 15). This period is outside of the adult migration, spawning, incubation, and emergence for CCV steelhead. Rearing juvenile steelhead may be present in the action area during construction activities, but they are highly mobile and can readily swim away from the project impacts into highly suitable habitat of the Stanislaus River.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and/or an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

The designation(s) of critical habitat for CCV steelhead use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.

- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

The descriptions of the status of species and conditions of the designated critical habitats in this BO are a synopsis of the detailed information available on NMFS' West Coast Regional website. The following federally listed species ESUs or DPSs and designated critical habitat occur in the action area and may be affected by the proposed action (Table 5):

Table 5. Listing for CCV steelhead and designated critical habitat.

Species	**Scientific Name**	**Original Listing Status**	**Current Listing Status**	**Critical Habitat Designated**
California Central Valley steelhead DPS	*Oncorhynchus mykiss*	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488

2.2.1 Species Listing and Critical Habitat Designation History for CCV Steelhead

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good et al. 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed the status of CCV steelhead as threatened and also listed the FRFH and Coleman NFH artificial propagation programs as part of the DPS on January 5, 2006 (71 FR 834). In doing so, NMFS applied the DPS policy to the species because the resident and anadromous life forms of steelhead remain "markedly separated" as a consequence of physical, ecological, and behavioral factors, and may therefore warrant delineation as separate DPSs

(71 FR 834; January 5, 2006). On May 5, 2016, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2016). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488).

2.2.2 Critical Habitat and Physical or Biological Features for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba rivers and the Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries; and the waterways of the Delta (Figure 6).

Currently, the CCV steelhead DPS and critical habitat extends up the San Joaquin River to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent would be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999) (70 FR 52488; September 2, 2005). The following subsections describe the status of the PBFs of CCV steelhead critical habitat, which are listed in the critical habitat designation (70 FR 52488; September 2, 2005).

Spawning Habitat

The PBFs of CCV steelhead critical habitat include freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, egg incubation, and larval development. Most of the available spawning habitat for steelhead in the Central Valley is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have adverse effects upon salmonids spawning and rearing below the dams (NMFS 2014). Even in degraded reaches, spawning habitat has a high value for the conservation of the species as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat

The PBFs of CCV steelhead critical habitat include freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging LWM, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids (NMFS 2014). Some complex, productive habitats with floodplains remain in the system (e.g., the lower Cosumnes River, Sacramento River reaches with setback levees [i.e., primarily located upstream of the City of Colusa]) and flood bypasses (i.e., Yolo and Sutter bypasses) (Summer et al 2004; Jeffries 2008). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators (NMFS 2014). Freshwater rearing habitat also has a high value for the conservation of the species even if the current conditions are significantly degraded from their natural state. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment.

Freshwater Migration Corridors

The PBFs of CCV steelhead critical habitat include freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging LWM aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream and downstream passage of adults and the emigration of smolts. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams *(*i.e.*,* hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration (NMFS 2014). For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik and Johnson 2013), and a number of challenges exist on many tributary streams. For juveniles, unscreened or complex in-river cover have degraded this PBF (NMFS 2014). However, since the primary freshwater migration corridors are used by numerous listed fish populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic value for the conservation of the species.

Estuarine Areas

The PBFs for CCV steelhead critical habitat include estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging LWM, aquatic vegetation, large rocks and boulders, side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation (50 CFR 226.211(c)).

The remaining estuarine habitat for this species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species (NMFS 2014). Regardless of the conditions, the remaining estuarine areas are considered to have a high value for the conservation of the species because they provide features that function to provide predator avoidance, as rearing habitat, and as a transitional zone to the ocean environment.

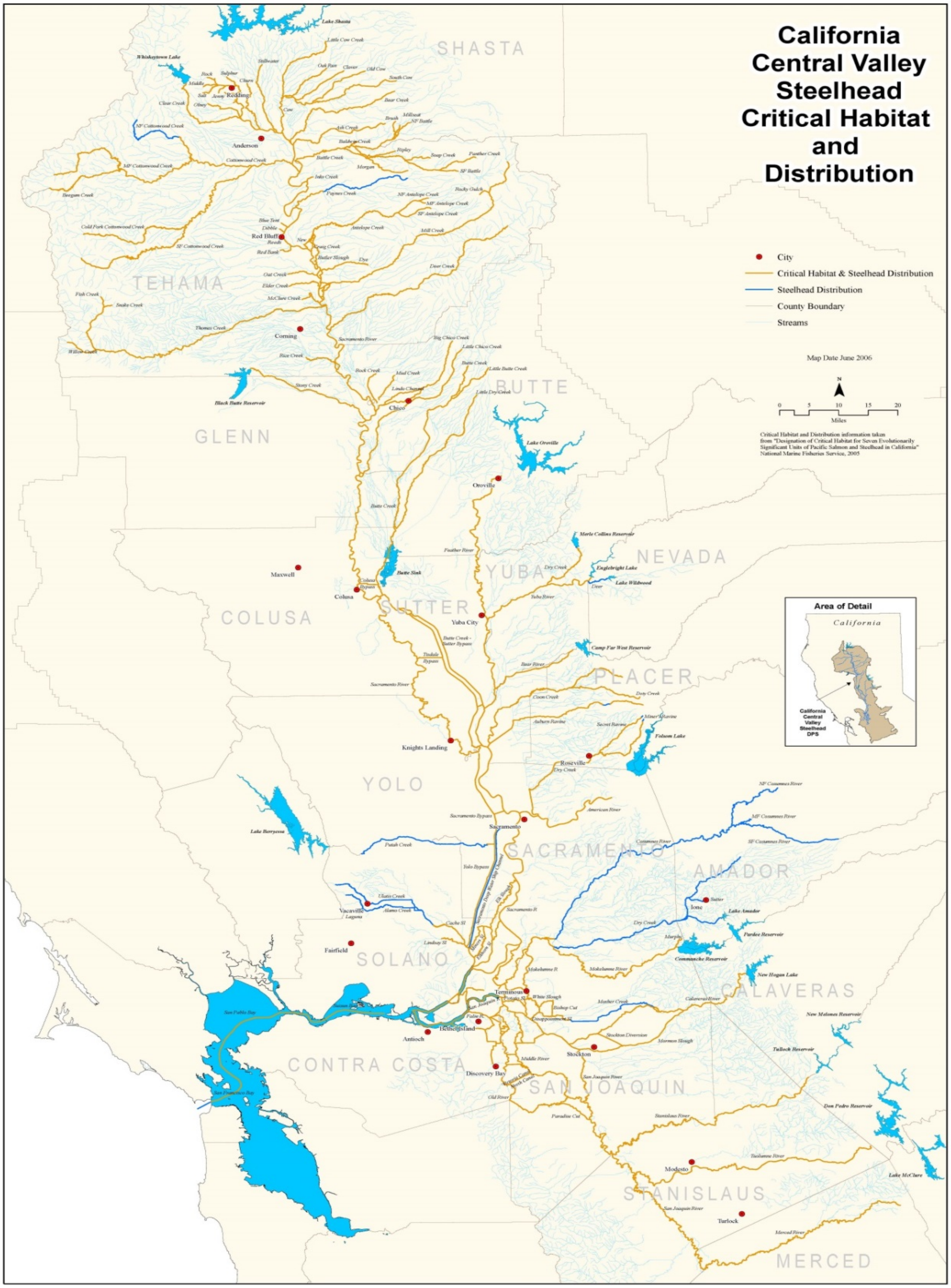

Figure 6. California Central Valley Steelhead Designated Critical Habitat.

2.2.3 Life History

Egg to Parr

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in 3 to 4 weeks at 50°F (10°C) to 59°F (15°C) (Moyle 2002). After hatching, alevins remain in the gravel for an additional 2 to 5 weeks while absorbing their yolk sacs and emerge in spring or early summer (Barnhart 1986). A compilation of data from multiple surveys has shown that steelhead prefer a range of substrate sizes between approximately 18 and 35 mm (Kondolf and Wolman 1993). Fry emerge from the gravel usually about 4 to 6 weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Coble (1961) noted that a positive correlation exists between dissolved oxygen levels and flow within redd gravel, and Rombough (1988) observed a critical threshold for egg survival between 7.5 and 9.7 mg/L. Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986, NMFS 1996).

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965, Everest and Chapman 1972, Fontaine 1988). Growth rates have been shown to be variable and are dependent on local habitat conditions and seasonal climate patterns (Hayes et al. 2008).

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or boulders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 59°F (15°C) to 68°F (20°C) (McCullough et al. 2001, Spina et al. 2006). Cherry et al. (1975) found preferred temperatures for rainbow trout (*O. mykiss*) ranged from 51.8°F (11°C) to 69.8°F (21°C) depending on acclimation temperatures (Myrick and Joseph J. Cech 2001).

Smolt Migration

Juvenile steelhead would often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch et al. 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating CCV steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. Some rearing behavior is thought to occur in tidal marshes, non-tidal freshwater marshes, and other shallow water habitats in the Delta before the fish enter the ocean (NMFS 2014).

Ocean Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that CCV steelhead may not migrate to the Gulf of Alaska region of the

North Pacific as commonly as more northern populations such as those in Washington and British Colombia. Burgner (1993) reported that no coded-wired-tagged steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of CCV steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

Pearcy et al. (1990) found that the diets of juvenile steelhead caught in coastal waters of Oregon and Washington were highly diverse and included many species of insects, copepods, and amphipods, but by biomass the dominant prey items were small fishes (including rockfish and greenling) and euphausids.

There are no commercial fisheries for steelhead in California, Oregon, or Washington, with the exception of some tribal fisheries in Washington waters.

Spawning
CCV steelhead generally enter freshwater from August to November (with a peak in September) (Hallock et al. 1961) (Table 6), and spawn from December to April (with a peak in January through March) in rivers and streams where cold, well-oxygenated water is available (Hallock et al. 1961, McEwan and Jackson 1996, Williams 2006). The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman et al. 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F (13.3°C) maximum water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern as this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

Few direct counts of fecundity are available for CCV steelhead populations, but because the number of eggs laid per female is highly correlated with adult size, adult size can be used to estimate fecundity with reasonable precision. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after 1 or 2 years at sea (Hallock et al. 1961), and adults typically range in size from 2 to 12 pounds (Reynolds et al. 1993). Steelhead about 55 cm (fork length) long may have fewer than 2,000 eggs, whereas steelhead 85 cm (FL) long can have 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991). The average for Coleman NFH since 1999 is about 3,900 eggs per female (USFWS 2011).

Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby et al. 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards females (Busby et al. 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek.

Null (2013) found between 36 percent and 48 percent of kelts released from Coleman NFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman NFH in the 1971 season, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider et al. 1986).

Kelts

Post-spawning steelhead (kelts) may migrate downstream to the ocean immediately after spawning, or they may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Recent studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo et al. 2011), but that most return to the ocean (Null 2013).

Table 6. The Temporal Occurrence of (a) Adult and (b) Juvenile California Central Valley Steelhead at Locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult Migration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
[1]Sacramento R. at Fremont Weir												
[2]Sacramento R. at RBDD												
[3]Mill & Deer Creeks												
[4]Mill Creek at Clough Dam												
[5]San Joaquin River												
(b) Juvenile Migration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
[1,2]Sacramento R. near Fremont Weir												
[6]Sacramento R. at Knights Landing												
[7]Mill & Deer Creeks (silvery parr/smolts)												
[7]Mill & Deer Creeks (fry/parr)												
[8]Chipps Island (clipped)												
[8]ChippsIsland (unclipped)												
[9]San Joaquin R. at Mossdale												
[10]Mokelumne R. (silvery parr/smolts)												
[10]Mokelumne R. (fry/parr)												
[11]Stanislaus R. at Caswell												

[12]Sacramento R. at Hood																								

Relative Abundance: = High = Medium = Low

Sources: [1](Hallock 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998–2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998–2011 USFWS data; [9]NMFS analysis of 2003–2011 USFWS data; [10]unpublished EBMUD RST data for 2008–2013; [11]Oakdale RST data (collected by FishBio LLC) summarized by John Hannon (Reclamation); [12](Schaffter 1980).

Description of Viable Salmonid Population Parameters

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a VSP. The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany et al. 2000). The VSP concept measures population performance in terms of four key parameters: abundance, population growth rate, spatial structure, and diversity.

Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock et al. (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 from 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations. Comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long-term adult implementation monitoring plan has been formulated (Eilers et al. 2010, Fortier et al. 2014).

There is very little monitoring focused on CCV steelhead; as a result, population trends and status are largely unknown. However, analyses of CCV steelhead abundance across the DPS indicate that naturally reproducing stocks are suffering severe and long-term declines, range-wide, within the San Joaquin River watershed. In the San Joaquin River tributaries, the CCV steelhead populations are very small, with most fish apparently demonstrating the resident phenotype (Zimmerman *et al*. 2009). Chipps Island trawl data also suggests that natural CCV steelhead production is very low (NMFS 2016). The apparent CCV steelhead population declines have been attributed to longstanding human induced factors that exacerbate the adverse effects of natural environmental variability (NMFS 1996). Important factors in this decline include habitat destruction and degradation of freshwater spawning and rearing habitat, river flow regulation, over-fishing, and the introduction of non-native piscivorous fish species (62 FR 43937). In particular, impassable dams block access to 80 percent of historically available CCV steelhead habitat and block access to all historical CCV steelhead spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006).

Current abundance data are limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data are the most reliable, as redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

Coleman NFH operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the CCV DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman NFH stopped transferring all adipose-fin clipped steelhead above the weir, resulting in a large decrease in the overall numbers of steelhead above the weir in recent years. In addition, in 2003, Coleman NFH transferred about 1,000 clipped adult steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery- and natural-origin steelhead in Battle Creek were not differentiable, and all steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin steelhead in Battle Creek began in 2001. These estimates of steelhead abundance include all CCV steelhead, including resident and anadromous fish.

Steelhead returns to Coleman NFH increased from 2011 to 2014 (Figure 7). After hitting a low of only 790 fish in 2010, 2013 and 2014 have averaged 2,895 fish (Figure 7). Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery-produced (adipose fin clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200 to 300 fish each year. Numbers of wild adults returning each year have ranged from 252 to 610 from 2010 to 2014 (Figure 7).

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 143 redds have been counted on the American River from 2002 to 2015 (Hannon et al. 2003, Hannon and Deason 2008, Chase 2010). Surveys were not conducted in some years on the American River due to high flows and low visibility. An average of 178 redds have been counted in Clear Creek from 2001 to 2015 (Figure 9; data from USFWS). The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001 (Figure 9). The average redd index from 2001 to 2011 is 178, representing a range of approximately 100 to 1,023 spawning adult steelhead on average each year, based on an approximate observed adult-to-redd ratio in Clear Creek (USFWS 2015). The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season, and the overall trend is a slight increase. However, it is generally believed that most of the steelhead spawning in the

Mokelumne River are resident fish (Satterthwaite et al. 2010), which are not part of the CCV steelhead DPS. Recent genetic studies have shown that Mokelumne River Hatchery steelhead are now closely related to Feather River Hatchery fish, because these fish are considered to be native Central Valley stock (Pearse and Garza 2015). Thus in the most recent 5-year status review, NMFS recommended that steelhead originating from the Mokelumne River Hatchery be included as part of the CCV steelhead DPSpopulation (NMFS 2016).

The returns of CCV steelhead to the FRFH experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009, and 2010, respectively (Figure 10). In recent years, however, returns have experienced an increase with 830, 1,797, and 1,505 fish returning in 2012, 2013, and 2014, respectively. Almost all these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for age classes that showed poor returns in the late 2000s.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the proportion of wild steelhead relative to hatchery steelhead (CDFG ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure 11). Variability in catch is likely due to differences in water year types as Delta exports fluctuate. The percentage of unclipped steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

The years 2009 and 2010 showed poor returns of steelhead to the FRFH and Coleman NFH, probably due to three consecutive drought years in 2007 to 2009, which would have impacted parr and smolt growth and survival in the rivers, and possibly due to poor coastal upwelling conditions in 2005 and 2006, which strongly impacted fall-run Chinook salmon post-smolt survival (Lindley et al. 2009). Wild (unclipped) adult counts appear not to have decreased as greatly in those same years, based on returns to the hatcheries and redd counts conducted on Clear Creek, and the American and Mokelumne rivers. This may reflect greater fitness of naturally produced steelhead relative to hatchery fish, and certainly merits further study.

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960s and 1970s, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns.

Figure 7 depicts steelhead returns to Coleman NFH from 1988 to 2014. It is important to note that starting in 2001, fish were classified as either wild (unclipped) or hatchery-produced (clipped). Figure 8 shows steelhead redd counts from surveys on the American River from 2002 to 2015, where surveys could not be conducted in some years due to high flows and low visibility. Figures 9 and 10 show redd counts from USFWS surveys on Clear Creek from 2001 to 2015 and steelhead returns to the FRFH from 1964 to 2015, respectively.

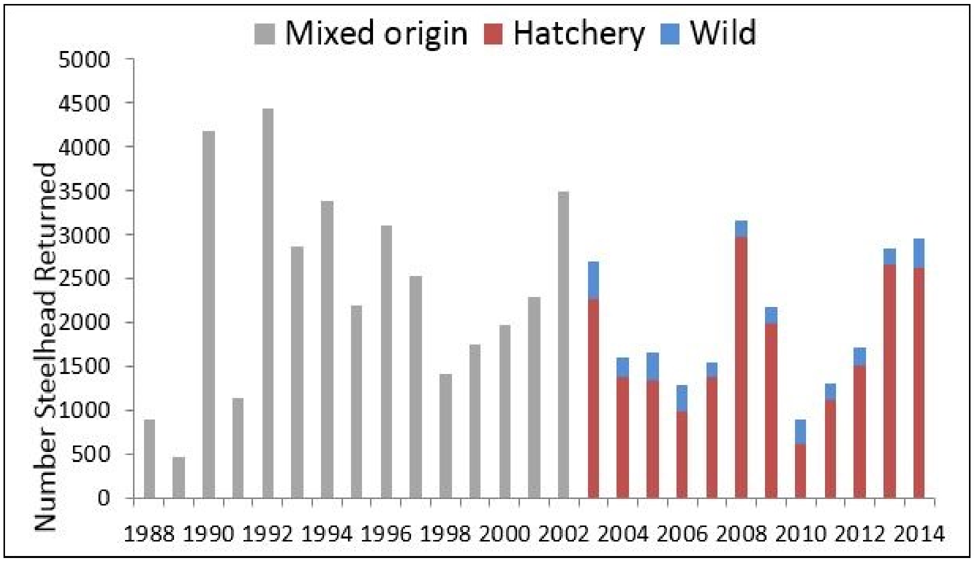

Figure 7. Steelhead Returns to Coleman National Fish Hatchery from 1988 to 2014.

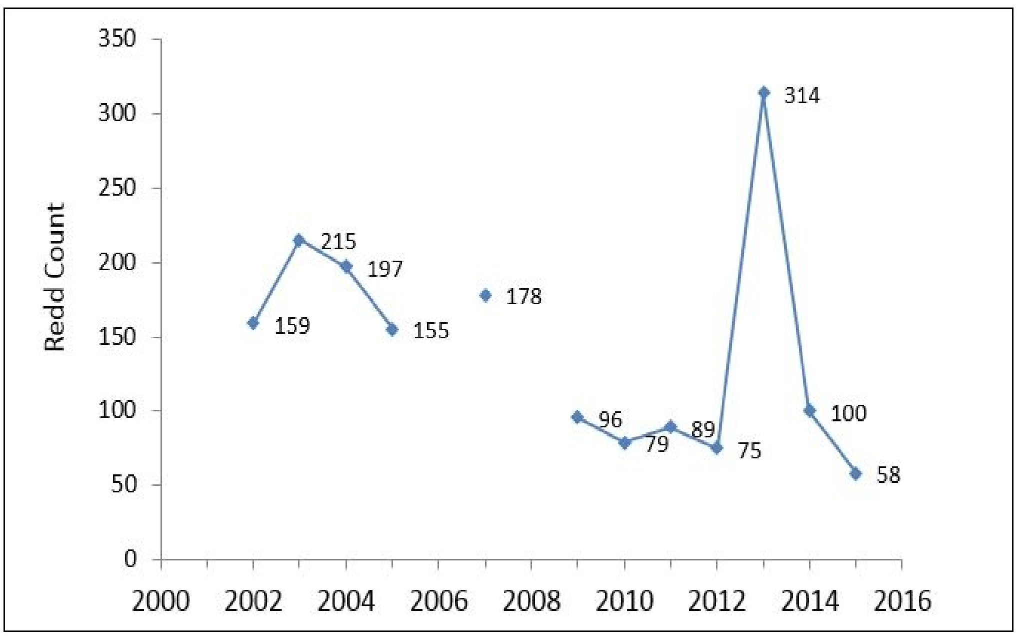

Figure 8. Steelhead Redd Counts from Surveys on the American River from 2002 to 2015.

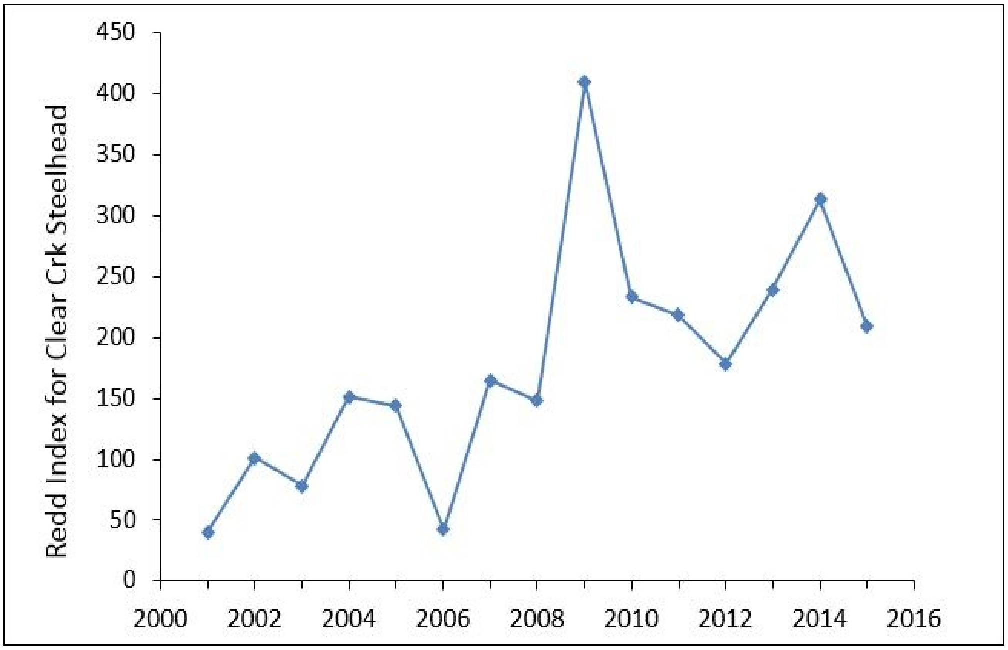

Figure 9. Redd Counts from USFWS Surveys on Clear Creek from 2001 to 2015.

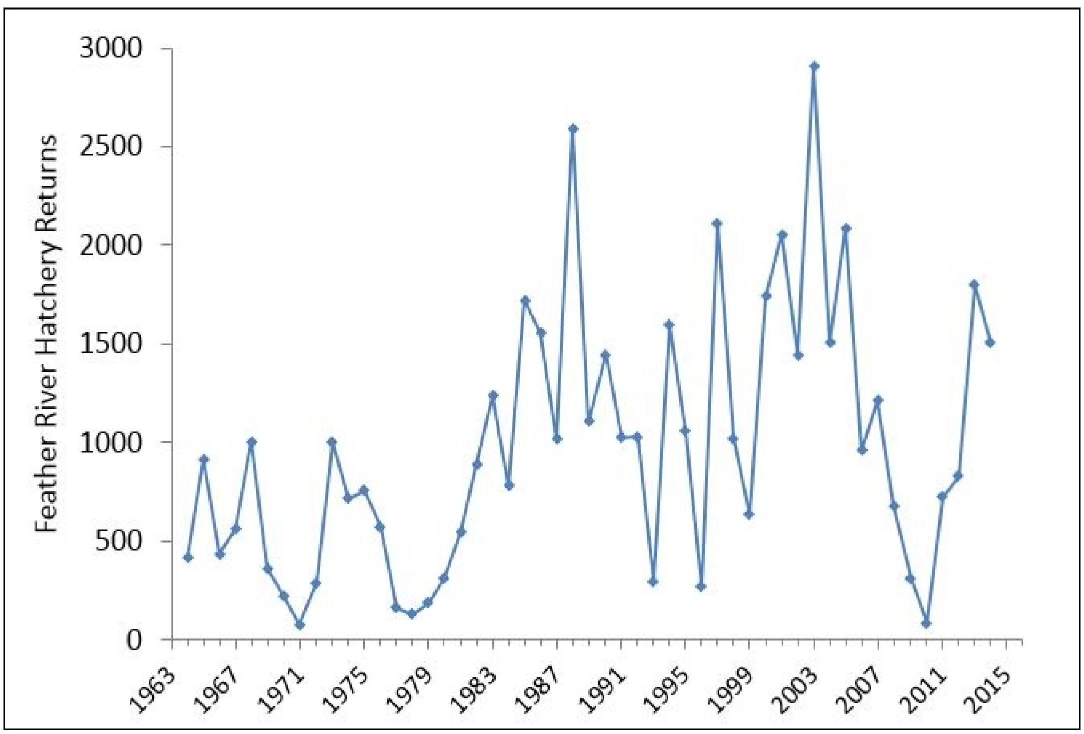

Figure 10. Steelhead Returns to the Feather River Fish Hatchery from 1964 to 2015.

Productivity

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. Also, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams et al. 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Good et al. (2005) made the following conclusion based on the Chipps Island data.

> *If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s.*

The Chipps Island midwater trawl dataset maintained by the USFWS provides information on the trend in abundance for the CCV steelhead DPS as a whole. Updated through 2014, the trawl data indicate that the level of natural production of steelhead has remained very low since the 2011 status review (Figure 11). Catch per unit effort (CPUE) has fluctuated but remained relatively constant over the past decade, but the proportion of the catch that is adipose-clipped (100 percent of hatchery steelhead production has been adipose fin-clipped starting in 1998) has risen, exceeding 90 percent in some years and reaching a high of 95 percent in 2010 (Williams et al. 2011). Because hatchery releases have been fairly constant, this implies that natural production of juvenile steelhead has been declining in the Central Valley.

The top of Figure 11 shows the catch of steelhead at Chipps Island by the USFWS midwater trawl survey. The middle section shows the fraction of the catch bearing an adipose fin clip. One hundred percent of steelhead production has been marked starting in 1998, denoted with the vertical gray line. The bottom section shows CPUE in fish per million m^3 swept volume. CPUE is not easily comparable across the entire period of record, as over time, sampling has occurred over more of the year and catches of juvenile steelhead are expected to be low outside of the primary migratory season.

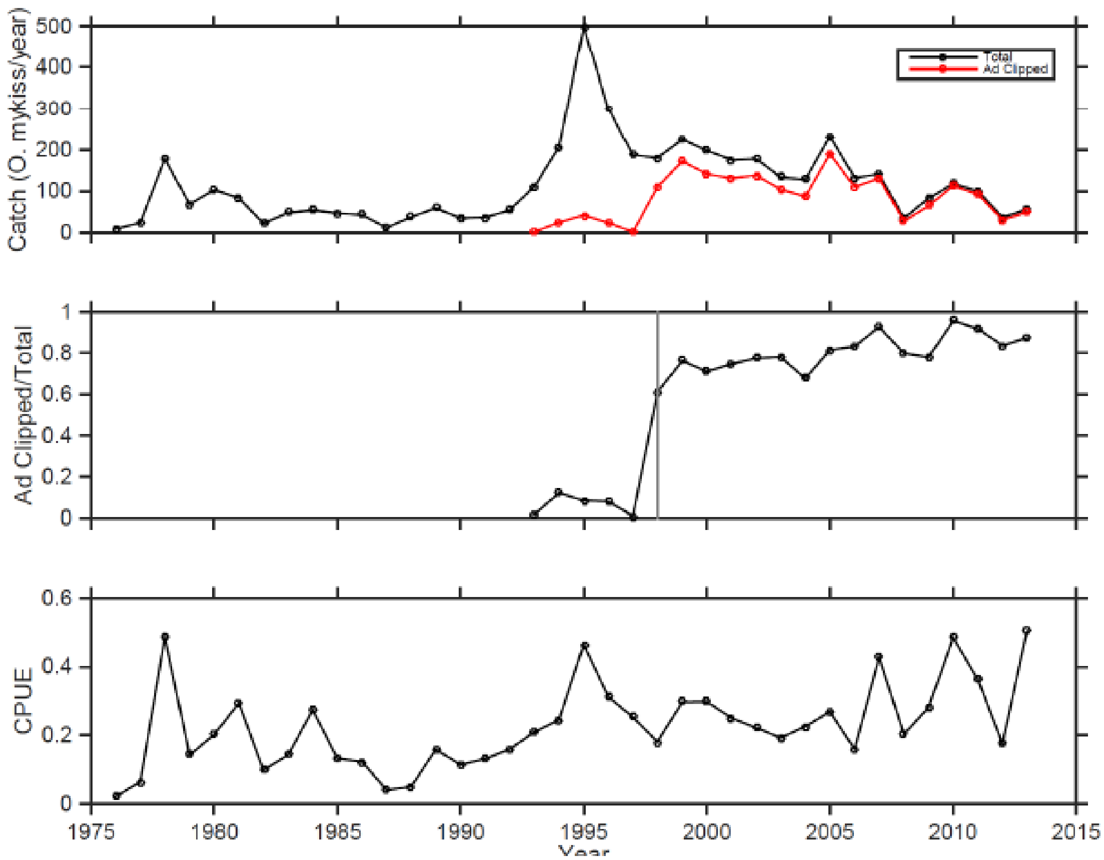

Figure 11. Steelhead Catch at Chipps Island Midwater Trawl (USFWS unpublished data).

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999 to 2000 spawning season (NMFS 2011). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000 to 2010). However, according to Satterthwaite et al. (2010), it is likely that most of the steelhead spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). This practice was discontinued, however, for Nimbus stock after 1991 and discontinued for Feather River stock after 2008. Genetic studies show that the Mokelumne River Hatchery steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock (Pearse and Garza 2015).

Additionally, on the Mokelumne River, it appears that many fish can reach a size large enough to smolt at age 1, but the slower-growing fish are better served to mature as YOY and spawn at age 1 rather than risk the extra freshwater mortality associated with waiting to smolt at age 2 (because much less time must elapse before the age 1 spawning opportunity compared to age 2 emigration). Slow-growing fish are large enough to have a moderate chance of survival in the ocean. Additional freshwater residence time exposes fish to risk of freshwater mortality, to grow to a large enough size to spawn with much success as a resident female at an even older age (Satterthwaite et al. 2010).

These results suggest that restoration activities for CCV steelhead should focus on habitat improvements that both increase parr survival and growth in natal rivers, especially in the summer and fall, and improve smolt survival in the lower river reaches, the Delta, and bays.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS as well as the production of wild steelhead relative to hatchery steelhead (ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead has declined dramatically since the early 2000s, with an overall average of 2,705 from 2004 to 2014, as measured by expanded salvage (Figure 12). The percentage of wild (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated. This relatively constant hatchery production, coupled with the dramatic decline in hatchery-origin steelhead catch at the south Delta fish collection facilities suggests that either stocked hatchery fish from the Sacramento basin are using a more natural outmigration path and are not being pulled into the south Delta fish facilities or the immediate survival of those stocked fish has decreased. With respect to wild steelhead, the data shown in Figure 12 indicate that from 2011 to 2014 fewer adults are spawning (fewer eggs deposited), survival of early life stages has decreased, and/or wild steelhead are experiencing reduced exposure to the south Delta fish facilities. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFW, at ftp.delta.dfg.ca.gov/salvage.

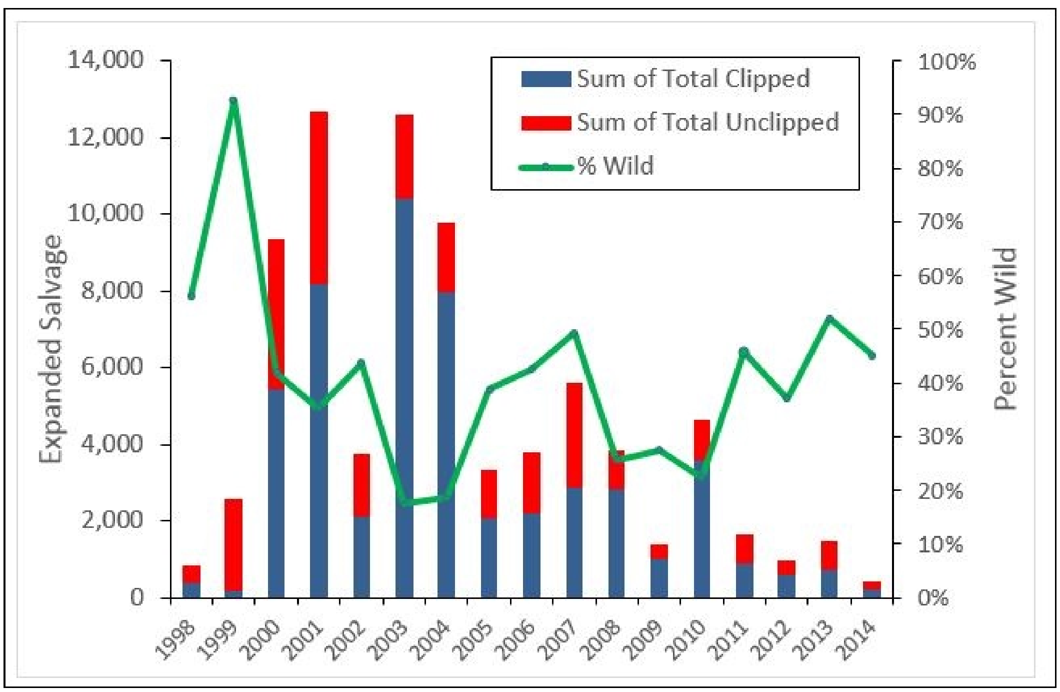

Figure 12. Steelhead Salvaged in the Delta Fish Collection Facilities.

Since 2003, fish returning to the Coleman NFH have been identified as wild (adipose fin intact) or hatchery-produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200 to 300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery-origin fish returning to the hatchery have fluctuated much more widely, ranging from 624 to 2,968 fish per year.

Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous steelhead in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration, which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama et al. 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups, such as the Chunut people, have had accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005, NMFS 2016). Zimmerman et al. (2009) used otolith microchemistry to show that steelhead of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident steelhead compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in RSTs at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer & Associates 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected steelhead passage. In 2012, 15 adult steelhead were detected passing the Tuolumne River weir and 82 adult steelhead were detected at the Stanislaus River weir (FISHBIO LLC 2012 , FISHBIO LLC 2013a). Also, RST sampling has occurred since 1995 in the Tuolumne River, but only one juvenile steelhead was caught during the 2012 season (FISHBIO LLC 2013b). RSTs are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. RST on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult steelhead has been reported passing the weir. Juvenile steelhead were not reported captured in the RSTs on the Merced River until 2012, when a total of 381 were caught (FISHBIO LLC 2013c). The unusually high number of steelhead captured may be attributed to a flashy storm event that rapidly increased flows over a 24-hour period. Annual Kodiak trawl surveys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 steelhead were caught during the 2012 season (CDFW 2013). However, no steelhead were caught during the 2017 season (CDFW 2018).

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adults intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River. This is confounded, of course, by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked. Clear Creek and Mill Creek are the exceptions.

Implementation of CDFW's Steelhead Monitoring Program began during the fall of 2015. Important components of the program include a mainstem Sacramento River Steelhead Mark-Recapture Program and an Upper Sacramento River Basin Adult Steelhead Video/DIDSON Monitoring Program. The monitoring program would use a temporally stratified mark-recapture survey design in the lower Sacramento River, employing wire fyke traps to capture, mark, and recapture upstream migrating adult steelhead to estimate adult steelhead escapement from the Delta. Data collected from recaptured adult steelhead would provide additional information on tributary escapement, survival, population structure, population distribution, and spatial and temporal behavior of both hatchery- and natural-origin steelhead.

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of Central Valley steelhead populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2016).

Diversity

Genetic Diversity
The CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen et al. 2003).

Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to steelhead above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CCV steelhead is also compromised by hatchery-origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley et al. 2007). There are four hatcheries (Coleman NFH, FRFH, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery-origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River Hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS. However, during the recent NMFS 5-year status review for CCV steelhead, NMFS recommended including the Mokelumne River Hatchery steelhead population in the CCV Steelhead DPS due to the close genetic relationship with FRFH steelhead that are considered part of the native Central Valley stock (NMFS 2016).

Life-history Diversity
Steelhead in the Central Valley historically consisted of both summer-run and winter-run Chinook salmon migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. As stated in Gerstung (1971):

> *Between 1944 and 1947, annual counts of summer-run steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish. After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead were no longer able to access their historic spawning areas, and perished in the warm water downstream of Old Folsom Dam (Gerstung 1971).*

Only winter-run (ocean-maturing) steelhead currently are found in CCV rivers and streams (McEwan and Jackson 1996, Moyle 2002). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold water pools in the headwaters of CV streams, presently located above impassible dams (Lindley et al. 2006).

Juvenile steelhead (parr) rear in freshwater for 1 to 3 years before migrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater is inversely related to their growth rate, with faster-growing members of a cohort smolting at an earlier age but a smaller size (Seelbach 1993, Peven et al. 1994). Hallock et al. (1961) aged 100 adult steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954 and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most steelhead return to their natal streams as adults at a total age of 2 to 4 years (Hallock et al. 1961, McEwan and Jackson 1996).

Deer and Mill creeks were monitored from 1994 to 2010 by the CDFW using RSTs to capture emigrating juvenile steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill creeks, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm in Deer and Mill creeks, while smolts averaged 210 and 204 mm. Most silvery parr and smolts were caught in the spring months from

March through May, while fry and parr peaked later in the spring (May and June) and were fairly common in the fall (October through December) as well.

In contrast to the upper Sacramento River tributaries, Lower American River juvenile steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolt at age-1 (Sogard et al. 2012).

Summary of Distinct Population Segment Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good et al. 2005, NMFS 2016); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River-origin steelhead stock.

The ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance has remained at a relatively steady state since the 2011 status review and remains much lower than percentages observed in previous decades. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past decade.

Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance and fluctuating return rates. Lindley et al. (2007) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the status of any of the naturally spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown because very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

The most recent status review of the CCV steelhead DPS (NMFS 2016) found that the status of the DPS appears to have remained unchanged since the 2011 status review (Good et al. 2005), and the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

2.2.4 Climate Change

One major factor affecting the range-wide status of the threatened and endangered anadromous fish in the Central Valley, and aquatic habitat at large is climate change. Lindley et al. (2007)

summarized several studies (Hayhoe et al. 2004; Dettinger et al. 2004; Dettinger 2005; VanRheenen et al. 2004; Knowles and Cayan 2002) on how anthropogenic climate change is expected to alter the Central Valley, and based on these studies, described the possible effects to anadromous salmonids. Climate models for the Central Valley are broadly consistent in that temperatures in the future would warm significantly, total precipitation may decline, the variation in precipitation may substantially increase (i.e., more frequent flood flows and critically dry years), and snowfall would decline significantly (Lindley et al. 2007). Climate change is having, and would continue to have, an impact on salmonids throughout the Pacific Northwest and California (Battin et al. 2007).

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991; Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April- to July has been decreasing since about 1950 (Roos 1987, 1991). Increased air temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (VanRheenen et al. 2004). Factors modeled by VanRheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 3.8°F (2.1°C) is expected to result in a loss of about half of the average April snowpack storage (VanRheenen et al. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south. Modeling indicates that stream habitat for cold water species declined with climate warming and remaining habitat suitable may only exist at higher elevations (Null et al. 2013). Climate warming is projected to cause average annual stream temperatures to exceed 24°C (75.2°F) slightly earlier in the spring, but notably later into August and September. The percentage of years that stream temperatures exceeded 24°C (for at least 1 week) is projected to increase, so that if air temperatures rise by 6°C, most Sierra Nevada rivers would exceed 24°C for some weeks every year.

Warming is already affecting CV Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if climate warms by 9°F (5°C), it is questionable whether any CV Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951 to 1980, the most plausible projection for warming over Northern California is 4.5°F (2.5°C) by 2050 and 9°F (5°C) by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming would shorten the period in which the low elevation habitats used by naturally producing Chinook salmon are thermally acceptable. This should particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

Central Valley salmonids are highly vulnerable to drought conditions. The increased in-river water temperature resulting from drought conditions is likely to reduce the availability of suitable holding, spawning, and rearing conditions in Clear Creek and in the Sacramento, Feather, and Yuba rivers. During dry years, the availability of thermally suitable habitats in spring-run Chinook salmon river systems without major storage reservoirs (e.g., Mill, Deer, and Butte creeks) is also likely to be reduced. Multiple dry years in a row could potentially devastate Central Valley salmonids. Prolonged drought due to lower precipitation, shifts in snowmelt runoff, and greater climate extremes could easily render most existing spring-run Chinook salmon habitat unusable, either through temperature increases or lack of adequate flows. The drought that occurred from 2007 to 2009 was likely a factor in the recent widespread decline of all Chinook salmon runs (including spring-run Chinook salmon) in the Central Valley (Williams et al. 2011).

The increase in the occurrence of critically dry years also would be expected to reduce abundance, as, in the Central Valley, low flows during juvenile rearing and outmigration are associated with poor survival (Kjelson and Brandes 1989; Baker and Morhardt 2001; Newman and Rice 2002). In addition to habitat effects, climate change may also impact Central Valley salmonids through ecosystem effects. For example, warmer water temperatures would likely increase the metabolism of predators, reducing the survival of juvenile salmonids (Vigg and Burley 1991). In summary, climate change is expected to exacerbate existing stressors and pose new threats to Central Valley salmonids, including CCV steelhead, by reducing the quantity and quality of inland habitat (Lindley et al. 2007).

Since 2005, there has been a period of widespread decline in all CV Chinook salmon stocks. An analysis by Lindley et al. (2009) that examined fall-run Chinook salmon found that unusual oceanic conditions led to poor growth and survival for juvenile salmon entering the ocean from the Central Valley during the spring of 2005 and 2006 and most likely contributed to low returns in 2008 and 2009. This reduced survival was attributed to weak upwelling, warm sea surface temperatures, low prey densities, and poor feeding conditions in the ocean. When poor ocean conditions are combined with drought conditions in the freshwater environment, the productivity of salmonid populations can be significantly reduced. Although it is unclear how these unusual ocean conditions affected CCV steelhead, it is highly likely they were adversely impacted by a combination of poor ocean conditions and drought (NMFS 2011).

Although CCV steelhead would experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile CCV steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 57°F to 66°F (14°C to 19°C). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). In fact, McCullough et al. (2001) recommended an optimal incubation temperature at or below 52°F to 55°F (11°C to 13°C). Successful smoltification in steelhead may be impaired by temperatures above 54°F (12°C), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild steelhead populations.

In summary, observed and predicted climate change effects are generally detrimental to all of the species addressed in this appendix (McClure 2011; Wade et al. 2013), so unless offset by improvements in other factors, the status of the species and critical habitat is likely to decline over time. The climate change projections referenced above cover the time period between the present and approximately 2100. While there is uncertainty associated with projections, which increase over time, the direction of change is relatively certain (McClure et al. 2013).

2.3 Action Area

"Action area" means 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).

The Stanislaus River is a tributary to the San Joaquin River in California. The proposed project location is on two private properties (Stanislaus County Assessor parcel number # 006-080-064, 006-080-088 and 006-080-089) on the lower Stanislaus River (Figure 1). The Proposed Project is accessible via Timmerman Lane off Rodden Road. An estimated 3.8 acres of floodplain and approximately 2,000 linear feet of side channel habitat are available to be rehabilitated. Currently, the site is perched floodplain habitat that has been disconnected from the main river channel due to years of channel incision. Floodplain inundation occurs only during high flood flows on the river, and is generally inaccessible to juvenile salmonids during spring rearing periods.

The action area for projects that involve instream construction work includes the project footprint and the area downstream, where instream construction activities can temporarily decrease water quality. The effects of increased turbidity would attenuate downstream as suspended sediment settles out of the water column. Instream projects with a larger footprint than the Proposed Project have created turbidity plumes of 25-75 nephelometric turbidity units (NTUs) extending up to 1,000 ft (304.8 meters [m]) downstream as a result of instream construction activities (NMFS 2006). Therefore, a conservative definition of the action area for the Proposed Project is the Project footprint and the reach of the Stanislaus River extending from the edge of the project boundary to 1,000 ft (304.8 m) downstream. In addition, the Proposed Project includes adjacent control sites, that are located both upstream and downstream of the project site, to collect baseline information before project construction to enable hypothesis testing following restoration, following a BACI study design (Cramer Fish Sciences 2017). Therefore, the action area for this project includes the stretch of the Stanislaus River from the upstream control site to the downstream control site which includes the project footprint and extending downstream 1,000 ft from the downstream end of the project footprint (Figure 1). This is the area where the Proposed Project could result in direct or indirect effects on federally listed fish species and their critical habitat. Figure 1 shows the Proposed Project boundary within the action area, and the action area boundary.

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

2.4.1 Occurrence of Listed Species and Critical Habitat

The Stanislaus River action area functions primarily as freshwater rearing habitat for juvenile steelhead and freshwater migration corridor for juvenile and adult CCV steelhead. The action area can function as spawning habitat, but occurs infrequently and only when temperatures are suitable in the action area. The life stages that would occupy the action area for these species are adults, juveniles, and redds. The action area is designated critical habitat for CCV steelhead.

CCV steelhead

Bergman *et al*. (2014) estimated the population of *O. mykiss* in an approximately 300 meter reach of the Stanislaus River immediately below Goodwin Dam to be 3,427 (SE =1,522) (95% CI = 1,492-7,873) using mark and recapture of trout identified using spot pattern recognition. Snorkel observations in the upper reach and in lower reaches of the Stanislaus River suggest that this upper reach probably represents the highest density of *O. mykiss* in the river, and indicates that there is a much greater resident than anadromous component to the population. The stable cool water conditions in this area should allow at least the resident component of the population to persist through most drought conditions.

CCV steelhead in the action area likely to spawn during a similar timeframe to other CCV steelhead populations in Central Valley rivers. However, due to the action area's heavily degraded substrate and habitat conditions, spawning mostly occurs upstream of the action area. In addition, the action area is in a reach where the substrate transitions from gravel to sand bedded reach. A survey was conducted upstream of the action area by Reclamation and CDFW on February 5, 2014, between Knights Ferry and Horseshoe Bar and near Goodwin Dam. Ten redds were found in the Knights Ferry reach and two were found in Goodwin Canyon at the cable crossing area. One of the redds was occupied by spawners with visually estimated lengths of 25 cm (10 inches) and 35 cm (14 inches); the California regulatory cutoff between steelhead and Rainbow Trout is 40 cm (16 inches) for anglers, which categorizes this pair as resident Rainbow Trout (NMFS 2014, SRFG *et al*. 2003).

Juvenile rearing CCV steelhead may be present in the nearshore zones of the Stanislaus River year-round. During a 2017 pre-project seine sampling of the main channel, juvenile CV fall-run Chinook salmon were captured within the project boundary. No juvenile CCV steelhead were captured during 2017 pre-project seine sampling (Table 7). In addition, the number of juvenile CV fall-run Chinook salmon and CCV steelhead observed during pre-project snorkel surveys for the nearby Salmonid Habitat Restoration Project at Buttonbush are shown in Table 8. This project is located upstream from the action area but provides useful information about how many steelhead juveniles may occur within the action area. As predicted, juvenile salmonid density within the Proposed Project was relatively low because of its low suitability for juvenile rearing.

During the 2016 fall-run Chinook salmon spawning season (October to December), twenty redds were observed within the two downstream riffles proposed for enhancement within the Proposed Project site (Cramer Fish Sciences unpublished data). Enhancing the three riffles within the site would result in increased spawning utilization and higher quality incubation habitat for salmonids.

Table 7: Total number of juvenile Chinook Salmon and O. mykiss captured during pre-project seine surveys for the Proposed Project in 2017.

Year	Month Range	# of surveys	Fall-run Chinook Salmon	*O. mykiss*
2017	Feb. and Apr.	2	91	0

Table 8: Total number of juvenile Chinook salmon and O. mykiss observed during pre-project snorkel surveys for the nearby Stanislaus River Salmonid Habitat Restoration Project at Buttonbush Park from 2010 to 2016.

Year	Month(s)	# of surveys	Fall-run Chinook Salmon	*O. mykiss*
2010	Jun.	1	4	72
2013	Feb. – May	4	1771	26
2014	Feb. - May	3	3481	79
2015	Feb. - May	3	663	126
2016	Feb. - May	4	1635	0

In addition, snorkel surveys on the Stanislaus River conducted in 2003 to 2005 identified the first *O. mykiss* fry observations around mid-March to early April each year. Fry were observed between Goodwin Dam and Orange Blossom Bridge, with observations occurring as far downstream as Valley Oak in one year. None were observed below Valley Oak. The action area is located downstream of Orange Blossom Bridge and Valley Oak. This indicates that spawning was limited to the area mostly upstream of Orange Blossom Bridge and the action area. Higher rearing densities were always found from Goodwin Dam down to the Lover's Leap area. This probably coincides with the area of most spawning for both resident trout and steelhead. A majority of outmigrating steelhead smolts leave the Stanislaus River during the late winter and early spring. Based on recoveries of steelhead in the Caswell and Oakdale rotary screw traps, approximately 70 percent of steelhead smolts have exited the Stanislaus River by the end of March (NMFS 2014).

The Stanislaus River is a Core 2 population for CCV steelhead. Although, the steelhead population in the Stanislaus River is small compared to other populations in the Central Valley, the Stanislaus River currently provides more suitable habitat than the Tuolumne or Merced rivers, and produces more *O. mykiss* than the other eastside tributaries of the San Joaquin River basin.

Critical Habitat

The Stanislaus River is designated critical habitat for CCV steelhead. The physical or biological features (PBFs) of Critical habitat for CCV steelhead present in the action area are freshwater rearing habitat, spawning habitat, and freshwater migration corridors. As described above, the Stanislaus River has been converted from a multi-channel system to a single, deeply incised and constricted channel. Features such as floodplains and other off-channel salmonid rearing habitat within the action area only function at extreme high flows (~6,000 cfs). Instream habitats and adjacent riparian/floodplain areas within the lower Stanislaus River have been modified or converted for uses such as agriculture, rural residential, gravel and gold mining, water impoundments, increased water diversions, and decreased instream flows. These major actions and other events have led to the deterioration of riparian and aquatic habitat conditions for salmonids.

The Stanislaus River is lacking in floodplain areas that inundate regularly and in channel complexity, which has resulted in very limited juvenile salmonid rearing habitat (NMFS 2014). The cover that is present in the Stanislaus River includes: submerged terrestrial vegetation and roots, aquatic macrophytes, instream woody material, and overhead cover provided by low-growing riparian vegetation (Cramer Fish Sciences 2015a, Cramer Fish Sciences unpublished data), but very little habitat complexity exists in the action area. Despite the anthropogenic impacts that have reduced the quality and quantity of juvenile salmonid rearing habitat in the Stanislaus River, a limited number of *O. mykiss* juveniles have been observed rearing during snorkel surveys at Buttonbush, 6.2 miles upstream from the Proposed Project location (Cramer Fish Sciences 2013, 2014b, 2015a). Spawning habitat for CCV steelhead is likely present within the action area, but is heavily degrated. However, CCV steelhead have not been observed spawning within the action area, and may only spawn infrequently when habitat conditions are suitable. CV fall-run Chinook salmon spawning has been observed within the site and there is overlap in their spawning habitat (Cramer Fish Sciences unpublished data). Gravel augmentation is expected to improve the quality and quantity of CCV steelhead spawning habitat within the action area. The Stanislaus River within the action area is mainly used as juvenile rearing and migration corridor for adult and juvenile CCV steelhead, which is currently degraded incised channel with little native riparian vegetation cover.

2.4.2 Factors Affecting Listed Species and Critical Habitat in the Stanislaus River

Instream habitats in the lower Stanislaus River below Goodwin Dam have been modified or converted for uses such as agriculture, rural residential, gravel and gold mining, water impoundments, increased water diversions, decreased instream flows, and levees. These major actions and other events have led to the deterioration of riparian and aquatic habitat conditions on the lower Stanislaus River. Many areas within the lower Stanislaus River's historic corridor, including floodplains, side channels, and other off channel areas, are now hydrologically disconnected from the main channel during more frequent flood flows (1.5 to 5 year recurrence interval) due to channel incision, levees, and reduction in flood flows due to flow regulation (Kondolf *et al*. 2001). Since at least the mid 1800's the geomorphology of the Stanislaus River has been impacted from agriculture, gravel mining, and flow and sediment regulation. Agricultural land use changes, instream gravel mining and flow regulation are three components that have directly affected the geomorphic structure and physical habitat of the river. From approximately the 1920's to the late 1960's, gravel and gold mining within the active channel of the river has caused major alterations to the river's geometry, impacting the occurrence and distribution of salmonid habitat such as pools, riffles, and floodplain. Overall, mining is thought to have extracted a considerable amount of coarse and fine sediment relative to the natural watershed supply (Kondolf *et al*., 2001; Schneider *et al*. 2003). While NMFS found no records of instream or floodplain gravel mining at the proposed project site, upstream mining activities may have affected downstream reaches of the river by reducing coarse sediment supply.

Stanislaus River channel morphology was further impacted by the construction of multiple dams. Goodwin Dam was built in 1912, Melones Dam in 1926, and finally the much larger New Melones Dam was built in 1978. The systemic alteration of river corridor topography from gravel and gold mining up until the late 1960's and the construction of these dams have resulted in an essentially static channel in the lower river reach accessible to anadromous salmonids. Pre-dam, Stanislaus River flows reached 10,000 cfs at least every 2 years and peak floods exceeded 60,000 cfs; in contrast, currently New Melones Dam releases no more than 8,000 cfs, which is the current prescribed 100 yr flow downstream of the dam and is the United States Army Corps of Engineers (USACE) floodway maintenance requirement downstream of the dam (USACE 1972). Because the reservoir releases much less than 8,000 cfs, even during flood season, agricultural encroachment into the floodplain has occurred and constrains the USACE from making large releases, in the interest of public safety. Brown and Bauer (2010) showed that mean annual flow was essentially reduced by half between 1979 to 2006 and that, in contrast with natural flow conditions in a Mediterranean climate, flows are generally reduced in the winter and spring and increased in the summer.

Estimates of sediment supply reduction due to flow regulation are given by Kondolf *et al*. (2001). For the period from 1949 to 1999 an estimated 6,324,300 yd^3 (4,835,045 m^3) of sand and gravel were extracted from mining pits between Goodwin Dam and Oakdale, with only 84,700 yd^3 (64,758 m^3) of inputs from tributaries below Goodwin Dam within the same time period (Kondolf *et al*., 2001). Sediment produced in the watershed above New Melones was estimated to be 949,200 yd^3 (725,715 m^3), but this sediment is trapped by the dam and cannot pass into the lower river. Due to these sediment impacts, the number of salmonid spawning riffles, as well as overbank flooding, in the river has decreased over time. In addition to the impacts caused by the lack of spawning substrate, it has been hypothesized that moderate flows have flushed fine sediments from mining pits that eventually infiltrate spawning riffles, causing further degradation. To offset the lack of coarse substrate recruitment and rehabilitate salmonid spawning riffles, at least 50,000 tons (45,359 metric tons) of gravel has been placed in the Stanislaus River since about 1994 by resource agencies, primarily in the Goodwin Canyon.

Currently, the Stanislaus River downstream of Goodwin Dam generally has a narrow strip of dense riparian vegetation along both of its banks. Riparian habitat along the lower Stanislaus River has been reduced by approximately 50 percent due to agricultural and residential development as well as channel and flow modification (USFWS 1995). Extensive vegetated floodplain areas are largely absent, with dense strips of vegetation largely confined to the area immediately bordering the wetted channel. The dense riparian vegetation established along the channel banks and bars have remained stable in the absence of high flows. It is possible that this vegetation has stabilized lateral sources of gravel in the river corridor (Gurnell 2014) confounding impacts to gravel and cobble sediment supply from upstream dams.

CV fall-run Chinook salmon and CCV steelhead are the primary focus of management efforts in the Stanislaus River; although spring-run Chinook Salmon were also historically present in the river system, they are now rarely observed (CDFW, unpublished data). Goodwin Dam (RM 58.4) is the uppermost extent of fish migration, limiting all anadromous species and life stages to the low gradient lower river and dramatically reducing suitable spawning and rearing habitat compared to pre-dam conditions. The AFRP production goal for the Stanislaus River is 22,000 CV fall-run Chinook salmon (USFWS 2001). The escapement to the Stanislaus River appears to be on an upward trajectory since 2014, with an estimated escapement of 9,330 CV fall-run Chinook salmon in 2016 (Figure 13). However, the recent escapement estimates are still considerably short of the AFRP production goal. The largest CV fall-run Chinook salmon escapement estimate since 1975 was 13,473 in 1985. The proposed action should help create habitat to support an increasing fall-run Chinook salmon population.

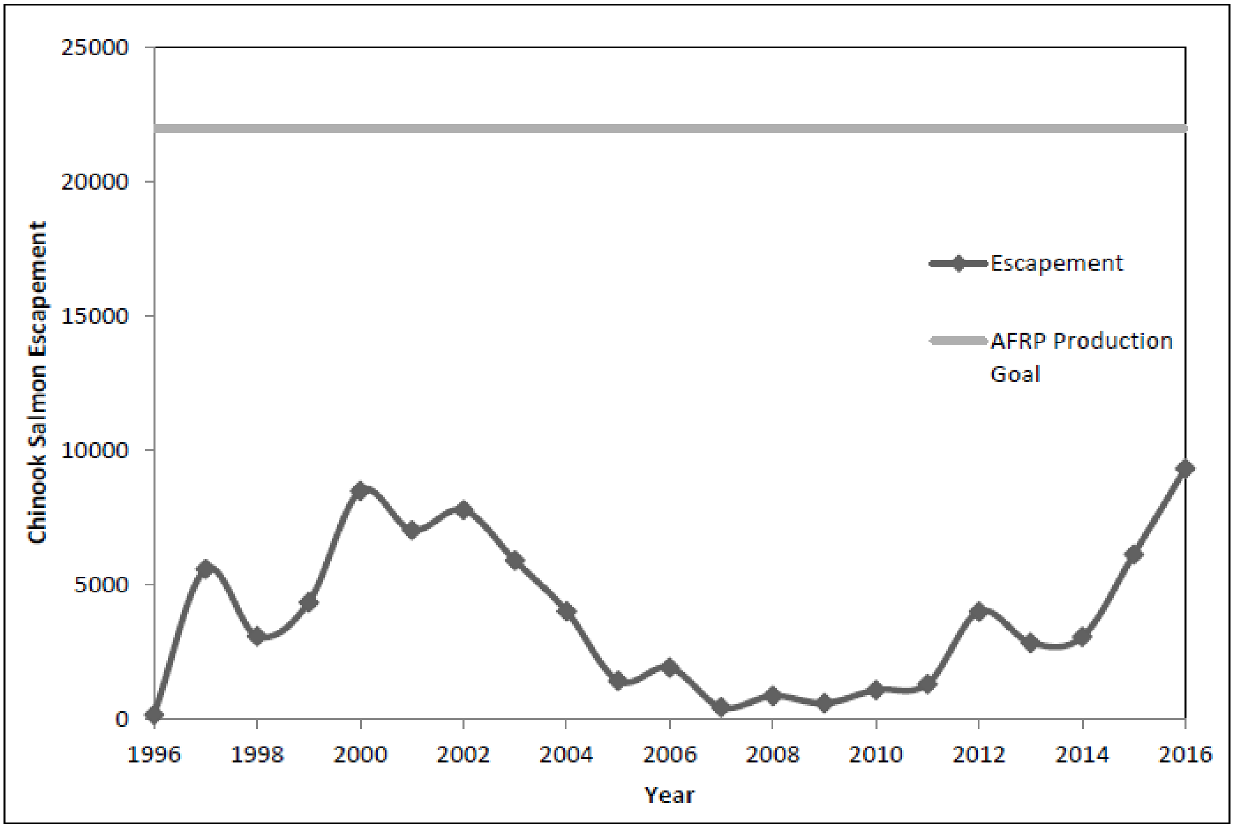

Figure 13. The estimated Chinook Salmon escapement to the Stanislaus River from 1996 to 2016 with the AFRP production goal for the Stanislaus River depicted. Data acquired from Grandtab (CDFW 2017).

The river corridor in the project location is partly confined with a meandering, and sometimes weakly anastomosing, river channel. Partly confined valleys represent a transition from valley confined settings (such as Goodwin Canyon, above Knight's Ferry) to laterally unconfined floodplains. In these types of river corridors floodplains are present, albeit in a discontinuous manner, where valley width is relatively large and/or tributaries deliver sustaining amounts of sediment. The Proposed Project site is located on the north bank of the Stanislaus River on a relict river terrace, likely of Pleistocene origin. The south bank of the river within the Proposed Project site is mostly confined and steep from local geology, although smaller discontinuous terraces are present too. This setting places a premium on juvenile rearing habitat, because floodplains are intrinsically limited and discontinuous. The perched floodplain within the north bank of the Proposed Project site has been disconnected from the main river channel following years of channel incision (see Kondolf *et al*. 2001). Under current conditions, the perched floodplain begins to inundate at approximately 4,000 cfs; however, water does not actively move through the perched floodplain until the flow levels reaches approximately 6,000 cfs. Because it only activates under these high flood flow conditions, the perched floodplain is generally inaccessible to juvenile salmonids during the rearing period (i.e., February through June).

Climate change may impact the action area by reducing snowpack in the upper watershed, resulting in warmer water temperatures in the lower Stanislaus River. Warmer water temperatures could impact various life stages. Climate change may also cause more frequent droughts resulting in lower flows and less habitat variability for CCV steelhead. However, the proposed project would help improve habitat conditions by increasing water surface elevation that would facilitate more inundated habitat with less flow (see Figure 4). In addition, there would be an increase in native riparian vegetation that would provide more cover and cooler water temperatures for rearing juvenile steelhead, especially during the warmer months of the year.

2.5 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that would be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The following is an analysis of the potential direct and indirect effects to listed fish species that may occur as a result of implementing the proposed action in the Stanislaus River at Rodden Road. For our analysis on the effects of the proposed action to listed species, we have used the presence of species in the action area to determine the risk each the species and life stage may face if exposed to project impacts. The effects of the proposed action components that were analyzed include: (1) sediment and turbidity, (2) contaminants, (3) noise exposure, (4) habitat modification, and (5) monitoring activities.

Our assessment considers the nature, duration, and extent of the proposed actions relative to the spawning, rearing, and migration timing, behavior, and habitat requirements of all life stages of federally listed fish in the action area. Effects of the restoration project on aquatic resources include direct and indirect effects. When the project is complete, the proposed project would provide long-term beneficial impacts to the listed species and critical habitat. Potential impacts from specific monitoring actions related to each restoration activity are also described below.

2.5.1 Construction Activities

NMFS expects that rearing juvenile CCV steelhead may be present in the action area during in-water construction activities (July 15 to October 15), potentially exposing juvenile steelhead to construction related adverse impacts such as increased sedimentation and turbidity, release of contaminants from construction equipment, increased noise and disturbance and modification of habitat (Table 9).

Impacts to adult migration and spawning, egg incubation, and emergence would be avoided because construction activities would occur outside of the timing of those life stages. Therefore, no adverse effects to those life stages are expected during construction activities.

Table 9. Potential effects of the Proposed Project due to construction activities.

Activity	Increased Sedimentation and Turbidity	Release of Contaminants from Construction Equipment	Increased Noise and Disturbance	Modification of Fish Habitat
Removal of non-native bank vegetation	X	X	X	X
Excavation of side channels		X	X	X
Reconnect side channels to main river	X	X	X	X
Floodplain grading and elevation lowering		X	X	X
Gravel augmentation	X	X	X	X

Sediment and Turbidity

Construction activities related to restoration actions would temporarily disturb soil and riverbed sediments, resulting in the potential for temporary increases in turbidity and suspended sediments in the Stanislaus River within the action area. Construction-related increases in sedimentation and siltation above the background level could potentially affect steelhead and their habitat.

High concentrations of suspended sediment can have both direct and indirect effects on salmonids. The severity of these effects depends on the sediment concentration, duration of exposure, and sensitivity of the affected life stage. Based on the types and duration of proposed in-water construction methods, short-term increases in turbidity and suspended sediment may disrupt feeding activities or result in avoidance or displacement of fish from preferred habitat. Juvenile salmonids have been observed to avoid streams that are chronically turbid (Lloyd 1987) or move laterally or downstream to avoid turbidity plumes (Sigler et al. 1984). Bisson and Bilby (1982) reported that juvenile Coho Salmon (*Oncorhynchus kisutch*) avoid turbidities exceeding 70 NTUs. Sigler et al. (1984) found that prolonged exposure to turbidities between 25 and 50 NTUs resulted in reduced growth and increased emigration rates of juvenile Coho Salmon and steelhead compared to controls. These findings are generally attributed to reductions in the ability of salmon to see and capture prey in turbid water (Waters 1995). Chronic exposure to high turbidity and suspended sediment may also affect growth and survival by impairing respiratory function, reducing tolerance to disease and contaminants, and causing physiological stress (Waters 1995). Berg and Northcote (1985) observed changes in social and foraging behavior and increased gill flaring (an indicator of stress) in juvenile Coho Salmon at moderate turbidity (30-60 NTU). In this study, behavior returned to normal quickly after turbidity was reduced to lower levels (0-20 NTU). In addition to direct behavioral and physical effects on fish, increased sedimentation can alter downstream substrate conditions, as suspended sediment settles and increases the proportion of fine particles in the system. Adult salmonids require coarse substrate (gravel and small cobbles) to construct redds, and deposition of fine substrate may reduce egg and alevin survival and lead to decreased production of the macroinvertebrate prey of juvenile salmonids (Wu 2000, Chapman 1988, Phillips et al. 1975, Colas et al. 2013). Deposited fine sediment can impair growth and survival of juvenile salmonids (Suttle et al. 2004, Harvey et al. 2009). However, minor accumulations of deposited sediment downstream of construction are generally removed during normal annual high flow events (Anderson et al. 1996).

Impacts to CCV steelhead would be minimized by conducting all in-water restoration activities during the dry season between July 15 and October 15, by avoiding the adult migrating, spawning, and incubation and emergence periods. However, rearing juveniles may be present in the river during this time period. If in-water restoration activities need to extend past October 15 then coordination would occur with USFWS, NMFS, and CDFW to obtain approval to extend the in-water work. Weekly redd surveys would be performed within the project site and in-water restoration work would cease as soon as evidence of salmon spawning has been observed. The number of juvenile steelhead potentially residing in the action area during in-water restoration is expected to be very low because of the time of year and low quality of existing habitat (Cramer Fish Sciences unpublished data). Individual fish that encounter increased turbidity or sediment concentrations would be expected to move laterally, downstream, or upstream of the affected areas. For steelhead juveniles, this may increase their exposure to predators if they are forced to leave protective habitat. Turbidity plumes would be expected to affect only a portion of the channel width and extend up to 1,000 ft downstream of the site. These plumes would occur intermittently during daylight hours, resulting in daily periods (at least 12 hours) in which water quality would return to background levels.

The Proposed Project may have direct effects on rearing CCV steelhead by reducing water quality during project construction. Impacts to rearing CCV steelhead would be minimized by the water quality conservation measures stated in section 1.3.4. In addition, juvenile steelhead are highly mobile and would likely avoid the proposed project impacts by swimming away and rearing in highly suitable habitats of the river. Because water quality impacts are temporary and short in duration, in addition to their highly mobile behavior, adverse direct and indirect effects of sediment and turbidity on CCV steelhead and their critical habitat would be avoided or minimized to the extent that the effects would be insignificant and not likely to reach a level that causes injury or death.

Contaminants

During restoration activities, there is potential for spills or leakage of toxic substances that could enter the Stanislaus River. Refueling, operation, and storage of construction equipment and materials could result in accidental spills of pollutants (e.g., fuels, lubricants, concrete, sealants, and oil).

High concentrations of contaminants can cause direct (sublethal to lethal) and indirect effects on fish. Direct effects include mortality from exposure or increased susceptibility to disease that reduces the overall health and survival of the exposed fish. The severity of these effects depends on the contaminant, the concentration, duration of exposure, and sensitivity of the affected life stage. A potential indirect effect of contamination is reduced prey availability; invertebrate prey survival could be reduced following exposure, therefore making food less available for fish. Fish consuming infected prey may also absorb toxins directly. For salmonids, potential direct and indirect effects of reduced water quality during project construction would be addressed by avoiding construction during times when salmonids are most likely to be present, utilization of vegetable-based lubricants and hydraulic fluids in equipment operated in the wet channel, and by implementing the conservation measures to reduce contaminants from entering the waterways.

Implementation of conservation measures would minimize adverse effects to juvenile CCV steelhead such that impacts would be insignificant to CCV steelhead and their critical habitat and would not likely to reach a level that causes injury or death.

Noise Exposure

Noise generated by heavy equipment and personnel during restoration activities could adversely affect fish and other aquatic organisms. The potential direct effects of underwater noise on fish and other organisms depend on a number of biological characteristics (e.g., fish size, hearing sensitivity, behavior) and the physical characteristics of the sound (e.g., frequency, intensity, duration) to which fish and invertebrates are exposed. Potential direct effects include behavioral effects, physiological stress, physical injury (including hearing loss), and mortality. The loudest noise generated at the site is expected from the sediment transport equipment. This equipment would not come in contact with aquatic habitat. Diesel engines are the second greatest noise expected at the site. No diesel engines or their exhaust systems would come in contact with the flowing channel. In addition, no indirect effects are anticipated as a result of construction noise. Exposure of juvenile steelhead to noise and disturbance would be minimized by conducting all instream activities during a single construction season between July 15 and October 15 period when most steelhead life stages are least likely present in the action area.

Noise and disturbance would be limited to the immediate action area and the area immediately surrounding the restoration activity. Once construction is underway, any potential for rearing juvenile steelhead that may be approaching the action area from upstream or downstream are likely to detect the sounds/vibrations and readily avoid the immediate Project Area.

By avoiding contact with flowing water from the sediment transport equipment and diesel engines that could generate noise, along with restricting the time period during which restoration activities would occur, the potential noise impacts would be minimized such that the impacts would be insignificant to CCV steelhead and not likely to reach a level that causes injury or death.

Habitat Modification

Floodplain Habitat and Side Channel Habitat Creation

Restoration activities would result in the disturbance of an estimated 3.8 acres of perched floodplain habitat**Error! Reference source not found.**. Approximately 23,000 cubic yards (yd3) of material would be excavated during floodplain lowering and side channel creation. Gravel would be deposited in-stream and placed by rubber-tired front-end loaders (Caterpillar 950

Loader). Creation of side channels and minor drainage channels would modify bank habitat; however, islands of native plants and trees would be preserved within the restoration area. Wetland areas on site would not be impacted or reduced in size, but minor channels would be created downstream to allow drainage at high flows. Habitat restoration would cause short-term adverse impacts and long-term beneficial impacts to steelhead habitat.

Disturbance to Riparian Habitat
To the maximum extent practicable, existing riparian habitat would be retained and disturbance of riparian habitat would be minimized. All large gallery trees present in the site would be retained. However, riparian vegetation that cannot be avoided would be replanted as stated in the project description. To prevent the spread of non-native species, a Hazard Analysis and Critical Control Points document would be developed for this project, containing best management practices that would be followed by all personnel involved in the project.

Following restoration activities, all disturbed or exposed soils would be stabilized and planted with native woody and herbaceous vegetation to control erosion and offset any unavoidable losses of vegetation. Non-native plant species would be replaced with native riparian plants. Some short-term losses of mature riparian vegetation may occur during restoration which may result in a short term reduction in natural cover for salmonids. However, plantings and natural riparian vegetation recruitment would establish and mature following project completion thereby resulting in an increase in the amount and extent of riparian habitat within the Project area.

Gravel Augmentation
Approximately 1,362 yd^3 of washed river rock would be placed in the main channel to enhance/create 1.1 acres of salmonid spawning habitat and increase water surface elevation to facilitate inundation of the floodplain and side channels (Figure 4). Channel habitat would be temporarily disturbed when side channel connections with the main channel are created and may result in a short-term decrease in natural cover for salmonids. Excavation of the primary and secondary side channels and lowering of the floodplain would change the hydrodynamics of the channel. Hydrodynamics would be changed to provide more complex habitat in the site. The amount of shallow water edge habitat used by rearing juvenile salmonids would increase along with frequency of floodplain and side channel inundation.

Gravel augmentation in the main channel has the potential to impact juvenile steelhead through disturbance and displacement. Gravel augmentation would occur during a time period (July 15 to October 15), when listed species are least likely present within the site. Gravel augmentation would temporarily impact salmonid spawning riffles. However, gravel augmentation would occur before the spawning season and would increase the quality and quantity of spawning habitat within the action area.

Juvenile CCV steelhead that may be present in locations where gravel augmentation would occur are expected to be able to avoid and temporarily or permanently relocate away from the area. Juvenile steelhead are highly mobile and would rapidly move away from an area when they are disturbed. When heavy equipment enters the river to place gravel, fish in the vicinity are expected to be startled and move rapidly away from the area of disturbance and thus avoid being injured or killed through crushing by the vehicle or gravel placement. Fish that are startled are likely to endure short-term stress from being forced to migrate away from their current holding/rearing area and needing to temporarily or permanently locate a new holding/rearing location. When gravel is being repeatedly added to an area, then fish are likely to temporarily or permanently relocate from the area. Juvenile fish may be subject to increased predation risk while they are locating to a new holding/rearing area. Displaced juvenile fish are likely to find a new holding/rearing location that is highly suitable as juvenile fish density, particularly *O. mykiss*, in the Stanislaus River within nearby locations has been observed to be low (Cramer Fish Sciences 2015a). The temporary displacement of fish and the stress they have to endure is not expected to affect the survival of individual fish or cascade through the population based on the size of the area that would likely be affected and the small number of juvenile CCV steelhead likely to be displaced.

Instream restoration activities are expected to cause benthic aquatic macroinvertebrates to be killed displaced, or their abundance reduced when they are covered with coarse sediment added to the channel to enhance salmonid spawning habitat. However, effects to aquatic macroinvertebrates from displacement and sediment smothering would be temporary because restoration activities would be relatively short lived and rapid recolonization (about one to two months) of the new sediment is expected (Merz and Chan 2005). The benthic macroinvertebrate production within the site is expected to increase when the project is complete as there would be an increase in area of perennial riffle habitat. The amount of food available for juvenile salmonids and other native fishes is therefore expected to increase overtime.

To minimize any potential negative effects on CCV steelhead, in-stream gravel placement activities would occur during the in-water work window when flows are low (approximately 300 cfs). Construction would occur over a single season and would require approximately 12 weeks, with instream construction requiring approximately 10 to 20 days. Work would occur Monday to Friday from 7:00 am to 5:00 pm.

Habitat Modification Conclusion

Overall, completion of the project is expected to have beneficial impacts by increasing the quality and quantity of spawning and rearing habitat for CV fall-run Chinook salmon and CCV steelhead. Existing low-lying areas associated with relict side channel and floodplain topography would be enhanced to activate more frequently and at depths and velocities more appropriate for rearing salmonids. Creation of side channel habitat and enhancement of existing riffles would improve and increase area of spawning and rearing habitat for salmonids. Imported coarse material would be used to enhance in-channel features for spawning, incubation, and rearing habitat. Although some short-term disturbance may occur when coarse sediment is placed into the river channel to improve spawning, incubation, and rearing habitat, these effects would be minimized through implementation of the salmonid protection measures described above. Disturbance to benthic macroinvertebrates would be temporary as they would rapidly colonize the newly added substrate. Riparian vegetation, including native trees and plants, would be retained and managed to maintain the vital ecological roles it currently provides within the community. Due to the timing of construction activities and mitigation measures that would be implemented, potential impacts from habitat modifications would be insignificant to CCV steelhead and their critical habitat and not likely to reach a level that causes injury or mortality of CCV steelhead. Lastly, there would be long-term beneficial impacts from the proposed project for all life stages of CCV steelhead.

2.5.2 Monitoring Activities

NMFS expects that all life stages of CCV steelhead would be present during the proposed monitoring activities (February through December). The long-term monitoring efforts accompanying this project aim to measure changes in the proposed site's hydrology, geomorphology, and river ecosystem as it relates to CCV steelhead and CV fall-run Chinook salmon life cycles (Cramer Fish Sciences 2017). The post-project monitoring would be performed for up to three years following construction. The specific targets of monitoring and anticipated effects are outlined below.

Wading Activities

Hydrology and Geomorphology
Evaluating the changes in the proposed site's hydrology and geomorphology would be predominantly done using digital elevation models and 2-dimensional hydraulic models. Data needed to parameterize these models include topography and bathymetry surveys, riverbed substrate composition, and water surface elevations. Collecting these data would require in-water wading by staff to conduct survey work with survey-grade GPS equipment. Wading activities would likely be restricted during low-flow periods in late summer (i.e., July through September) when the presence of juvenile and adult salmonids is minimized due to the timing of their life cycles. Alterations to the riverbed topography and substrate from wading are trivial, and wading is generally considered a low-level and short-term disturbance to juvenile and adult salmonids. If juvenile or adult salmonids are observed during survey work then all effort would be made to avoid disturbing them by not wading or surveying in their vicinity. Therefore, impacts to juvenile and adult CCV steelhead are considered to be discountable.

Stream Temperature
Long-term changes in stream temperature would be evaluated during and after the project is implemented. These evaluations would require the installation of water temperature recorders within the proposed project site. Installation of these temperature recorders may require minimal wading. However, the installation of the water temperature recorders would be in locations and at times of the year when presence of juvenile or adult salmonids are least likely present. The installation and presence of these recorders would not have measureable biological impacts on the site and impacts to CCV steelhead individuals would be discountable.

Juvenile Salmonid Prey Base
Changes to juvenile salmonid prey-base would be assessed before and after project implementation. These assessments would require sampling of macroinvertebrates present in the drift and benthos. Sampling would occur February through June, annually. Sampling efforts may require minor disturbance of benthic substrate through wading and to dislodge macroinvertebrates. The total area of benthic substrate disturbed during sampling (using a Hess sampler) is small (< 10 ft^2) and time spent wading is short-term (minutes). Care would be taken to avoid areas being used by salmonids (e.g., active redds). Juvenile salmonids are capable of avoiding staff and equipment associated with these sampling activities. Juvenile and adult salmonids that are startled away from their holding/rearing area during invertebrate sampling would return to the area when the disturbance from sampling has ceased. If juvenile or adult salmonids are observed during macroinvertebrate sampling, all effort would be made to avoid

disturbing them by not sampling or wading in their vicinity. Biological impacts from macroinvertebrate sampling are considered temporary and insignificant to juvenile and adult CCV steelhead.

Salmonid Redd Counts (Spawning Surveys)

Redd counts, snorkel, and video surveys would be conducted to estimate habitat use and the abundance of salmonids and other fish species present in the proposed restoration site before and after project implementation. Redd counts would be performed during the period of CV fall-run Chinook salmon spawning, with redd counts performed twice a month from October through December. This time period may overlap the spawning period for CCV steelhead (December to April). Redd counts would be performed by raft in combination with walking the bank and in the channel, if necessary. When a redd is observed its coordinates would be recorded with a GPS unit (Trimble GeoXT) and its dimensions and average water column velocity just upstream of the pot recorded. All surveyors would wear polarized sunglasses to maximize redd observations. Care would be taken to avoid stepping on or disturbing any redds or startling fish away from redds. However, some spawning fish are likely to be disturbed or startled during redd counts. Adults would rapidly return to their redds when the disturbance has abated which would cause them to startled away from the redd, particularly if the disturbance is short lived. Performing redd counts is likely to result in adverse impacts to adult CCV steelhead from observation and harassment.

Snorkel Surveys

Snorkel surveys would require survey staff to observe and enumerate rearing juvenile salmonids within the project site and record the GPS coordinates and depth and velocity in the locations in which juvenile salmonids are observed. Snorkel surveys would require a day to complete and would typically be performed monthly from February through May, the time period when rearing juvenile salmonids are present. Adult CCV steelhead may be observed during the juvenile salmonid snorkel surveys. Adult CCV Steelhead may be observed during February through April as these months overlap with the migration, holding, and spawning of CCV steelhead in the Stanislaus River. All effort would be made to avoid actively spawning adult steelhead during snorkel surveys by not wading or surveying in their vicinity. The presence of individuals conducting the snorkel surveys would have short-term impacts on fish behavior and habitat use. Performing snorkel surveys is likely to result in adverse impacts to juvenile and adult CCV steelhead through observation and harassment.

Video Surveys

Two types of video surveys would be used, shallow water and deep pool. Both survey types would take a day to complete with shallow water video occurring up to monthly from February to May and deep pool video up to twice a year. During shallow water video, disturbing adult CCV steelhead would be avoided by not placing the cameras or wading in the vicinity of where actively spawning or holding adult steelhead are observed. Juvenile and adult CCV steelhead may be observed during deep pool video surveys and the presence of the camera and boat may have short-term impacts on fish behavior and habitat use. Performing video surveys is likely to result in adverse impacts to juvenile and adult CCV steelhead through observation and harassment.

Juvenile Salmonid Seine (Beach Seine) and Fyke-net Sampling
Monitoring juvenile salmonid habitat use within the main channel, side-channel, and floodplain in the proposed site may require seine sampling. Up to four locations would be seined within each habitat type (main channel, side channel, and floodplain) with up to three seine hauls per location. Seine sampling may occur monthly from February through May. Seine sampling would be used when water turbidity (i.e. visibility) precludes snorkel surveys. The seine size used would be based on the configuration of the seine location with a larger seine used in the main channel and a smaller seine used in the side channel. Seining would require wading by individuals operating the seine net and the net would possibly agitate stream bottom substrate where it is deployed.

The fyke-net sampling would be used to determine if juvenile salmonids are using and benefitting from the floodplain and side channel areas that were restored/rehabilitated as part of the project. The fyke net(s) would be installed in an exit channel of the floodplain or side channel when a flow event is forecasted to result in inundation. The fyke net would be "fished" continuously during the period of floodplain inundation and then removed when the floodplain or side channel was no longer inundated. We would most likely install and operate the fyke nets during managed pulse flows as they have known timing, duration, and magnitude, which would simplify fyke net operation logistics. The fyke-nets would be checked twice a day to process fish in the live boxes and to clean debris from the traps and live boxes.

Captured fish would be held in cool, oxygenated freshwater and anesthetized prior to any handling. Captured juvenile CV fall-run Chinook Salmon and CCV steelhead would be weighed and measured and then placed in an aerated recovery bucket. All other captured fish species would have a subsample of 20 of each species measured and the rest enumerated and placed in an aerated recovery bucket. Once fish in the recovery buckets are behaving normally then the fish would be returned to a proper release location within the area from which they were captured. Potential effects of seine and fyke sampling on juvenile salmonids include minor abrasions from the seine or fyke net and short-term effects from the anesthetic and handling. Seine and fyke sampling is expected to result in adverse impacts to juvenile CCV steelhead through capture and handling. If a fish mortality occurs during seining or fyke-net sampling then the sampling would cease immediately and NMFS and CDFW would be contacted. Sampling would only be performed with the approval of NMFS and CDFW.

Direct Effects from Take of listed species from Monitoring Activities

The proposed avoidance, minimization, and mitigation measures are expected to reduce the construction activities to CCV steelhead, to a level that is insignificant or discountable. However, monitoring activities would result in take of juvenile and adult CCV steelhead. Table 9 lists the different take methods. However, below are detailed summaries of the different take methods that would directly affect listed CCV steelhead.

Observe/Harass
Some of the proposed monitoring activities would result in observing or harassing listed fish as a result of snorkel surveys, spawning surveys, or video monitoring. Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative abundance. Its effects are also generally the shortest-lived and least harmful of the research

activities discussed in this section. A cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Juvenile salmonids frightened by the turbulence and sound created by observers, are likely to seek temporary refuge in deeper water, behind or under rocks, or riparian vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities, redds may be visually inspected, but would easily avoid trampling redds. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravel, and, to the maximum extent possible, the individual fish themselves, and allow any disturbed fish the time they need to reach cover.

Capture/Handle/Release
Any physical handling is known to be stressful to fish (Sharpe et al. 1998). The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and wherever the fish are held in buckets/live boxes), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18º Celsius or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly. The permit conditions contain measures that mitigate the factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover fairly rapidly from handling.

2.5.3. Project Effects on Critical Habitat

The proposed restoration project is expected to cause direct short and long-term effects on critical habitat for CCV steelhead. Potential project effects include temporary water quality degradation from localized increases in turbidity and suspended sediment, temporary disturbance to spawning riffles during gravel augmentation, temporary channel disturbance during connection of side channels to the main channel, short-term reduction of natural cover resulting from channel and riparian disturbance, and potential discharges of contaminants in the Stanislaus River during restoration activities. Long-term direct effects on designated critical habitat would be beneficial, including: increased channel complexity, reduced sedimentation and turbidity, increased side channel, floodplain, incubation, and spawning habitat, and improved riparian vegetation quality.

The project is expected to adversely impact several PBFs of critical habitat for CCV steelhead. Project modifications would result in a beneficial change to freshwater rearing and spawning PBFs because of the existing low quality rearing and spawning habitat in the action area and the increased quality and quantity of the restored habitat. The action area would continue to function as a freshwater migration corridor by providing adequate passage for adult and juvenile salmonids.

Restoration activities would improve existing and provide additional spawning, incubation, and rearing habitat for CCV steelhead. Therefore, the proposed project would have long-term benefits to critical habitat.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

2.6.1 Agricultural Practices

Agricultural practices in the action area may adversely affect riparian habitats through upland modifications of the watershed that lead to increased siltation, reductions in water flow, or agricultural run-off. Grazing activities from cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which can flow into the receiving waters of the associated watersheds. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect listed salmonids reproductive success and survival rates (Dubrovsky 1998, Daughton 2002).

2.6.2 Increased Urbanization

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth would place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, would not require Federal permits, and thus would not undergo review through the ESA section 7 consultation process with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially would degrade riparian and wetland habitat by eroding channel banks and midchannel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially re-suspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the associated water bodies.

2.6.3 Rock Revetment and Levee Repair Projects

Depending on the scope of the action, some non-federal riprap projects carried out by state or local agencies do not require federal permits. These types of actions and illegal placement of riprap occur within the watershed. The effects of such actions result in continued degradation, simplification and fragmentation of riparian and freshwater habitat.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) Appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Status of the CCV Steelhead DPS

The 2016 status review (NMFS 2016) concluded that overall, the status of CCV steelhead appears to have changed little since the 2011 status review when the Technical Recovery Team concluded that the DPS was in danger of extinction. Further, there is still a general lack of data on the status of wild steelhead populations. There are some encouraging signs, as several hatcheries in the Central Valley (such as Mokelumne River), have experienced increased returns of steelhead over the last few years. There has also been a slight increase in the percentage of wild steelhead in salvage at the south Delta fish facilities, and the percent of wild fish in those data remains much higher than at Chipps Island. Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates.

2.7.2. Status of the Environmental Baseline and Cumulative Effects in the action area

CCV steelhead use the action area as a spawning, rearing, egg incubation, and migratory corridor. Within the action area, the essential features of freshwater spawning, egg incubation, rearing and migration habitats for steelhead have degraded over time due to agriculture, rural residential, gravel and gold mining, water impoundments, increased water diversions, decreased instream flows, and levees. The construction of Goodwin Dam and gold mining has resulted in an essentially static channel in the lower river reach accessible to anadromous salmonids. The change in ecosystem as a result of halting the lateral migration of the river channel, the loss of floodplains, the removal of riparian vegetation, loss of gravel and instream woody material have likely affected the functional ecological processes that are essential for growth and survival of CCV steelhead in the action area.

The *Cumulative Effects* section of this BO describes how continuing or future effects such as the discharge of point and non-point source chemical contaminants discharges and increased urbanization affect the species in the action area. These actions typically result in habitat fragmentation, and conversion of complex nearshore aquatic habitat to simplified habitats that incrementally reduces the carrying capacity of the spawning, rearing, and migratory corridors.

2.7.3. Summary of Project Effects on CCV Steelhead

1. Construction-related Effects

During construction, some injury or death to individual fish is likely to result from placement of the gravel, or predation related to displacement of individuals away from the shoreline or at the margins or turbidity plumes. These construction type actions would occur during the summer and early fall months, when the abundance of individual steelhead is low and avoids adult and incubation periods, which would result in correspondingly low levels of injury or death.

2. Monitoring-related Effects

During monitoring activities, some injury or death to individuals may occur as a result of capture and handling of fish. However, proper care and precautions would be taken during the monitoring activities to minimize stress and mortality to individual fish.

2.7.4 Summary of Project Effects on CCV Steelhead Critical Habitat

Within the action area, the relevant PBFs of the designated critical habitat for listed salmonids are spawning, egg incubation, rearing, and migration.

The PBFs for the above habitats is expected to be affected by the temporary removal of vegetation, short-term channel modifications, temporary increases in turbidity, and wading, seining, and macroinvertebrate sampling, during monitoring activities. These activities are expected to temporarily decrease the quality of habitat. The minor disturbances to habitat as part of monitoring efforts are expected to have insignificant effects to the habitat. Long-term impacts to critical habitat would be beneficial as it would increase the quality and quantity of habitat for all life stages of CCV steelhead.

2.7.5 Summary

Although there are some direct short-term impacts from the proposed project, when added to the environmental baseline and cumulative effects, the adverse impacts from the proposed project in the action area are small. Overall, the project would result in long-term beneficial effects to the individual steelhead and their critical habitat as it would result in an increase in quality and quantity of the habitat in the action area.

The Stanislaus River steelhead population is considered to be a "Core 2" population and is in the Southern Sierra Diversity Group. Core 2 populations have a lower potential to support viable populations than Core 1 populations, but they still provide increased life history diversity to the DPS and are likely to provide a buffering effect against local catastrophic occurrences that can affect Core 1 populations. The proposed restoration project is likely to adversely impact individuals in the Core 2 population, but the impacts are temporary and the long-term benefits as a result of the project outweigh the short-term impacts. Therefore, the project is not expected to reduce appreciably the likelihood of either the survival and recovery of a listed species in the wild by reducing their numbers, reproduction, or distribution; or appreciably diminish the value of designated critical habitat for the conservation of the species.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, its NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of CCV steelhead or destroy or adversely modify designated critical habitat of these species.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a 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 regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

NMFS anticipates incidental take of CCV steelhead through the implementation of the proposed monitoring efforts in the action area. NMFS determined that incidental take is reasonably certain to occur as follows: incidental take of juvenile and adult CCV steelhead in the proposed action area. NMFS anticipates that juveniles and adults would be observed, harassed, captured, handled, or killed as a result of the proposed monitoring activities that would be occurring between February through December, up to three years. Specifically, incidental take is expected to occur during beach seining, snorkel surveys, spawning surveys, video monitoring, and fyke-net sampling activities, up to three years.

Table 10 summarizes the life stage, take method, and expected take amount for CCV steelhead after one year. However, post-project monitoring efforts would be performed up to three years.

Table 10. Annual summary of expected take for CCV steelhead.

Method	Take Action	Life Stage	Expected Annual Take	Indirect Mortality
Beach Seine	Capture/ Handle/ Release Fish	Juvenile	150	1
Snorkel Surveys	Observe/Harass	Juvenile	250	0
Snorkel Surveys	Observe/Harass	Adult	10	0
Spawning Surveys	Observe/Harass	Adult	4	0
Video Monitoring	Observe/Harass	Juvenile	50	0
Video Monitoring	Observe/Harass	Adult	1	0
Fyke-net Sampling	Capture/Handle/Release Fish	Juvenile	250	2

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to CCV steelhead or destruction or adverse modification their designated critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. Measures shall be taken to ensure that all activities minimize, to the maximum extent practicable, any adverse effects on CCV steelhead.

2. Measures shall be taken by USFWS to monitor incidental take of CCV steelhead and provide NMFS with a report following each monitoring season.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the USFWS or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The USFWS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

    a. The USFWS and the applicant must handle ESA-listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the applicant must process ESA-listed fish first to minimize handling stress.

    b. The USFWS and the applicant must stop handling (i.e. no sedation, measurements, weighing procedures, etc.) ESA-listed fish if the water temperature exceeds 70 degrees Fahrenheit at the capture site. Under these conditions, listed fish may only be identified and counted.

    c. If the USFWS and the applicant anesthetizes ESA-listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

    d. When using anesthesia, extreme care shall be taken to use the minimum amount of substance necessary to immobilize ESA-listed salmonids for handling and sampling procedures. It is the responsibility of the researcher to determine when anesthesia is necessary to reduce injuries to ESA-listed salmonids during handling and sampling activities.

    e. In the event that debris (rocks, logs, abundant vegetation, etc.) are trapped within the beach seine, researchers will remove debris before fish are centralized in the net to prevent harm. Researchers will select the smallest mesh-size seine-net or dip-net that is appropriate to achieve sampling objectives while reducing the probability that smaller fish will become gilled in the net.

    f. If the USFWS or the applicant unintentionally captures any ESA-listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

g. The USFWS or the applicant must exercise care during spawning ground surveys to avoid disturbing ESA-listed adult salmonids and redds when they are spawning. Visual observation must be used instead of intrusive sampling methods, especially when just determining fish presence.

h. The USFWS or the applicant must obtain approval from NMFS before changing sampling locations or research protocols.

i. The USFWS or the applicant must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The USFWS or the applicant must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

j. The USFWS or the applicant must allow any NMFS employee or representative to accompany field personnel while they conduct monitoring and evaluation activities.

k. The USFWS and the applicant must allow NMFS employee or representative to inspect any records or facilities related to the authorized monitoring and evaluation activities.

2. The following terms and conditions implement reasonable and prudent measure 2:

   a. The USFWS and/or the applicant shall submit a riparian planting plan for on-site plantings prior to restoration activities. Measures would be taken to ensure the performance criteria of 70 percent survival of plantings, for a period of three consecutive years.

   b. On or before January 31st of every year, the USFWS and/or the applicant must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on our permit website, and the forms can be found at *https://apps.nmfs.noaa.gov/*. Falsifying annual reports or records is a violation of this authorization.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. The USFWS should minimize any potential for further take whenever possible, and implement practices that avoid or minimize negative impacts to salmon and steelhead and critical habitat.

2. The USFWS should continue supporting and promoting aquatic and riparian habitat restoration within the Stanislaus River and other watersheds, especially those with listed aquatic species. Practices that avoid or minimize adverse effects to listed species should be encouraged.

3. The USFWS should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects. Implementation of future restoration projects is consistent with agency requirements set forth in section 7(a)(1).

2.11 Reinitiation of Consultation

This concludes formal consultation for the Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road.

As 50 CFR 402.16 states, 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 taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the USFWS and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

EFH designated under the Pacific Coast Salmon FMP may be affected by the Proposed Action. Additional species that utilize EFH designated under this FMP within the action area include fall-run/late fall-run Chinook salmon. Habitat Areas of Particular Concern (HAPCs) that may be either directly or indirectly adversely affected include (1) complex channel and floodplain habitat, (2) spawning habitat, and (3) thermal refugia.

3.2 Adverse Effects on Essential Fish Habitat

Effects to the HAPCs listed in section 3.1 are discussed in context of effects to critical habitat PBFs as designated under the ESA in section 2.2.2. A list of adverse effects to EFH HAPCs is included in the EFH consultation. Affected HAPCs are indicated by number corresponding to the list in section 3.1:

1. Sediment and Turbidity
    a. Reduce habitat complexity (1, 2, 3)
    b. Degraded water quality (1, 2, 3)
    c. Reduction/change is aquatic macroinvertebrate production (1, 3)

2. Contaminants
    a. Degraded Water Quality (1)
    b. Reduction in aquatic macroinvertebrate (1, 3)

3. Modification of Physical Habitat and Riparian Habitat
    a. Temporary loss of riparian habitat which provide shade, cover, nutrients, and habitat complexity due to vegetation removal or trimming (1, 3)

3.3 Essential Fish Habitat Conservation Recommendations

The following conservation recommendations are necessary to avoid, mitigate, or offset the impact of the proposed action on EFH:

1. NMFS recommends the following measures in order to mitigate for sediment and turbidity:

    a. USFWS shall implement erosion control measures such as silt fencing or fiber rolls to trap sediments and erosion control blankets on exposed slopes.
        a. USFWS shall appropriately screen and clean gravel prior to placement in the main channel and side channels to avoid introduction of additional fine material into the Stanislaus River.

b. Grade and stabilize spoils sites to minimize erosion and sediment input to surface waters.
c. Stream bank impacts shall be isolated and minimized to reduce bank sloughing. The banks would be stabilized following project activities.

2. NMFS recommends the following measures in order to mitigate for contaminants:

a. USFWS shall implement construction-site housekeeping practices, including prohibitions on discharging or washing potentially harmful materials into areas that could lead to waterways. Vehicles and equipment would be washed/cleaned only at approved off-site areas. All equipment would be steam cleaned prior to working within the stream channel to remove contaminants that may enter the river or adjacent lands.
b. All equipment working within the stream corridor would be inspected daily for fuel, lubrication, and coolant leaks; and for leak potentials (e.g., cracked hoses, loose filling caps, stripped drain plugs); and, all equipment must be free of fuel, lubrication, and coolant leaks. All equipment would be fueled and lubricated in designated staging area located outside the stream channel and banks. Only vehicles serviced with vegetable-based lubricants would work in the active channel to reduce the potential for water quality impacts to the Stanislaus River.
c. A Spill Prevention and Response Plan that identifies any hazardous materials to be used during restoration work; describes measures to prevent, control, and minimize the spillage of hazardous substances; describes transport, storage and disposal procedures for these substances; and outlines procedures to be followed in case of a spill of a hazardous material. The Spill Prevention and Response Plan would require that hazardous and potentially hazardous substances stored onsite be kept in securely closed containers located away from drainage courses, agricultural areas, storm drains, and areas where stormwater is allowed to infiltrate. It would also stipulate procedures, such as the use of spill containment pans, to minimize hazard during onsite fueling and servicing of construction equipment. Finally, the Spill Prevention and Response Plan would require that the County be notified immediately of any substantial spill or release.

3. NMFS recommends the following measures in order to mitigate for the modification of physical and riparian habitat:

a. During restoration activities, as much understory brush and as many trees as possible would be retained. The emphasis would be on retaining shade-producing and bank-stabilizing vegetation.
b. Any disturbed and decompacted areas outside the restoration area would be revegetated with locally native species.
c. There would be no impacts on heritage size trees (i.e. greater than 16 inches diameter breast height).
d. Sensitive vegetation in the near vicinity of restoration areas would be flagged or fenced.

e. All contractors and equipment operators would be given instructions to avoid impacts and be made aware of the ecological value of the site.

Fully implementing these EFH conservation recommendations would protect 4.9 acres or 2,769 feet of the Stanislaus River by avoiding or minimizing the adverse effects described in section 3.2, above, of designated EFH for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, USFWS must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The USFWS must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are USFWS. Other interested users could include: Stanislaus County, the communities of Oakdale, and the California Department of Fish and Wildlife. Individual copies of this opinion were provided to the USFWS. This opinion would be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

A. Literature Cited

Aceituno, M.E. 1990. Habitat preference criteria for Chinook salmon of the Stanislaus River, California. U.S. Fish and Wildlife Service. Sacramento, California.

Allen, M. A. and T.J. Hassler. 1986. Species Profiles: Life Histories and Environmental Requirements of Coast Fishes and Invertebrates (Pacific Southwest) -- Chinook Salmon. U.S. Fish Wildl. Serv. Bio. Rep. 82(11.49). U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Anderson, P. G., B. R. Taylor, and G. C. Balch. 1996. Quantifying the Effects of Sediment Release on Fish and their Habitats. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2336.

Bailey, E.D. 1954. Time pattern of 1953-54 migration of salmon and Steelhead into the upper Sacramento River. CDFG unpublished report. 4 p.

Bain, M. B. and N. J. Stevenson. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland.

Baker, P. F. and J. E. Morhardt. 2001. Survival of Chinook Salmon Smolts in the Sacramento San Joaquin Delta and Pacific Ocean. Fish Bulletin 2:163-182.

Bams, RA. 1970. Evaluation of a revised hatchery method tested on pink and chum salmon fry. J. Fish. Res. Board Can. 27:1429–1452.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), Steelhead. United States Fish and Wildlife Service Biological Report 82 (11.60).

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected Impacts of Climate Change on Salmon Habitat Restoration. Proc Natl Acad Sci U S A 104(16):6720-6725.

Beamesderfer, R.C.P. 2000. Managing fish predators and competitors: deciding when intervention is effective and appropriate. Fisheries 25: 18-23.

Beechie, T.J., M. Liermann, E.M. Beamer, and R. Henderson. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. Transactions of the American Fisheries Society 134: 717-729.

Behnke, R. J. 1992. Native Trout of Western North America. American Fisheries Society, Monograph 6, Bethesda, Maryland.

Berg, L. and T.C. 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.

Bergman, P, D.Delaney, J.Merz, C.Watry. 2014. Memo: A Pilot Mark-Recapture Study using Spot Patterns of *Oncorhynchus mykiss* in the Stanislaus River, California. Cramer Fish Sciences. March 10, 2014 Submitted to Erwin Van Nieuwenhuyse, USBR.

Bilski, R., and E. Rible. 2011. Lower Mokelumne River Salmonid Redd Survey Report: October 2010 through March 2011. East Bay Municipal Utility District, Lodi, CA. 17 pp.

Bisson, P. A. and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management. 2 (4):371-374.

Bjornn, T. C. and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19: 83-138.Bustard and Narver 1975.

Brandes, P.L. McLain JS. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Pages 39 – 138 in R.L. Brown, Editor. Contributions to the Biology of Central Valley Salmonids, Volume 2, Fish Bulletin 179. California Department of Fish and Game, Sacramento, California.

Brown, L.R., and M.L. Bauer. 2010. Effects of hydrologic infrastructure on flow regimes of California's Central Valley rivers: implications for fish populations. River Research and Applications 26: 751-765.

Buklis LS, Barton LH. 1984. Yukon River fall chum salmon biology and stock status. Informational Leaflet 239. Available at the Alaska Department of Fish and Game, Division of Commercial Fisheries, P.O. Box 25526, Juneau, Alaska 99802, U.S.A.

Burgner, R. L., J.T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1993. Distributions and Origins of Steelhead Trout (Onchorhynchus Mykiss) in Offshore Waters of the North Pacific Ocean. International North Pacific Fisheries Commission Bulletin 51:1-92.

Busby, P.J., O.W. Johnson, T.C. Wainwright, F.W. Waknitz, and R.S. Waples. 1993. Status review for Oregon's Illinois River winter Steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-10, 85 pp.

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. NOAA Tech Memo, Vol. NWFSC-27. 261 pp.

CALFED Bay-Delta Program. 2000. Ecosystem Restoration Program. CALFED Bay-Delta Program, Sacramento, CA.

California Department of Fish and Game (CDFG). 1993. Restoring Central Valley streams: A plan for action. State of California, Resources Agency, Department of Fish and Game.

California Department of Fish and Wildlife. 2013. 4(D) Permit #16877 Annual Report – Mossdale Kodiak Trawl Operations. La Grange, CA.

California Department of Fish and Wildlife. 2018. 4(D) Permit #20923 Annual Report – Mossdale Kodiak Trawl Operations. La Grange, CA.

CDFW. 2017. California Central Valley Chinook Population Database Report. Compiled on 4/7/2017. California Department of Fish and Wildlife. Accessed October 2017. Available: http://www.calfish.org/ProgramsData/Species/CDFWAnadromousResourceAssessment.aspx

Cavallo, B., R. Kurth, J. Kindopp, and A. Seesholtz. 2004. Distribution and habitat use of juvenile steelhead and other fishes of the lower Feather River. SP F-10 3A Final Report. Oroville Facilities Relicensing FERC Project No. 2100. Prepared by the Department of Water Resources, Sacramento, CA.

Cavallo, B., J. Merz, and J. Setka. 2013. Effects of predator and flow manipulation on Chinook salmon (Oncorhynchus tshawytscha) survival in an imperiled estuary. Environmental Biology of Fishes 96: 393-403.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117: 1–21.

Chase, R. 2010. Lower American River Steelhead (Oncorhynchus Mykiss) Spawning Surveys 2010. Department of the Interior, US Bureau of Reclamation.

Chebanov N. 1991. The effect of spawner density on spawning success, egg survival, and size structure of the progeny of the sockeye salmon, *Oncorhynchus nerka*. Journal of Ichthyology 31:101-106.

Cherry, D. S., K.L. Dickson, and J. Cairns Jr. . 1975. Temperatures Selected and Avoided by Fish at Various Acclimation Temperatures. Journal of the Fisheries Research Board of Canada(32):485-491.

Chevalier BC, Carson C, Miller WJ. 1984. Report of engineering and biological literature pertaining to the aquatic environment: with special emphasis on dissolved oxygen and sediment effects on salmonid habitat. Colorado State University, Department of Agriculture and Chemical Engineering, ARS Project 5602-20813-008A, Fort Collins.

Coble, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of Steelhead trout embryos. Transactions of the American Fisheries Society 90(4):469-474.

Cohen, S. J., K. A. Miller, A. F. Hamlet, and W. Avis. 2000. Climate Change and Resource Management in the Columbia River Basin. Water International 25(2):253-272.

Colas, F., J. Baudoin, M. Danger, P. Usseglio-Polatera, P. Wagner, and S. Devin. 2013. Synergistic impacts of sediment contamination and dam presence on river functioning. Freshwater Biology 58: 320–336.

Conard, S.G., R.L. MacDonald, and R.F. Holland. 1980. Riparian vegetation and flora of the Sacramento Valley, in riparian forests in California: their ecology and conservation. Institute of Ecology Publication No. 15, Agricultural Sciences Publications, University of California, Berkeley.

Courter, I.I., Child, D.B., Hobbs, J.A., Garrison, T.M., Glessner, J.J.G., Duery, S. 2013. Resident rainbow trout produce anadromous offspring in a large interior watershed. Canadian Journal of Fisheries and Aquatic Sciences 70(5): 701-710.

Cramer SP, Ackerman, NK. 2009. Prediction of stream carrying capacity for steelhead: the unit characteristic method. Pages 255–288 in E. E. Knudsen and J. H. Michael, Jr., editors. Pacific salmon environmental and life history models: advancing science for sustainable salmon in the future. American Fisheries Society, Symposium 71, Bethesda, Maryland.

Cramer Fish Sciences (CFS). 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010-2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.

CFS. 2013. Buttonbush Recreation Area Salmonid Habitat Restoration Project in the Stanislaus River. Phase II: Pre-Project Monitoring Report. Prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. 27 pp. + appendices.

CFS. 2014a. Juvenile salmonid out-migration monitoring at Caswell Memorial State Park in the Stanislaus River, California, annual report 2013-2014. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 51 pp.

CFS. 2014b. Stanislaus River Salmonid Habitat Restoration Project. Phase II: Pre-Project Monitoring Report – Year 2. Prepared for the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program. 21 pp. + appendices.

CFS. 2015a. Stanislaus river salmonid habitat restoration project phase II: pre-project monitoring report – year 3. Prepared for USFWS AFRP, Lodi, CA. 58 pp.

CFS. 2015b. Juvenile salmonid out-migration monitoring at Caswell Memorial State Park in the Stanislaus River, California, annual report 2014-2015. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 46 pp.

CFS. 2017. Buttonbush Park Recreation Area and Rodden Road Salmonid Habitat Enhancement Monitoring Plan. Prepared for USFWS AFRP, Lodi, CA. 46 pp.

Crisp. D.T. and P.A. Carling. 1989. Observations on siting, dimensions and structure of salmonid redds. Journal of Fish Biology 34:119–134.

Daughton, C.G. 2002. Cradle-to-Cradle Stewardship of Drugs for Minimizing their Environmental Disposition while Promoting Human Health. I. Rationale for Avenues toward a Green Pharmacy. Environmental Health Perspectives 111(5):757-774.

Dettinger, M. D. 2005. From Climate Change Spaghetti to Climate-Change Distributions for 21st Century California. San Francisco Estuary and Watershed Science 3(1):article 4.

Dettinger, M. D. and D. R. Cayan. 1995. Large-Scale Atmospheric Forcing of Recent Trends toward Early Snowmelt Runoff in California. Journal of Climate 8(3):606-623.

Dettinger, M. D., Daniel R. Cayan, Mary K. Meyer, Anne E. Jeton. 2004. Simulated Hydrologic Responses to Climate Variations and Changes in the Merced, Carson and American RiverBasins, Sierra Nevada, California, 1900-2099. Climatic Change 62(62):283-317.

Dittman, A.H., and T.P. Quinn. 1996. Homing on Pacific salmon: Mechanisms and ecological basis. The Journal of Experimental Biology 199:83-91.

Docker, M. F., and D.D. Heath. 2003. Genetic comparison between sympatric anadromous Steelhead and freshwater resident rainbow trout in British Columbia, Canada. Conservation Genetics *4*(2): 227-231.

Dolloff, C.A., J. Kershner, and R. Thurow. 1996. Underwater observation. Pages 533-554 in B.R. Murphy and D.W. Wouldis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Dubrovsky, N.M., D.L. Knifong, P.D. Dileanis, L.R. Brown, J.T. May, V. Connor, C.N. Alpers. 1998. Water Quality in the Sacramento River Basin. U.S. Geological Survey Circular 1215. United States Geological Survey.

Edmundson, E., F.E. Everest, and D.W. Chapman. 1968. Permanence of station in juvenile Chinook salmon and steelhead trout. Journal of the Fisheries Research Board of Canada 25: 1453-1464.

Eilers, C. D., J. Bergman, and R. Nelson. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. The Resources Agency: Department of Fish and Game: Fisheries Branch Administrative Report Number: 2010–2.

Everest, F. H. and D. W. Chapman. 1972. Habitat Selection and Spatial Interaction by Juvenile Chinook Salmon and Steelhead Trout in Two Idaho Streams. Journal of the Fisheries Research

Board of Canada 29(1):91-100.

FISHBIO, L. 2012. San Joaquin Basin Update. San Joaquin Basin Newsletter, Oakdale, California.

FISHBIO, L. 2013a. 4(D) Permit #16822 Annual Report - Tuolumne River Weir (2012 Season). Oakdale, CA.

FISHBIO, L. 2013b. 4(D) Permit #16825 Annual Report - Tuolumne River Rotary Screw Trap (2012 Season). Oakdale, CA.

FISHBIO, L. 2013c. 10(a)(1)(a) Permit #16531 Annual Report - Merced River Salmonid Monitoring. Oakdale, CA.

Fisher A, Hanemann M, Keeler A., 1991. Integrating fishery and water resource management: a biological model of a California salmon fishery. Journal of Environmental Economics and Management 20, 234–261.

Fleming, I.A. and M.R. Gross. 1990. Latitudinal clines; a tradeoff between egg number and size of Pacific salmon. Ecology 71:1-11.

Fontaine, B. L. 1988. An Evaluation of the Effectiveness of Instream Structures for Steelhead Trout Rearing Habitat in the Steamboat Creek Basin. Master's thesis. Oregon State University, Corvallis, OR.

Fortier, R., J. Nelson, R. Bellmer, and R. Nielson. 2014. Implementation Plan for the Central Valley Steelhead Monitoring Program. State of California, The Natural Resources Agency, Department of Fish and Wildlife. July 2014.

Garza, J. C. and D. E. Pearse. 2008. Population Genetic Structure of Oncorhynchus Mykiss in the California Central Valley: Final Report for California Department of Fish and Game. University of California, Santa Cruz, and National Marine Fisheries Service, Santa Cruz, California.

Geist, D.R., Abernethy C.S., Hand K.D., V.I. Cullinan , Chandler JA, Groves PA. 2006. Survival, development, and growth of fall Chinook salmon embryos, alevin, and fry exposed to variable thermal and dissolved oxygen regimes. Transactions of the American Fisheries Society 135:1462–1477.

Gerstung, E. 1971. Fish and Wildlife Resources of the American River to Be Affected by the Auburn Dam and Reservoir and the Folsom South Canal, and Measures Proposed to Maintain These Resources. California Department of Fish and Game.

Goniea TM, Keefer ML, BjornnTC, Peery CA, Bennett DH, Stuehrenberg LC. 2006. Behavioral thermoregulation and slowed migration by adult fall Chinook salmon in response to high Columbia River water temperatures. Trans Am Fish Soc 135:408–419.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed Esus of West Coast Salmon and Steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66, 637 pp.

Groot C, Margolis L, editors. 1991. Pacific salmon life histories. Vancouver: University of British Columbia Press.

Gurnell, A. 2014. Plants as river system engineers. Earth Surface Processes and Landforms 39: 4-25.

Hallock, R. J. 1989. Upper Sacramento River Steelhead, Oncorhynchus Mykiss, 1952-1988. U.S. Fish and Wildlife Service.

Hallock, R. J., D. H. Fry Jr., and D. A. LaFaunce. 1957. The Use of Wire Fyke Traps to Estimate the Runs of Adult Salmon and Steelhead in the Sacramento River. California Fish and Game 43(4):271-298.

Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery reared Steelhead rainbow trout (Salmon gairdnerii gairdnerii) in the Sacramento River system. California Department of Fish and Game 114. 74 pp.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834-844.

Hannon, J. and B. Deason. 2008. American River Steelhead (Oncorhynchus Mykiss) Spawning 2001 – 2007. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region.

Hannon, J., M. Healey, and B. Deason. 2003. American River Steelhead (Oncorhynchus Mykiss) Spawning 2001 – 2003. U.S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, CA.

Hartman, G. F. 1965. The Role of Behavior in the Ecology and Interaction of Underyearling Coho Salmon (Oncorhynchus Kisutch) and Steelhead Trout (Salmo Gairdneri). Journal of the Fisheries Research Board of Canada 22(4):1035-1081.

Harvey, C. 1995. Adult Steelhead Counts in Mill and Deer Creeks, Tehama County, October 1993-June 1994. California Department of Fish and Game, Inland Fisheries Administrative Report Number 95-3.

Harvey, B.C., J.L. White, and R.J. Nakamoto. 2009. The effect of deposited fine sediment on summer survival and growth of rainbow trout in riffles of a small stream. North American Journal of Fisheries Management 29:434-440.

Hayes, S. A., M. H. Bond, C.V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A.J. Ammann and R. B. MacFarlane. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Transactions of the American Fisheries Society 137(1): 114-128.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions Pathways, Climate Change, and Impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101(34):6.

Healey, M.C. 1991. Life history of chinook salmon (Oncorhynchus tshawytscha). Pages 311-394 in C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver.

Healey, M.C. and W.R. Heard. 1984. Inter-and intra-population variation in the fecundity of Chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory. Canadian Journal of Fisheries and Aquatic Sciences 41:476-483.

Heard, W.R. 1978. Probable case of streambed overseeding: 1967 pink salmon, *Oncorhynchus gorbuscha*, spawners and survival of their progeny in Sashin Creek, southeastern Alaska. National Oceanic and Atmospheric Administration (United States) Fishery Bulletin 76:569-582.

Heming TA. 1982. Effects of temperature on utilization of yolk by chinook salmon (*Oncorhynchus tshawytscha*) eggs and alevins. Canadian Journal of Fisheries and Aquatic Sciences 39:184-190.

Hillemeier D. 1999. An assessment of pinniped predation upon fall-run Chinook salmon in the Klamath River, CA, 1997. Yurok Tribal Fisheries Program, Klamath, California. 23 pp.

Hokanson, K. E. F., C. F. Kleiner, and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates of juvenile rainbow trout, Salmo gairdneri. Journal of the Fisheries Research Board of Canada 34:639-648.

Holland, V.L. and D.J. Keil. 1995. California Vegetation. Kendall/Hunt Publishing Company, Dubuque, IA.

Inoue, M., and S. Nakano. 1998. Effects of woody debris on the habitat of juvenile masu salmon (*Oncorhynchus masou*) in Northern Japanese streams. Freshwater Biology 40: 1-16.

Jackson, T.A. 1992. Microhabitat utilization by juvenile chinook salmon (*Oncorhynchus tshawytscha*) in relation to stream discharge in the lower American River, California. M.S. Thesis Oregon State University.

Jeffres CA, Opperman JJ, Moyle, PB. 2008. Ephemeral Foodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes 83:449–458.

Jensen, D.W., E.A. Steel, A.H. Fullerton, and G.R. Pess. 2009. Impact of fine sediment on egg-to-fry survival of Pacific salmon: a meta-analysis of published studies. Reviews in Fisheries Science 17: 348-359.

Johnson, M. R. and K. Merrick. 2012. Juvenile Salmonid Monitoring Using Rotary Screw Traps in Deer Creek and Mill Creek, Tehama County, California. Summary Report: 1994-2010. California Department of Fish and Wildlife, Red Bluff Fisheries Office - Red Bluff, California.

Kammel, L. and G.B. Pasternack. 2014. *O. mykiss* adult spawning physical habitat in the lower Yuba River. Prepared for the Yuba Accord River Management Team. University of California, Davis, CA, 140pp.

Kaufman RC, Houck AG, Workman M, Cech JJ. 2009. Chinook salmon length/fecundity: A regression model for the Mokelumne River, California. California Fish and Game 95:88-105.

Kjelson, M. A. and P. L. Brandes. 1989. The Use of Smolt Survival Estimates to Quantify the Effects of Habitat Changes on Salmonid Stocks in the Sacramento-San Joaquin Rivers, California In: Proceedings of the National Workshop on the Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publications in Fisheries and Aquatic Sciences, 105:100-115.

Knowles, N. and Cayan, D.: 2002, 'Potential Effects of Global Warming on the Sacramento/San Joaquin Watershed and the San Francisco Estuary', Geophys. Res. Lett. 29.

Kondolf, G.M., A. Falzone, and K.S. Scheider. 2001. Reconnaissance level assessment of channel change and spawning habitat on the Stanislaus River below Goodwin Dam. Report to the USFWS, Sacramento, CA. Fish Bulletin 87:219-264.

Kondolf GM, and M.G. Wolman. 1993. The sizes of salmonid spawning gravels. Water Resources Research 29:2275–2285.

Latta, F. F. 1977. Handbook of Yokuts Indians. Second edition. Bear State Books, Santa Cruz, CA.

Leider, S. A., M. W. Chilcote, and J. J. Loch. 1986. Movement and Survival of Presmolt Steelhead in a Tributary and the Main Stem of a Washington River. North American Journal of Fisheries Management 6(4):526-531.

Lindley, S.T. and M.S. Mohr. 2003. Modeling the effect of Striped Bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run Chinook Salmon (*Onchorhynchus tshawytscha*). Fishery Bulletin 101(2): 321-331.

Steelhead and its alteration by dams." San Francisco Estuary and Watershed Science 4.1.
Lindley, S. T., M. S. M. C. B. Grimes, W. Peterson, J. Stein, J. T. Anderson, L. W. Botsford, , D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, , and F. B. S. M. Palmer-Zwahlen, J. Smith, C. Tracy, R. Webb, B. K. Wells, T. H. Williams. 2009. What Caused the Sacramento River Fall Chinook Stock Collapse?

Lindley, S. T., R. S. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2006. Historical Population Structure of Central Valley Steelhead and Its Alteration by Dams. San Francisco Estuary and Watershed Science 4(1):19.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management: Vol. 7, No. 1 pp. 34–45.

Loch, J. J., S. A. Leider, M. W. Chilcote, R. Cooper, and T. H. Johnson. 1988. Differences in Yield, Emigration Timing, Size, and Age Structure of Juvenile Steelhead from Two Small Western Washington Streams. California Fish and Game 74:106-118.

McCain, M.E. 1992. Comparison of habitat use and availability for juvenile fall chinook salmon in a tributary of the Smith River, CA. USFS, R-5 Habitat Relationship Technical Bulletin Number 7.

McClure, M. 2011. Climate Change *in* Status Review Update for Pacific Salmon and Steelhead Listed under the Esa: Pacific Northwest., M. J. Ford, editor, NMFS-NWFCS-113, 281 p.

McClure, M. M., M. Alexander, D. Borggaard, D. Boughton, L. Crozier, R. Griffis, J. C. Jorgensen, S. T. Lindley, J. Nye, M. J. Rowland, E. E. Seney, A. Snover, C. Toole, and V. A. N. H. K. 2013. Incorporating Climate Science in Applications of the U.S. Endangered Species Act for Aquatic Species. Conservation Biology 27(6):1222-1233.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5. Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. Prepared as Part of U.S. Epa, Region 10 Temperature Water Quality Criteria Guidance Development Project.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42, 174 pp.

McEwan, D.R. 2001. Central valley Steelhead. Pages 1-44 in: R. Brown editor, Contributions to the Biology of Central Valley Salmonids. California Department of Fish and Game Fish Bulletin 179.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California Department of Fish and Game, Inland Fisheries Division, Sacramento, Management Report.

McNeil WJ. 1964. Redd superimposition and egg capacity of pink salmon spawning beds. J. Fish. Res. Board Can. 21: 1385-1396.

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

Merz JE. 2001. Diet of juvenile Chinook salmon in the lower Mokelumne River, California. Calif. Fish Game, 87: 102–114.

Merz, J.E., 2002. Seasonal feeding habits, growth, and movement of steelhead trout in the lower Mokelumne River, California. California Fish and Game, 88(3), pp.95-111.

Merz, J.E., Delaney, D.G., Setka, J.D. and Workman, M.L., 2015. Seasonal Rearing Habitat in a Large Mediterranean-Climate River: Management Implications at the Southern Extent of Pacific Salmon (*Oncorhynchus* spp.). River Research and Applications.

Merz, J.E., J.D. Setka, G.B. Pasternack. And J.M. Wheaton. 2004. Predicting benefits of spawning-habitat rehabilitation to salmonid (*Oncorhynchus* spp.) fry production in a regulated California river. Canadian Journal of Fisheries and Aquatic Sciences, 61(8), pp.1433-1446.

Merz, J.E., G.B. Pasternack, and J.M. Wheaton. 2006. Sediment budget for salmonid spawning habitat rehabilitation in a regulated river. Geomorphology 76: 207-228.

Merz, J.E. and L.K. Chan. 2005. Effects of gravel augmentation on macroinvertebrate assemblages in a regulated California river. River Research and Applications 21:61-74.

Merz, J.E. and Vanicek, C.D., 1996. Comparative feeding habits of juvenile Chinook Salmon, steelhead, and Sacramento Squawfish in the lower American River, California. California Fish and Game, 82(4), pp.149-159.

Merz, J.E., Workman, M., Threloff, D. and Cavallo, B., 2013. Salmon lifecycle considerations to guide stream management: examples from California's Central Valley. San Francisco Estuary and Watershed Science, 11(2).

Miyakoshi, Y., H. Hayano, H. Omori, M. Nagata, and J. Irvine. Importance of instream cover for young masu salmon , *Oncorhynchus masou*, in autumn and winter. Fisheries Management and Ecology 9: 217-223.

Miller J.A., A. Gray, and J. Merz. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook Salmon *Oncorhynchus tshawytscha*. Mar Ecol Prog Ser 408: 227−240.

Montgomery, D.R., E.M. Beamer, G.R. Pess, and T.P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Science 56:377-387.

Moyle, P. B. 2002. Inland fishes of California. Revised and expanded. University of California Press, Berkeley and Los Angeles, CA. 502 pp.

Moyle, P.B., R.M. Quinones, J.V. Katz, and J. Weaver. 2015. Fish Species of Special Concern in California. Sacramento: California Department of Fish and Wildlife.

Mulchaey B, and J. Setka. 2007. Salmonid survey monitoring report, October 2006 through March 2007, Mokelumne River, California. East Bay Municipal Utility District, Lodi, CA.

Myers JM, Kope RG, Bryant GJ. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA.

Myrick, C. A. and J. Joseph J. Cech. 2001. Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations. Bay-Delta Modeling Forum Technical Publication 01-1.

Myrick, C. A., and J. J. Cech. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain Steelhead. North American Journal of Aquaculture 67:324–330.

Nagayama, S., Y. Kawaguchi, D. Nakano, and F. Nakamura. 2009. Summer microhabitat partitioning by different size classes of masu salmon (Oncorhynchus masou) in habitats formed by installed large wood in a large lowland river. Canadian Journal of Fisheries and Aquatic Sciences 66: 42-51.

Narum, S.D., D. Hatch, A.J. Talbot, P. Moran, and M.S. Powell. 2008. Iteroparity in complex mating systems of Steelhead trout. Journal of Fish Biology 72:45-60.

National Marine Fisheries Service (NMFS). 1996. Factors for decline; a supplement to the notice of determination for West Coast Steelhead under the federal ESA. Portland, Oregon.

NMFS. 2004. Endangered and Threatened Species; Establishment of Species of Concern List, Addition of Species to Species of Concern List, Description of Factors for Identifying Species of Concern, and Revision of Candidate Species List Under the Endangered Species Act. Federal Register 69(73): 19975-19979.

NMFS. 2005. Critical Habitat for seven evolutionary significant units (ESUs) of salmon (*Oncorhynchus* spp.) in California. Federal Register 70(170):52590-52603.

NMFS. 2006. Biological Opinion for the Sacramento River Flood Control Project, Critical Levee Erosion Repair Project. 151422SWR2006SA00115:HLB. Long Beach, CA. June.

NMFS. 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. Endangered Species Act Section 7 Consultation with U.S. Bureau of Reclamation, Central Valley Office.

NMFS. 2011. 5-Year Review: Summary and Evaluation of Central Valley Steelhead. U.S. Department of Commerce, 34 pp.

NMFS. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

NMFS. 2016. California Central Valley Steelhead distinct population segment 5 year review: summary and evaluation. NMFS Central Valley Office, Sacramento, CA. 44 pp.

Newman, K. B. and J. Rice. 2002. Modeling the Survival of Chinook Salmon Smolts Outmigrating through the Lower Sacramento River System. Journal of the American Statistical Association 97(460):11.

Nielsen, J.L. 1994. Molecular genetics and stock identification in Pacific salmon (*Oncorhynchus* spp.). Ph.D. Thesis. Univ. of California, Berkeley. 167 pp.

Nielsen, J. L., S. Pavey, T. Wiacek, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. U.S.G.S. Alaska Science Center - Final Technical Report Submitted December 8, 2003. California Department of Fish and Game, Sacramento, California and US Fish and Wildlife Service, Red Bluff Fish, California.

Nobriga, M. and P. Cadrett. 2001. Differences among Hatchery and Wild Steelhead: Evidence from Delta Fish Monitoring Programs. IEP Newsletter 14(3):30-38.

Null, R. E., K. S. Niemela, and S. F. Hamelberg. 2013. Post-Spawn Migrations of Hatchery-Origin Oncorhynchus Mykiss Kelts in the Central Valley of California. Environmental Biology of Fishes(96):341–353.

Pearcy, W. G., R. D. Brodeur, and J. P. Fisher. 1990. Distribution and Biology of Juvenile Cutthroat Trout Oncorhynchus-Clarki-Clarki and Steelhead O-Mykiss in Coastal Waters Off Oregon and Washington. Fishery Bulletin 88(4):697-711.

Pearse, D. E, & Garza, J. C. 2015. You can't unscramble an egg: Population genetic structure of Oncorhynchus mykiss in the California Central Valley inferred from combined microsatellite and SNP data. San Francisco Estuary and Watershed Science, 1, Article 3.

Peven, C. M., R. R. Whitney, and K. R. Williams. 1994. Age and Length of Steelhead Smolts from the Mid-Columbia River Basin, Washington. North American Journal of Fisheries Management 14(1):77-86.

PFMC (Pacific Fishery Management Council). 1998. Description and identification of essential fish habitat for the Coastal Pelagic Species Fishery Management Plan. Appendix D to Amendment 8 to the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council, Portland, Oregon. December.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

PFMC. 2007. U.S. West Coast highly migratory species: Life history accounts and essential fish habitat descriptions. Appendix F to the Fishery Management Plan for the U.S. West Coast Fisheries for Highly Migratory Species. Pacific Fishery Management Council, Portland, Oregon. January.

PFMC. 2005. Amendment 18 (bycatch mitigation program), Amendment 19 (essential fish habitat) to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery. Pacific Fishery Management Council, Portland, Oregon. November.

PFMC. 2008. Management of krill as an essential component of the California Current ecosystem. Amendment 12 to the Coastal Pelagic Species Fishery Management Plan. Environmental assessment, regulatory impact review & regulatory flexibility analysis. Pacific Fishery Management Council, Portland, Oregon. February.

Parenskiy VA. 1990. Relation between the spawning success of Sockeye Salmon, *Oncorhynchus nerka*, and behavior on spawning grounds. Journal of Ichthyology 30:48–58.

Pasternack. G.B. 2008. Spawning habitat rehabilitation: advances in analysis tools. In (D.A. Sear, P. DeVries, S. Greig, Eds) Salmonid spawning habitat in rivers: physical controls, biological responses, and approaches to remediation. Symposium 65, American Fisheries Society, Bethesda, MD.

Patterson, D.A., Guderley H, Bouchard P, Macdonald JS, Farrell AP. 2004. Maternal influence and population differences in activities of mitochondrial and glycolytic enzymes in emergent Sockeye Salmon (*Oncorhynchus nerka*) fry. Can J Fish Aquat Sci 61:1225–1234.

Phillips, R.W., and H.J. Campbell. 1961. The embryonic survival of Coho Salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pacific Marine Fisheries Commission Research Division, Oregon State Game Commission Research Division, Oregon State University, Corvallis, OR.

Phillips, R.W., R.L. Lantz, E.W. Claire, and J.L. Moring. 1975. Some effects of gravel mixtures on emergence of Coho Salmon and steelhead trout fry. Transactions of the American Fisheries Society 104: 461–465.

Quinn, T.P. 1980. Evidence for celestial and magnetic compass orientation in lake migrating Sockeye Salmon fry. J. comp. Physiol. 137, 243–248.

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

Richter, A. and S. A. Kolmes. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science 13(1):23-49.

Roberts, W.G., J.G. Howe, and J. Major. 1980. A survey of riparian flora and fauna in California. Pages 3-19 in A. Sands, editor. Riparian forests in California: their ecology and conservation. Agricultural Sciences Publications, University of California, Berkeley.

Rombough, P. J. 1988. Growth, Aerobic Metabolism, and Dissolved Oxygen Requirements of Embryos and Alevins of Steelhead, *Salmo Gairdneri* Canadian Journal of Zoology 66:651-660.

Roni, P. 2005. Monitoring Stream and Watershed Restoration. American Fisheries Society, Bethesda, Maryland.

Roni, P., G.R. Pess, T.J. Beechie, and K.M. Hanson. 2014. Fish-habitat relationships and the effectiveness of habitat restoration. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-1.

Roni, P. and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58: 282-292.

Roos, M. 1987. Possible Changes in California Snowmelt Patterns, Pages 22-31 in Proc., 4th Pacific Climate Workshop, Pacific Grove, California.

Roos, M. 1991. A Trend of Decreasing Snowmelt Runoff in Northern California. Page 36 Western Snow Conference, April 1991, Washington to Alaska.

Sabal, M., S. Hayes, J. Merz and J. Setka. 2016. Habitat Alterations and a Nonnative Predator, the Striped Bass, Increase Native Chinook Salmon Mortality in the Central Valley, California. North American Journal of Fisheries Management, 36(2): 309-320.

Sasaki S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *Salmo gairdnerii*, in the Sacramento-San Joaquin Delta. California Department of Fish and Game, Fish Bulletin 136:108-114.

Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2010. State-Dependent Life History Models in a Changing (and Regulated) Environment: Steelhead in the California Central Valley. Evolutionary Applications 3(3):221-243.

Sawyer, A.M., G.B. Pasternack, J.E. Merz, M. Escobar, and A.E. Senter. 2009. Construction constraints on geomorphic-unit rehabilitation on regulated gravel-bed rivers. River Research and Applications 25: 416-437.Schaffter, R. 1980. Fish Occurrence, Size, and Distribution in the Sacramento River near Hood, California During 1973 and 1974. California Department of Fish and Game, Administrative Report No. 80-3.

Schneider, K.S., G.M. Kondolf, and A. Falzone. 2003. Channel-floodplain disconnection on the Stanislaus River: a hydrologic and geomorphic perspective. Pages 163-168 in P.M. Faber, editor. California riparian systems: Processes and floodplain management, ecology, and restoration. Riparian habitat and floodplain conference proceedings, Riparian habitat joint venture, Sacramento, CA.

Seelbach, P. W. 1993. Population Biology of Steelhead in a Stable-Flow, Low-Gradient Tributary of Lake-Michigan. Transactions of the American Fisheries Society 122(2):179-198.

Sellheim, K. L., C. B. Watry, B. Rook, S. C. Zeug, J. Hannon, J. Zimmerman, K. Dove, and J. E. Merz. 2016. Juvenile Salmonid Utilization of Floodplain Rearing Habitat after Gravel Augmentation in a Regulated River. River Research and Applications 32(4):610-621.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead Rainbow Trout (*Salmo gairdneri gairdner*) and Silver Salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Fish Bulletin 98. 375 pp.

Shirvell, C.S. 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and Steelhead trout (O. mykiss) cover habitat under varying streamflows. Canadian Journal of Fisheries and Aquatic Sciences 47: 852-861.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelhead and Coho Salmon. Transactions of the American Fisheries Society 113:142-150.

Sogard, S. M., J. E. Merz, W. H. Satterthwaite, M. P. Beakes, D. R. Swank, E. M. Collins, R. G. Titus, and M. Mangel. 2012. Contrasts in Habitat Characteristics and Life History Patterns of Oncorhynchus Mykiss in California's Central Coast and Central Valley. Transactions of the American Fisheries Society 141(3):747-760.

Sommer T, M.L. Nobriga, W.C. Harrell, W. Batham and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook Salmon: Evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 325–333.

S.P. Cramer & Associates. 2000. Stanislaus River Data Report. S.P. Cramer & Associates, Inc.

Spina, A., M. R. McGoogan, and T. S. Gaffney. 2006. Influence of Surface-Water Withdrawal on Juvenile Steelhead and Their Habitat in a South-Central California Nursery Stream. California Fish and Game 92(2):81-90.

Stanislaus River Fish Group (SRFG), Carl Mesick Consultants, S.P. Cramerand Associates, Inc., and the California Rivers Restoration Fund. 2003. A Plan to Restore Anadromous Fish Habitat in the Lower Stanislaus River. (Review Draft).

Sturrock, A.M., J.D. Wikert, T. Heyne, C. Mesick, A.E. Hubbard, and T.M. Hinkelman, et al. 2015. Reconstructing the migratory behavior and long-term survivorship of juvenile Chinook Salmon under contrasting hydrologic regimes. PLoS ONE 10(5):e0122380.

Suttle, K.B., M.E. Power, J.M. Levine, and C. McNeely, 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological Applications. 14: 969-974.

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.

Teo, S. L. H., P. T. Sandstrom, E. D. Chapman, R. E. Null, K. Brown, A. P. Klimley, and B. A. Block. 2011. Archival and Acoustic Tags Reveal the Post-Spawning Migrations, Diving Behavior, and Thermal Habitat of Hatchery-Origin Sacramento River Steelhead Kelts (Oncorhynchus Mykiss). Environmental Biology of Fishes.

Thompson, K. 1980. Riparian forests of the Sacramento Valley, California. In: Sands, editor. Riparian forests in California: their ecology and conservation, Priced publication 4101. Division of Agricultural Sciences, University of California.

Tierney K.B., D.A. Patterson, and C.J. Kennedy. 2009. The influence of maternal condition on offspring performance in Sockeye Salmon *Oncorhynchus nerka*. Journal of Fish Biology 75: 1244–1257.

United States Army Corps of Engineers (USACE). 1972. Environmental Impact Statement: New Melones Lake, Stanislaus River, California. USACE Sacramento District, Sacramento, California.

U.S. Fish and Wildlife Service (USFWS). 1995. Working paper on restoration needs: Habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. May 9, 1995. Prepared for the USFWS under the direction of the AFRP core group. Stockton, CA.

USFWS. 2001. Final restoration plan for the Anadromous Fish Restoration Program. A Plan to increase Natural Production of Anadromous Fish in the Central Valley of California. Report of the Anadromous Fish Restoration Program Core Group, Central Valley Project Improvement Act to the Secretary of the Interior. Stockton, CA.

USFWS. 2011. Biological Assessment of Artifical Propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: Program Description and Incidental Take of Chinook Salmon and Steelhead. U.S. Fish and Wildlife Service, 406 pp.

USFWS. 2015. Clear Creek Habitat Synthesis Report USFWS Anadromous Fish Restoration Program Sacramento, CA

USFWS. 2017. Sacramento Fish and Wildlife Office. Federal Endangered and Threatened Species that may occur in or may be affected by the Stanislaus River Channel and Floodplain Salmonid Habitat Rehabilitation Project at Rodden Road. 16 August 2017.

Vaghti, M. and CFS. 2017. Stanislaus River Salmonid Habitat Restoration Project at Rodden Road: pre-project vegetation sampling. Prepared for USFWS AFRP, Lodi, CA.

Van Doornik, D. M., & Berejikian, B. A. 2015. Landscape factors affect the genetic population structure of *Oncorhynchus mykiss* populations in Hood Canal, Washington. *Environmental Biology of Fishes*, *98*(2), 637-653.

VanRheenen, N. T., Andrew W. Wood, Richard N. Palmer, Dennis P. Lettenmaier. 2004.Potential Implications of Pcm Climate Change Scenarios for Sacramento-San Joaquin River Basin Hydrology and Water Resources. Climatic Change 62(62):257-281.

Vigg, S. and C. C. Burley. 1991. Temperature-Dependent Maximum Daily Consumption of Juvenile Salmonids by Northern Squawfish (*Ptycholeilus Oregonenisis*) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48(12):2491-2498.

Vincik, R. F. and J. R. Johnson. 2013. A Report on Fish Rescue Operations at Sacramento and Delevan Nwr Areas, April 24 through June 5, 2013. California Department of Fish and Wildlife, Region II, Rancho Cordova, California.

Wade, A. A., T. J. Beechie, E. Fleishman, N. J. Mantua, H. Wu, J. S. Kimball, D. M. Stoms, J. A. Stanford, and A. Punt. 2013. Steelhead Vulnerability to Climate Change in the Pacific Northwest. Journal of Applied Ecology:n/a-n/a.

Waters, T.F. 1995. Sediment in streams – sources, biological effects and control. American Fisheries Society Monograph 7. Bethesda, MD. 251 pp.

Wheaton, J.M., G.B. Pasternack, and J.E. Merz. 2004a. Spawning habitat rehabilitation – I. Conceptual approach and methods. International Journal of River Basin Management 2: 3-20.

Wheaton, J.M., G.B. Pasternack, and J.E. Merz. 2004b. Spawning habitat rehabilitation – II. Using hypothesis testing and development in design, Mokelumne River, California, USA. International Journal of River Basin Management 2: 21-37.

Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): 416.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Update to January 5, 2011 Report., National Marine Fisheries Service, Southwest Fisheries Science Center. Santa Cruz, CA.

Williams, J.G. 2001. Chinook salmon in the lower American River, California's largest urban stream. In: Brown, R.L., editor. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179:1-38.

Withler, I.L. 1966. Variability in life history characteristics of Steelhead trout (Salmo gairdneri) along the pacific coast of North America. Journal of Fisheries Research Board of Canada 23:365-393.

Workman, M.L. 2005. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam August 2004 through July 2005. East Bay Municipal Utility District, Lodi, CA.

Workman, R. D., D. B. Hayes, and T. G. Coon. 2002. A Model of Steelhead Movement in Relation to Water Temperature in Two Lake Michigan Tributaries. Transactions of the American Fisheries Society 131(3):463-475.

Wu, F.C. 2000. Modeling embryo survival affected by sediment deposition into salmonid spawning gravels: Application to flushing low prescriptions. Water Resources Research 36: 1595-1603.

Wurtsbaugh, W. A. and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. Journal of Fish Biology 11:87-98.

Yoshiyama, R. M., E. R. Gertstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. University of California, Davis, Davis, California.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 2001. Historical and present distribution of Chinook Salmon in the Central Valley drainage of California. Pages 71-76 in: R.L. Brown, editor. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Fish Bulletin 179.

Zeug, S.C., K. Sellheim, C. Watry, B. Rook, J. Hannon, J. Zimmerman, D. Cox, and J. Merz. 2014a. Gravel augmentation increases spawning utilization by anadromous salmonids: a case study from California, USA. River research and applications, 30(6), pp.707-718.

Zeug, S.C., K. Sellheim, C. Watry, J.D. Wikert, and J. Merz. 2014b. Response of juvenile Chinook Salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. Fisheries Management and Ecology 21:155-168.

Zimmerman, C.E., G.W. Edwards and K. Perry. 2009. Maternal origin and migratory history of steelhead and Rainbow Trout captured in rivers of the Central Valley, California. Transactions of the American Fisheries Society 138: 280-291.

B. Federal Register Notices Cited

62 FR 43937. August 18, 1997. Final Rule: Endangered and Threatened Species: Listing of Several Evolutionary Significant Units of West Coast Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 62 pages 43937-43954.

63 FR 13347. March 19, 1998. Final Rule: Notice of Determination. Endangered and Threatened Species: Threatened Status for Two ESUs of Steel head in Washington, Oregon, and California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 63 pages 13347-13371.

70 FR 52488. September 2, 2005. Final Rule: Endangered and Threatened Species:Designation of Critical Habitat for Seven Evolutionarily Significant Units of PacificSalmon and Steelhead in California. United States Department of Commerce, NationalOceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 70 pages 52487-52627.

71 FR 834. January 5, 2006. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71 pages 834-862.