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-2018-9430

July 25, 2018

Mark T. Ziminske
Chief, Environmental Resources Branch
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response, and Fish and Wildlife Coordination Act Recommendations for the Feather River Mile 1.0 Left Bank Erosion Repair Site Project

Dear Mr. Ziminske:

Thank you for letter, received 20 March 2018, 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 Feather River Mile 1.0 Left Bank Erosion Repair Site Project.

Based on the best available scientific and commercial information, the biological opinion concludes that the Feather River Mile 1.0 Left Bank Erosion Repair Site Project, is not likely to jeopardize the continued existence of the federally listed threatened Central Valley (CV) spring-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*), threatened California Central Valley (CCV) steelhead distinct population segment (DPS) (*O. mykiss*), threatened southern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*), and is not likely to destroy or adversely modify their designated critical habitats. For the above species, 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.

NMFS reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast Salmon. Therefore, we have included the results of that review in Section 3 of this document.

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources, and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661 *et seq.*).

Please contact Jahnava Duryea at the NMFS California Central Valley Office at (916) 930-3725 or via email at Jahnava.Duryea@noaa.gov, if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,

for Barry A. Thom
Regional Administrator

Enclosure

cc: To the File 151422-WCR2018-SA00428
Mrs. Patricia Goodman, Patricia.K.Goodman@usace.army.mil

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

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

Feather River Mile 1.0 Left Bank Erosion Repair Site Project

NMFS Consultation Number: WCR-2018-9430

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?*	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha)*	Threatened	Yes	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No
Southern DPS of North American green sturgeon *(Acipenser medirostris)*	Threatened	Yes	No	No

Fishery Management Plan That Describes 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 Maria Rea

Barry A. Thom
Regional Administrator

Date: **JULY 25, 2018**

LIST OF ACRONYMS

AB – aggregate base
BA – biological assessment
BMPs – best management practices
BO – biological opinion
CCV – California Central Valley
CCVO – California Central Valley Office
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Register
CFS – cubic feet per second
CNFH – Coleman National Fish Hatchery
Corps – U.S. Army Corps of Engineers
CRR – Cohort replacement rate
CV – Central Valley
CVFPB – Central Valley Flood Protection Board
CVP – Central Valley Project
CVRWQCB – Central Valley Regional Water Quality Control Board
DO – dissolved oxygen
DPS – distinct population segment
DQA – Data Quality Act
ECT – Electronic Calculation Template
EFH – essential fish habitat
ESA – Endangered Species Act
ESU – evolutionarily significant unit
FMP – Fishery Management Plan
FR – Federal Register
FRFH – Feather River Fish Hatchery
FWCA – Fish and Wildlife Coordination Act
HAPC – habitat area of particular concern
IEP – Interagency Ecological Program
ITS – incidental take statement
IWM – instream woody material
LFC – low flow channel
LWM – large woody material
MSA – Magnuson-Stevens Fishery Conservation and Management Act
MSWSE – Mean Summer Water Surface Elevation
msl – mean sea level
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NTU – Nephelometric Turbidity Units
OHWM – ordinary high water mark
opinion – biological opinion
PBF – physical and biological features
PCE – primary constituent elements
PVA – population viability analysis
RBDD – Red Bluff Diversion Dam

RIBITS – Regulatory In-lieu Fee and Bank Information Tracking System
RM – river mile
SJRRP – San Joaquin River Restoration Project
SPCCP – spill prevention, control, and counter-measure plan
SRA – shaded riverine aquatic
SWE – snow water equivalent
SWP – State Water Project
SWPPP – stormwater pollution prevention plan
T&C – term and condition
USFWS – U.S. Fish and Wildlife Service
VSP – viable salmonid population
WRI – Weighted Response Indices
WY – water year

TABLE OF CONTENTS

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

NOAA's 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.

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources, and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661 *et seq.*).

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 (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System (https://pcts.nmfs.noaa.gov/). A complete record of this consultation is on file at NMFS' California Central Valley Office (CCVO).

1.2 Consultation History

- **20 March 2018 –** NMFS CCVO received a consultation initiation request and biological assessment (BA) from the U.S. Army Corps of Engineers (Corps) for the Feather River Mile 1.0 Left Bank Erosion Repair Site Project. NMFS initiated consultation.
- **3 April 2018 –** NMFS initiated consultation on the Feather River Mile 1.0 Left Bank Erosion Repair Site Project

A complete administrative record is on file at the NMFS CCVO.

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 Corps and its non-federal sponsor, the Central Valley Flood Protection Board (CVFPB) propose to implement bank protection measures on the Feather River at river mile (RM) 1.0L, one mile north of Verona, California in Sutter County (**Figure 1**). The Corps will be responsible for implementing the bank protection at this erosion site and will issue one contract for the bank protection and one contract for revegetation. The levee erosion at RM 1.0L is likely due to extremely high-velocity flows experienced during the 2017 winter flood season, boat wake wave impacts, and erodible levee materials.

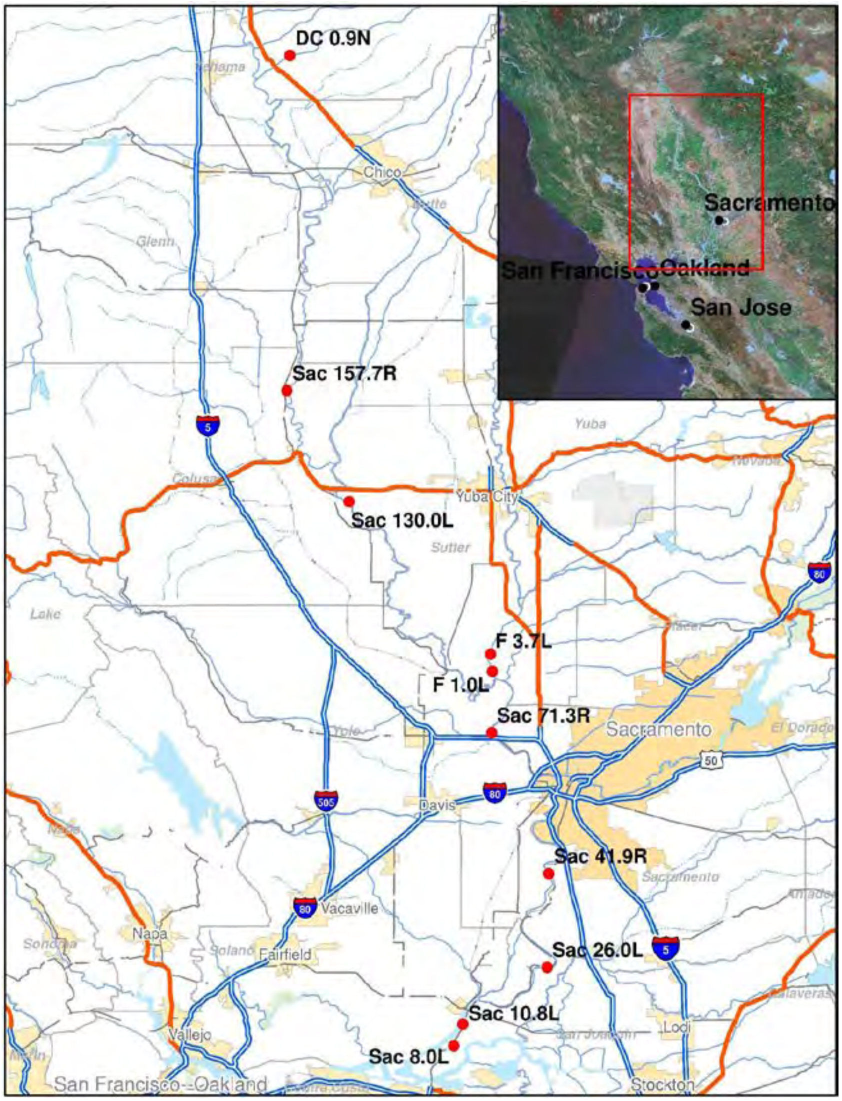


Figure 1. Map of the Project Location and Vicinity. Feather River 1.0 Left Bank is labeled F 1.0L.

The proposed action consists of repair of the eroded river bank by placing rock revetment (*i.e.*, quarry stone riprap) on the slope to provide bank protection and prevent continuing erosion. The design incorporates the construction of vegetated benches, installation of instream woody material (IWM), maximum retention of existing trees, and revegetation of the benches and levee slopes. Updates to the previous Sacramento River Bank Protection Project design templates include modifications to erosion repair length and geometry (*i.e.*, a more gentle slope on the riparian bench), quantities of materials required, substitution of an aggregate layer for coir fabric to retain soil fill, and sequencing of construction actions (**Figure 2**).

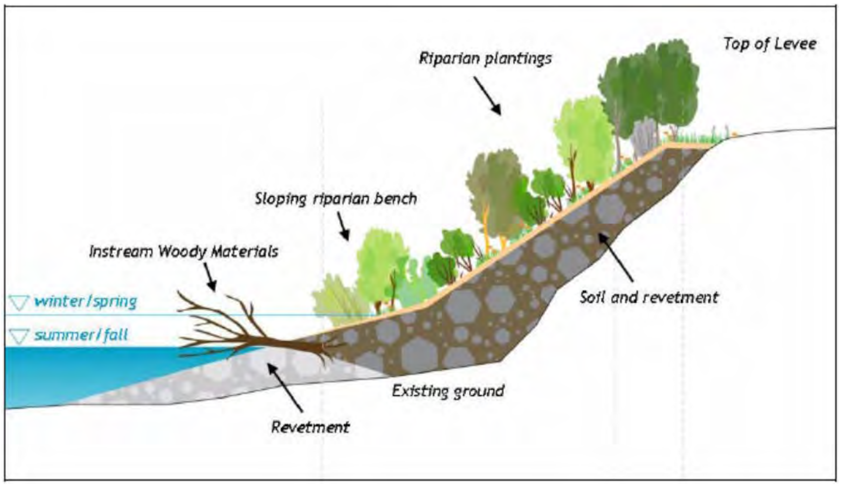


Figure 2. Conceptual design diagram for the Feather RM 1.0L bank erosion repair.

"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). There are no interrelated or interdependent actions associated with the proposed action.

1.3.1 Project Location

The Project is located one mile north of Verona, Sutter County, California on the Feather River, upstream from its confluence with the Sacramento River (**Figure 1)**.

1.3.2 Project Description

The objectives of the proposed action are to repair an existing erosion site and provide bank protection along 997 feet of the left bank of the Feather River (**Table 1**). The Project will incorporate a shallow sloping riparian bench and anchor IWM at the MSWSE to enhance wildlife habitat and provide overhead cover and near-shore aquatic habitat for rearing habitat for juvenile salmonids and their prey during the low-flow season. The proposed action would result in permanent and temporary physical disturbance to a total area of 7.65 acres.

Table 1. Feather River 1.0L Bank Protection Characteristics Summary

Length of Repair	997 feet
Site area, including construction easement	7.65 acres
Quarry stone volume	7,674 cubic yards
Soil-filled quarry stone volume	12,712 cubic yards
Soil cover volume	1,233 cubic yards
Final bank slope above riparian bench	2.5H:1V
Final bank slope of the riparian bench	10H:1V
IWM to be removed	18 linear feet
IWM to be anchored at MSWL	72 pieces/ approximately 50% shoreline coverage

Land based construction will take place as the site is not accessible to construction equipment from the water due to shallow water. A crane located on the levee could be used to mechanically place the rock along the shore and beneath the water line. Preparation of the staging area and access ramps will begin after the final Notice to Proceed is issued. In-water construction activities will be conducted between August 1, 2019 and November 30, 2019 to avoid and/or reduce effects on Federally listed fishes such as adult and juvenile steelhead, Chinook salmon, and green sturgeon. No construction is planned during the winter months (*i.e.*, December through March). Construction will continue with the placement of revetment from the levee toe up to approximately the Mean Summer Water Surface Elevation (MSWSE). The contractor could choose to use excavators, loaders, and other construction equipment along the benches on portions that are inappropriate for a crane once the revetment has reached the MSWSE. Once the bench is established, rock and soil will be placed along the upper slopes of the levee to the extent necessary to prevent further erosion. Above the water line, it is anticipated that construction activities will take place between July 1 and November 30, 2019. The anticipated construction season could require modification in response to high water levels in the river, the presence of special-status species, or other constraints.

Following completion of quarry stone and stone/soil mix placement, the contractor will place soil along the upper banks, and install the IWM and erosion controls. IWM will be incorporated into the erosion repair design to replace and/or enhance the instream cover and the high habitat value it provides to fish and wildlife that will be lost through construction. After completion of erosion repairs, the sites will be revegetated to offset the loss of habitat values of riparian removal and stabilize the bank protection.

This proposed bank protection action includes an expected yearly maintenance, which may require the placement of up to 600 cubic yards of material. Should a greater volume be required, the necessary permits/authorizations will be obtained from the appropriate regulatory agencies. Any post-construction in-water maintenance work will be conducted in coordination with the applicable Federal and state resource agencies to avoid adverse effects on sensitive fish species.

The proposed action consists of the following components:

(1) Pre-construction site preparation (vegetation trimming and removal)
(2) Construction staging, haul routes, borrow areas, and traffic control
(3) Placement of lower slope rock reventment to repair the levee below the MSWSE
(4) Placement of aggregate base gravel (9 inches thick)
(5) Placement of soil-filled quarry stone
(6) Creation of the riparian bench (10H:1V slope)
(7) IWM installation and placement of supplemental willow fascine bundles
(8) Site revegetation
(9) Monitoring and maintenance

Pre-construction Site Preparation

Construction activities for this bank protection action will begin with pre-construction in winter, December 2018 to February of 2019, consisting of tree trimming and brush clearing while outside of nesting season for migratory birds.

- During the pre-construction preparation, onsite woody vegetation will be pruned and trimmed by a licensed arborist to facilitate the movement of equipment on the bank protection site.

- Protective fencing will be installed to protect sensitive resources such as elderberry shrubs.

- In addition, any onsite trash or concrete rubble will be removed and disposed at an appropriate facility.

- No other site preparation activities, such as grading, will occur in winter.

Construction Staging, Access Roads, Borrow Areas, and Traffic Control

- *Construction Staging* – An on-site staging area has been identified for this bank protection site in a disturbed area void of vegetation where the maintenance road is located on the waterside of the levee. It will be the sole location used for staging vehicles, plant materials, and other associated construction equipment. The staging area has been subject to the same environmental and cultural review as the project footprint to ensure that any potential resources will not be adversely affected or offset by mitigation.

- *Haul Routes and Access Ramps* – Materials will be brought to the site by truck using county roads leading to the construction site with at least two temporary access ramps, possibly four ramps to increase avoidance of elderberry shrubs. The ramps lead from the crown of the levee to benches and will be used for constructing the riparian bench and placing quarry stone on the levee slope.

- *Borrow Areas* – Construction materials, including riprap, will be hauled from a commercial quarry or previously permitted borrow site located within 100 miles of the project site.

- *Traffic Control* – Temporary lane closures could be required for access and egress. Construction signs will be posted along the haul route and flaggers will be used, as necessary, to minimize traffic problems and ensure public safety near the construction site.

Lower Slope Rock Revetment

- For the portion of the repair below the MSWSE, clean quarry stone will be placed from the toe of the levee slope (*i.e.*, the bottom of the channel) to the MSWSE on the riparian bench, to reduce loss of soil-filled quarry stone.

- The layer of quarry stone will have a minimum thickness of 2 feet.

- The slope of the quarry stone below the MSWSE will be no steeper than 2H:1V.

Aggregate Base Gravel

- In lieu of the previous practice of using a coir fabric to reduce the loss of soil from the riparian bench settling into the interstitial spaces of the lower slope quarry stone, a layer of aggregate base (AB) gravel will be placed between the quarry stone and the soil-filled quarry stone on the riparian bench.

- This design element separates the soil filled quarry stone from the lower slope quarry stone and is necessary to retain soil in the planting zone until plants are established.

- The layer will be nine inches thick to allow the quarry stone and soil filled quarry stone to interface.

Soil-filled Rock Revetment

- Following the installation of the AB gravel, soil-filled quarry stone will be placed on the levee bank slope above the MSWSE.

- Soil-filled quarry stone is a combination of quarry stone and soil fill material. The purpose of the soil component is to fill voids in the quarry stone and provide a medium for vegetation to grow.

- The top elevation for placement of the soil-filled quarry stone is designed on a site-by site-basis based on water velocities and shear stresses along the levee.

- The top elevation of the soil-filled quarry stone will be level with the edge of the levee's upper bench.

Riparian Bench

- The riparian bench is a vegetation-supporting low bench with a 10H:1V slope constructed of soil-filled quarry stone that will project into the channel along the length of the erosion site.

- The riparian bench could also be used as a construction platform to help avoid effects on existing vegetation during the construction of the upper slope bank fill revetment.

- The riparian bench will be 10 to 15 feet wide with an average elevation of 2 to 3 feet above the MSWSE to provide a substantial volume of moist, but unsaturated soil as a growing medium.

- The lower bench design includes planting of native riparian shrubs above the MSWSE. The planting is intended to replace and enhance the riparian and shaded riverine aquatic (SRA) habitat degraded through construction. Additional environmental benefits of planting include stabilization of the bank, provision of overhead shade, and the introduction of new wood material to the river. In order to increase the likelihood and speed of riparian vegetation establishment, plantings will be containerized. Plantings on the erosion bank repair sites shall be in accord with ETL 1110-2-583 Guidelines for Landscape Planting and Vegetation Management at Floodwalls, Levees, and Embankment Dams (USACE 2014).

Instream Woody Material

- 72 pieces of IWM will be anchored at the repair site, consisting of hardwood tree species 10 to 24 inches in diameter with an extensive branch and root structure. Almond and walnut trees are typically used for IWM, although pistachio, orange, and lemon trees may also be used.

- The IWM will be placed on the lower slope near the MSWSE and anchored into the quarry stone by the root ball and half of the tree length.

- The IWM will be angled pointing downstream at 15 degrees from the MSWSE, oriented with the tree canopy in a downstream direction, spaced at 5 to 10 foot intervals, and placed in groups of alternating numbers of either 3 or 5 trees.

- Willow fascines are also incorporated into the site designs to augment the IWM. Angled downstream, the fascines will be placed at a 15-foot spacing and will be anchored just below the riparian bench at the MSWSE. A total of 69 willow fascines will be placed.

- Given that the IWM and fascines will protrude from the riparian bench at the MSWSE, they could also serve as a visual warning to river users that a bench is present.

Site Revegetation

- Following the completion of construction, the upper slope will be hydroseeded with a native mix and covered with erosion control measures to minimize bank erosion before plantings have had time to become established.

- Plants in containers, willow cuttings, and herbaceous vegetation will be installed after construction in the spring of 2020, weather permitting. If conditions preclude spring planting, the revegetation planting will be completed by fall of 2020.

- Vegetation planted at the sites will be in conformance with the Corps criteria for vegetation in the vicinity of levee structures (USACE 2014). This requires that no woody plants or plants that will obstruct the view of the levee will be planted within 15 feet from the waterside toe of the levee slope (*i.e*., vegetation-free zone) and the vegetation-free zone is maintained and flood protection is not threatened.

- Beaver exclusion fencing will be installed around the planted vegetation to prevent damage from beavers. The fencing typically consists of a welded wire fence with 2-inch-square openings that is buried 6 inches into the topsoil and secured every 8 feet with rebar or posts. Willow cuttings, container plants, and herbaceous vegetation will be installed/seeded after construction in the spring or fall 2020.

- Precise planting timelines are subject to water levels and upon the availability of planting materials in coordination with NMFS, U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Wildlife (CDFW).

Monitoring and Maintenance

- Monitoring and maintenance during the plant establishment period (3 years after construction) would be necessary to ensure that the replacement vegetation establishment is successful and that the IWM is functioning as intended. After this time, it is anticipated that the vegetation will be established and self-sustaining.

- Anticipated activities during the 3-year establishment period include removal of problematic invasive species, irrigation and pruning of vegetation to promote optimal growth, replacement of any dead and/or declining vegetation, and maintenance of beaver exclusion fencing.

- Maintenance activities also include monitoring the vegetation and IWM to ensure that hazards to navigation are not present, assessing the status of the rock revetment and soil fill during high flow events, and monitoring the sites for vandalism.

1.3.3 Avoidance and Minimization Measures

For in-water work, the area affected by the construction for the Feather River will be limited in time and space to the initial placement of quarry stone up to the MSWSE, with turbidity and noise being the major effects for 500 feet upstream and downstream. The effect will be limited to times when local species are not likely to be in the area or migrating through the channel. The following proposed conservation measures specific to anadromous fishes will be implemented to avoid or minimize potential adverse effects on federally listed fishes:

1) **Contractor Education and Environmental Awareness Training Program**:

- The Corps will provide a copy of the opinion associated with this BA to the prime contractor, making the prime contractor responsible for implementing all construction-related requirements and obligations included in these documents and to educate and inform all contractors involved in the project as to the requirements of the programmatic opinion and the opinion associated with this BA. A notification that contractors have been supplied with this information will be provided to the mailing address of the NMFS' Central Valley Area Office.

- A NMFS-approved Worker Environmental Awareness Training Program for construction personnel will be conducted by a NMFS-approved biologist for all construction workers prior to the commencement of construction activities. The program will provide workers with information on their responsibilities with regard to Federally-listed fishes, their critical habitat, an overview of the life-history of all the species, information on take prohibitions, protections afforded these animals under the ESA, and an explanation of the relevant terms and conditions of this opinion and the programmatic opinion. Written documentation of the training is required to be submitted to NMFS within 30 days of the completion of training.

2) **Environmental Timeframes –** All activities will occur at times of the year determined to be the least detrimental to the environment and special-status species.

- In-water construction activities will be conducted between August 1, 2019 and November 30, 2019 to avoid and/or reduce effects on Federally-listed fishes, such as adult and juvenile CV spring-run Chinook salmon, CCV steelhead, and green sturgeon.

- In-water work will not occur outside of this window, unless approved by NMFS and CDFW.

3) **Fish Conservation Measures –** The Corps will implement the following conservation measures to reduce the direct, indirect, and cumulative effects on CV spring-run Chinook salmon, CCV steelhead, and green sturgeon:

- Maintain, monitor, and adaptively manage conservation measures of the proposed project to ensure their effectiveness. These measures include the following:

    - Continue to coordinate with the IWG agencies and the Technical Team of the Interagency Collaborative Flood Management Program during the implementation and monitoring of this repair.

    - Update the O&M Manual to ensure that the self-mitigating efforts and repair designs meet the expectation of the SAM values.

    - Provide additional annual reports, as necessary, to describe the implementation of O&M actions, and summarize monitoring results.

    - Ensure that, for the life of the project, future maintenance actions ensure performance of the site to a level necessary to retain the SAM-modeled habitat values.

- Measures will be taken to minimize the effects of bank protection by implementing integrated onsite and off-site conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the sDPS of North American green sturgeon. These measures include the following:

    - The Corps will minimize the removal of existing riparian vegetation and IWM to the maximum extent practicable, and where appropriate, removed IWM would be anchored back into place. The trunks of trees left in place will be protected from construction damage by wrapping them with coir fiber, jute fabric, 2X4s, or other mechanisms that prevent trunk damage while minimizing the risk of levee scour.

    - The Corps will purchase salmon and steelhead credits from a NMFS-approved conservation bank to compensate for the effects to salmonids resulting from the project. Although the riparian plantings are expected to offset some of the effects of vegetation removal at some water surface elevations, it will take time for these plants to mature enough to fully replace the benefits lost by removal of riparian vegetation. The purchase of credits is necessary to adequately mitigate for this temporal loss of riparian habitat. Considering salmonid life stages are present at summer and fall, they could experience an initial loss of habitat following construction, the credit purchase would be at a 1:1 ratio of the highest negative SAM value determined.

4) Water Quality – Turbidity/Sedimentation Control

Measures to avoid and minimize the potential for adverse effects of turbidity or resuspension of sediment during in-water work on the listed anadromous species shall include the following:

- The contractor will implement a Storm Water Pollution Prevention Plan (SWPPP) in coordination with the CV Water Board and other regulatory agencies. The SWPPP will include an erosion control plan, water quality monitoring plan, hazardous material management plan, and best management practices for construction activities.

- The SWPPP will contain specific directives for establishing sampling locations and for acceptable levels of turbidity and settleable solids. Sampling will be conducted at an upstream location in the vicinity of the construction site once daily to establish background levels. Water samples for determining down-current turbidity and settleable solids levels would be collected 5 feet from the shoreline and 300 feet down-current of any floating turbidity curtain. Benchmark levels for turbidity under the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan would not exceed 1 Nephelometric Turbidity Unit (NTU) above ambient conditions where natural turbidity levels range from 0-5 NTU; 20 percent where natural turbidity levels range from 5-50 NTU; 10 NTU where natural turbidity levels range from 50-100 NTU; or 10 percent where natural turbidity levels are greater than 100 NTU. In determining compliance with these turbidity limits averaging periods could be applied, provided that beneficial uses remain fully protected.

- Prior to placement of any material within the ordinary high water mark of the water body, a Section 401 Water Quality Certification will be obtained from the CVRWQCB. All conditions of the Water Quality Certification will be met.

- Project construction contractors will obtain and comply with the conditions of a General Construction Activity Stormwater Permit adopted by the California State Water Resources Control Board.

- During placement of riprap into the water, materials such as coir mats or hay bales, rock groins, sand bags, and drain screens will be utilized to prevent sediment from traveling outside the construction area footprint.

- Appropriate measures will be implemented to prevent debris, soil, rock, or other material from entering the water when not actively placing riprap. Use of water trucks or other appropriate measures to control dust on haul roads, construction areas, and stockpiles will be implemented.

- Mature riparian vegetation will be avoided to the extent feasible. Trees with a DBH of 4 inches or less previously identified for removal have been reevaluated and will now be protected in place if possible. A number of trees were originally scheduled for removal on the basis that they had fallen over or were likely to fall as the result of erosion undercutting the roots, and therefore, presented a potential risk to the levee or were not compatible with the final repair design. Under reevaluation, the Corps determined that it is feasible to protect some of these trees in place, thereby retaining their existing riparian habitat value.

- All areas of ground disturbance will be revegetated with native plant species. Vegetative cover reduces the potential for erosion and storm water sediment runoff.

5) Hazardous Waste Spill Control

- The contractor will develop and implement a hazardous materials management plan prior to initiation of construction. The plan will include BMPs that would reduce the potential for spills of toxic chemicals and other hazardous materials during construction.

- The contractor will develop and implement a Spill Prevention, Control and Countermeasures Plan (SPCCP) with the CVRWQCB prior to the onset of construction to regulate the use of hazardous materials, such as petroleum-based products for equipment fuel and lubricants. The SPCCP will include measures to be implemented onsite that will keep construction and hazardous materials out of waterways and drainages. The SPCCP will include provisions for daily checks for leaks; hand-removal of external oil, grease, and mud; and the use of spill containment booms for refueling.

- The plan will include a specific protocol for the proper handling and disposal of materials and contingency procedures to follow in the event of a hazardous materials spill. The plan will also describe the specific protocol for the proper handling and disposal of potentially hazardous materials that could be encountered during construction. Any spills of hazardous materials to the river will be cleaned up immediately and reported immediately to the CVRWQCB, NMFS, and USFWS.

- Fuel and maintain vehicles in a specified area that is designed to capture spills. This area cannot be near any ditch, stream, or other body of water or feature that may convey water to a nearby body of water.

- Inspect and maintain vehicles and equipment to prevent dripping of oil or other liquids. Properly dispose of oil or other liquids.

- Schedule construction to avoid the rainy season as much as possible. Ground disturbance activities are scheduled to begin August of 2019. If rains are forecasted during construction, erosion control measures will be implemented as described in the RWQCB Erosion and Sediment Control Field Manual.

6) Mitigation Credits

1) The Corps proposes to implement advance, off-site compensatory mitigation measures to compensate for long-term impacts of the Feather River Mile 1.0L Erosion Repair Project to riparian, riverine, and benthic habitat. The Corps will purchase compensatory mitigation credits at a NMFS-approved mitigation bank with a service area that includes the project site. NMFS-approved mitigation banks with service areas that include the proposed project site include the Bullock Bend Mitigation Bank and the Fremont Landing Conservation Bank. The Corps will provide mitigation to compensate for SAM modeled deficits (*i.e.*, the largest modeled negative WRI value for all species, life stages, and seasons of -48,483 ft^2 or 1.1 acres). In addition, to compensate for the permanent loss of benthic habitat, the Corps will purchase credits at a 3:1 ratio for the spatial extent of 15,596 ft^2 of bare rock that will cover the natural riverbed below the OHWM. Adjusting 15,596 ft^2 to a 3:1 mitigation ratio yields 46788 ft^2 or an additional 1.1 acre, therefore, the Corps will purchase a total of 2.2 acres of compensatory mitigation credits for the impacts of this project. Compensatory mitigation credits will be purchased prior to construction.

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, Federal agencies must ensure that their 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 habitat. If incidental take is expected, 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 and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This opinion includes both a jeopardy analysis and 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 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 designations of critical habitat for species uses 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:

(1) Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
(2) Describe the environmental baseline in the action area.
(3) Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
(4) Describe any cumulative effects in the action area.

(5) 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.
(6) Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
(7) If necessary, define a reasonable and prudent alternative to the proposed action.

2.1.1 Use of Analytical Surrogates

Analytical Surrogates for Salmonids

The effects of the SRBPP Feather RM 1.0L levee repair on salmonids are primarily analyzed using the Standard Assessment Methodology (SAM). The Corps provided the background data, assumptions, analyses, and assessment of habitat compensation requirements for the Federally protected fish species relevant to this consultation. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species.

It is a computational modeling and tracking tool that evaluates bank protection alternatives by taking into account several key factors affecting threatened and endangered fish species. By identifying and then quantifying the response of focal species to changing habitat conditions over time, project managers, biologists, and design engineers can make changes to project design to avoid, minimize, or provide on- or off-site compensatory mitigation for impacts to habitat parameters that influence the growth and survival of target fish species by life stage and season.

The model is used to assess species responses as a result of changes to habitat conditions, either by direct quantification of bank stabilization design parameters (*e.g.*, bank slope, substrate). The preferred hierarchy of mitigation in all cases is avoid, minimize, compensate onsite, and compensate off-site. In the case of most levee projects, most or all of these mitigation strategies are applied due to their large size, challenges associated with completely avoiding and minimizing impacts to species and habitat, temporal delays in habitat function of onsite compensatory mitigation, and limitations associated with being able to provide full compensation at project sites, which warrants the need for some form of off-site compensation.

In 2003, the Corps established a program to carry out "a process to review, improve, and validate analytical tools and models for USACE Civil Works business programs." Reviews are conducted to ensure that planning models used by the Corps are technically and theoretically sound, computationally accurate, and in compliance with the Corps' planning policy. As such, all existing and new planning models developed by the Corps are required to be certified through the appropriate Planning Center of Expertise and Headquarters in accordance with the Corps rules and procedures. The assumptions, model variables, and modeling approaches used in the SAM have been developed to be adapted and validated through knowledge gained from monitoring and experimentation within the SRBPP while retaining the original overall assessment method and framework.

In late 2010, the certification process for the SAM was initiated by the Corps Sacramento District in coordination with the Ecosystem Planning Center of Expertise. The process entailed charging a panel of six experts to review the SAM. The Review Panel was composed of a plan formulation expert, a fisheries biologist, an aquatic ecologist, a geomorphologist/geologist, a population biologist/modeling expert, and a software programmer. A major advantage of the SAM is that it integrates species life history and seasonal flow-related variability in habitat quality and availability to generate species responses to project actions over time. The SAM systematically evaluates the response of each life stage to habitat features affected by bank protection projects.

The SAM quantifies habitat values in terms of a weighted response index (WRI) that is calculated by combining habitat quality (*i.e*., fish response indices) with quantity (*i.e*., bank length or wetted area) for each season, target year, and relevant species/life stage. The fish response indices are derived from hypothesized relationships between key habitat attributes (described below) and the species and life stage responses. Species response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival, growth, and/or reproduction. For a given site and scenario (*i.e*., with or without project), the SAM uses these relationships to determine the response of individual species and life stages to the measured or predicted values of each habitat attribute for each season and target year, and then multiplies these values together to generate an overall species response index. This index is then multiplied by the linear feet or area of shoreline to which it applies to generate a weighted species response index expressed in feet or square feet. The species WRI provides a common metric that can be used to quantify habitat values over time, compare project conditions to existing conditions, and evaluate the effectiveness of onsite and off-site compensation actions.

The WRI represents an index of a species growth and survival based on a 30-day exposure to post-project conditions over the life of the project. As such, negative SAM values can be used as a surrogate to quantify harm to a target fish species by life stage and season. Also, although SAM values represent an index of harm to a species, since the values are expressed as "weighted bankline feet" or "weighted area", these values can be used to help quantify compensatory conservation actions such as habitat restoration, and are used for that purpose in this opinion. The *Effects of the Action* section of this opinion analyzes the effects of the SRBPP Feather River Mile 1.0L Erosion Repair Project.

Analytical Surrogates for Green Sturgeon

Impacts to the southern DPS of North American green sturgeon are also estimated using an analytical surrogate. Although the SAM model does have a green sturgeon component, NMFS has determined that the model may not have the precision to accurately index green sturgeon responses to changes in modeled habitat attributes and that a more rigorous modeling approach needs development. Critical habitat for green sturgeon in the action is designated in the Feather River from its confluence with the Sacramento River, upstream to the Fish Barrier Dam adjacent to the Feather River Fish Hatchery (FRFH). No benthic surveys were able to be conducted due to high water levels in the winter of 2016/2017. For this opinion, NMFS has determined that the spatial extent of critical habitat below the ordinary high water mark (OHWM) which will be covered by bare rock revetment (*i.e.* where there is not soil mixed in and the surface is not planted) would serve as the best analytical surrogate for impacts to all life stages of green sturgeon.

2.1.2 Conservation Banking in the Context of the ESA Environmental Baseline

Conservation banks present a unique factual situation, and this warrants a particular approach as to how they are addressed in the context of the *Effects Analysis* and the *Environmental Baseline* in ESA section 7 consultations. Specifically, when NMFS is consulting on a proposed action that includes conservation bank credit purchases, it is likely that physical restoration work at the bank site has already occurred and/or that a section 7 consultation occurred at the time of bank establishment. A traditional interpretation of the *Environmental Baseline* might suggest that the overall ecological benefits of the conservation bank actions therefore belong in the baseline. However, under this interpretation, all proposed actions, whether or not they included proposed credit purchases, would benefit from the "environmental lift" of the entire conservation bank because it would be factored into the environmental baseline. In addition, where proposed actions did include credit purchases, it would not be possible to attribute their benefits to the proposed action, without double-counting. These consequences undermine the purposes of conservation banks and also do not reflect the unique circumstances under which they are established. Specifically, conservation banks are established based on the expectation of future credit purchases. In addition, credit purchases as part of a proposed action will also be the subject of a future section 7 consultation.

It is therefore appropriate to treat the beneficial effects of the bank as accruing incrementally at the time of specific credit purchases, not at the time of bank establishment or at the time of bank restoration work. Thus, for all projects within the service area of a conservation bank, only the benefits attributable to credits sold are relevant to the *Environmental Baseline*. Where a proposed action includes credit purchases, the benefits attributable *to those credit purchases* are considered effects of the action. That approach is taken in this Opinion.

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 (**Table 2**). 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 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 value for the conservation of the listed species.

In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat. This section analyzes the status of those federally-listed anadromous fish species found within the Feather River, focusing on broader geographical scales, representing the entire range of the ESU/DPS, or perhaps slightly more narrowly focused upon habitat within California's CV.

Table 2. ESA listing history and critical habitat designations.

Species	ESU or DPS	Original Final FR Listing	Current Final Listing Status	Critical Habitat Designated
Chinook salmon (*Oncorhynchus tshawytscha)*	Central Valley spring-run ESU	9/16/1999 64 FR 50394 Threatened	6/28/2005 70 FR 37160 Threatened	9/2/2005 70 FR 52488
Steelhead (*O. mykiss*)	California Central Valley DPS	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488
Green sturgeon (*Acipenser medirostris*)	Southern DPS	4/7/2006 71 FR 17757 Threatened	4/7/2006 71 FR 17757 Threatened	10/9/2009 74 FR 52300

The most recent status reviews conducted by NMFS for CV spring-run Chinook salmon (NMFS 2016a), CCV steelhead (NMFS 2016b), and the sDPS of North American green sturgeon (NMFS 2015), concluded that the species' status should remain as previously listed in 2005/2006 (81 FR 33468; May 26, 2016). The previous status reviews completed in 2011, also concluded that the species' status should remain as previously listed (NMFS 2011a, b, c).

2.2.1 Central Valley Spring-run Chinook Salmon

CV spring-run Chinook salmon were listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The FRFH spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent modification of the CV spring-run Chinook salmon listing status on June 28, 2005 (70 FR 37160). Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488), and includes the action area for the proposed project. It includes stream reaches of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the main stem of the Sacramento River from Keswick Dam through the Delta; and portions of the network of channels in the northern Delta.

Historically spring-run Chinook salmon were the second most abundant salmon run in the CV and one of the largest on the west coast (CDFG 1990, 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The CV Technical Review Team estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions (diversity groups) (Lindley *et al.* 2004). Of these 18 populations, only three extant populations currently exist (Mill, Deer, and Butte creeks on the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. All populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated. The northwestern California diversity group did not historically contain independent populations, and currently contains two or three populations that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

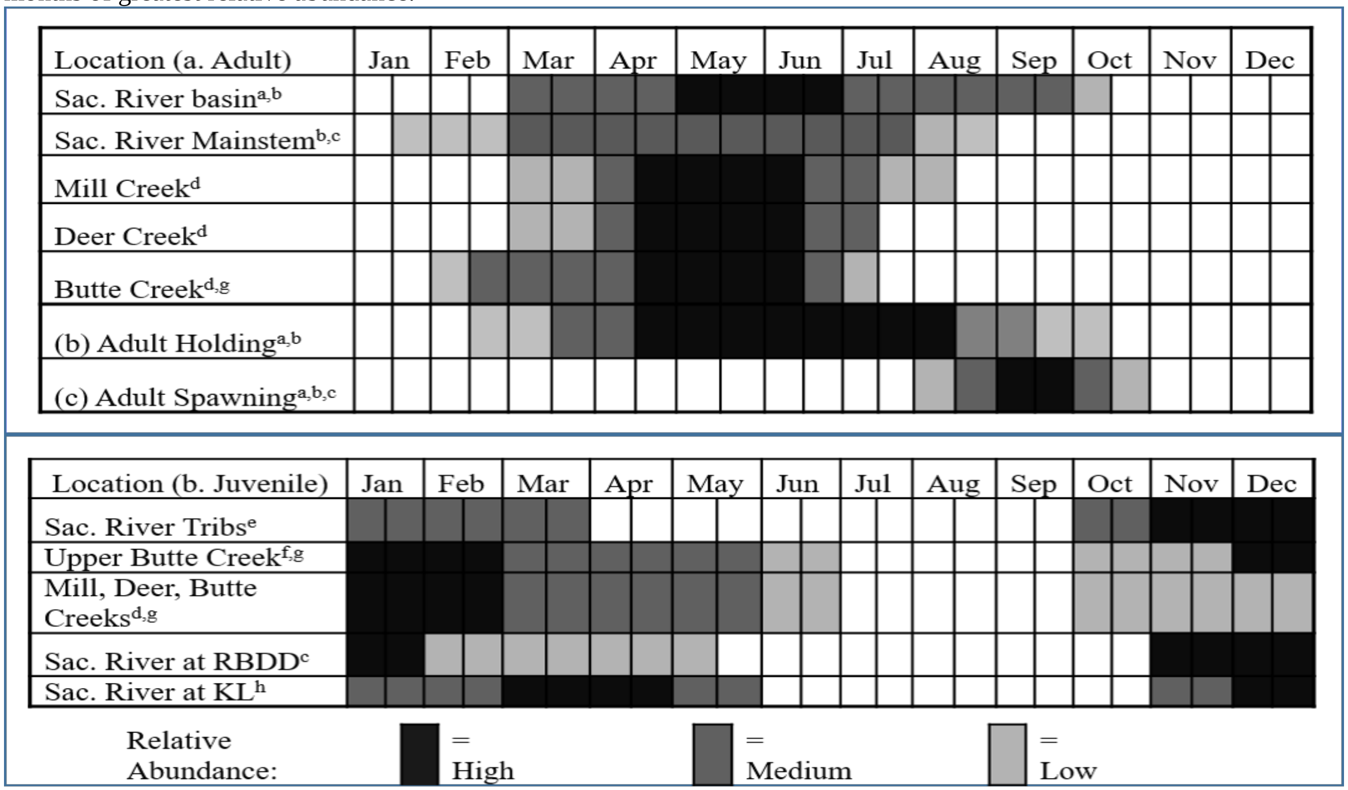
Construction of low elevation dams in the foothills of the Sierras on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American and Yuba rivers of the Sacramento River basin. However, observations in the last decade suggest that perhaps a naturally occurring population may persist in the Stanislaus and Tuolumne as well as the Yuba River (Franks 2015). Naturally-spawning populations of CV spring-run Chinook salmon are currently restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and the Yuba River (CDFG 1998).

The construction of Shasta and Keswick dams on the Sacramento River and Oroville Dam on the Feather River and subsequent blocking of upstream migration has eliminated the spatial separation between spawning fall-run and spring-run Chinook salmon (Lindley *et al.* 2007). Reportedly, spring-run Chinook salmon migrated to the upper Feather River and its tributaries from mid-March through the end of July (CDFG 1998). Fall-run Chinook salmon reportedly migrated later and spawned in lower reaches of the Feather River than spring-run Chinook salmon (Yoshiyama *et al.* 2001). The same pattern also likely exists on the Sacramento River. Restricted access to historic spawning grounds currently causes spring-run Chinook salmon to spawn in the same lowland reaches that fall-run Chinook salmon use as spawning habitat. The overlap in spawning site locations, combined with an overlap in spawning timing (Moyle 2002) with temporally adjacent runs, is responsible for interbreeding between spring-run and fall-run Chinook salmon in the lower Feather River (Hedgecock *et al.* 2001) and in the Sacramento River below Keswick Dam. In the upper Sacramento River, lower Feather River, and lower Yuba River, spring-run Chinook salmon spawning may occur a few weeks earlier than fall-run spawning, but currently there is no clear distinction between the two because of the disruption of spatial segregation by Shasta and Keswick dams on the Sacramento River, Oroville Dam on the Feather River, and Englebright Dam on the Yuba River. Thus, spring-run and fall-run Chinook salmon spawning overlap temporally and spatially.

This presents difficulties from a management perspective in determining the proportional contribution of total spawning escapement by the spring- and fall-runs. Because of unnaturally high densities of spawning, particularly in the in the low flow channel (LFC) of the Feather River, spawning habitat is likely a limiting factor. Intuitively, it could be inferred that the slightly earlier spawning Chinook salmon displaying spring-run behavior would have better access to the limited spawning habitat, although early spawning likely leads to a higher rate of redd superimposition. Redd superimposition occurs when spawning Chinook salmon dig redds on top of existing redds dug by other Chinook salmon. The rate of superimposition is a function of spawning densities and typically occurs in systems where spawning habitat is limited (Fukushima *et al.* 1998). Redd superimposition may disproportionately affect early spawners and, therefore, potentially affect Chinook salmon exhibiting spring-run life history characteristics salmon (Lindley *et al.* 2007).

The distribution and timing of CV spring-run Chinook salmon varies depending on the life stage, and are shown below **(Table 3)**.

Table 3. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.



Sources: [a](Yoshiyama et al. 1998); [b](Moyle 2002); [c]Myers *et al.* (1998b); [d]Lindley et al. (2004); [e]CDFG (1998); [f](McReynolds et al. 2007); [g]Ward et al. (2003); [h]Snider and Titus (2000) ; Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

Summary of CV Spring-run Chinook Salmon DPS Viability

Since the independent populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on Viable Salmonid Population (VSP) parameters in these watersheds. Lindley *et al.* (2007) indicated that the spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run Chinook salmon ESU failed to meet the "representation and redundancy rule" since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them, or out of the four diversity groups as described in the NMFS Central Valley Salmon and Steelhead Recovery Plan (2014). Over the long-term, these three remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

In the 2011 status review of the CV spring-run Chinook salmon ESU, the authors concluded that the ESU status had likely deteriorated on balance since the 2005 status review and the Lindley *et al.* (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to the rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report (Williams *et al.* 2011) that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased. The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

Critical Habitat: Physical and Biological Features (PBFs)

Critical habitat for CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488; September 2, 2005) and the lateral extent as defined by the ordinary high-water mark (OHWM). In areas where the OHWM has not been defined, the lateral extent will 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 one to two years on the annual flood series) (Bain & Stevenson 1999; 70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the PBFs essential to the conservation of the species. Following are the inland habitat types used as PBFs for CV spring-run Chinook salmon.

Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the CV for Chinook salmon is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for CV spring-run Chinook salmon occurs on the mainstem Sacramento River between Red Bluff Diversion Dam (RBDD) and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks; as well as the Feather and Yuba rivers, and Big Chico, Battle, Antelope, and Clear creeks. However, little spawning activity has been recorded in recent years on the Sacramento River mainstem for spring-run Chinook salmon. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat

Freshwater rearing sites are those 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 salmonid development; and natural cover such as shade, submerged and overhanging large woody material (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. 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). 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 piscivorous fishes and birds. Freshwater rearing habitat also has a high intrinsic conservation value 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

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks, which augment juvenile and adult mobility, survival, and food supply. 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 passage of adults and the downstream emigration of juveniles. 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. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For adults, upstream passage through the Delta and much of the Sacramento River is not a problem, yet a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PBF. However, since the primary migration corridors are used by numerous populations and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

Estuarine Areas

This PBF is outside of the action area for the proposed action. The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

Description of Viable Salmonid Population (VSP) Parameters

Abundance

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH spring-run Chinook salmon population represents a remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy, for the hatchery program. Abundance from 1993 to 2004 were consistently over 4,000 (averaging nearly 5,000), while 2005 to 2014 were lower, averaging just over 2,000 (CDFW 2015).

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem difficult to determine, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; in 2012 zero redds were observed, and in 2013, 57 redds were observed in September 2014 (CDFW 2015). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

For many decades, CV spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the Basin (Fry 1961, Fisher 1994). More recently, there have been reports of adult Chinook salmon returning in February through June to San Joaquin River tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Franks 2014, Workman 2003, FishBio 2015). These spring-running adults have been observed in several years and exhibit typical spring-run life history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Franks 2014, Workman 2003, FishBio 2015). For example, 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only seven individuals without adipose fins (FishBio 2015).

Additionally, in 2014, implementation of the spring-run Chinook salmon reintroduction plan into the San Joaquin River has begun, which if successful will benefit the spatial structure, and genetic diversity of the ESU. These reintroduced fish have been designated as a nonessential experimental population under ESA Section 10(j) when within the defined boundary in the San Joaquin River (78 FR 79622; December 31, 2013). Furthermore, while the San Joaquin River Restoration Project (SJRRP) is managed to imprint CV spring-run Chinook salmon to the mainstem San Joaquin River, we do anticipate that the reintroduced spring-run Chinook salmon are likely to stray into the San Joaquin tributaries at some level, which will increase the likelihood for CV spring-run Chinook salmon to repopulate other Southern Sierra Nevada diversity group rivers where suitable conditions exist.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998. Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000 (although 2008 was nearly 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005).

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21ºC for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and

Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the diseases. In 2015, Butte Creek again experienced severe temperature conditions, with nearly 2,000 fish entering the creek, only 1,081 observed during the snorkel survey, and only 413 carcasses observed, which indicates a large number of pre-spawn mortality.

Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011a). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include Butte, Deer and Mill creeks (NMFS 2011a). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased, in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 abundance was lower, with just over 5,000 fish for the tributaries combined, which indicates a highly fluctuating and unstable ESU abundance. Even more concerning was returns for 2015, which were record lows for some populations. In the next several years, numbers are anticipated to remain quite low as the effects of the 2012-2015 drought are fully realized.

Productivity

The productivity of a population (*i.e.,* production over the entire life cycle) can reflect conditions (*e.g.,* environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). In general, declining productivity equates to declining population abundance. McElhany *et al.* (2000) suggested criteria for a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation.

From 1993 to 2007 the 5-year moving average of the CV spring-run Chinook salmon tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (**Table 4**). The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown; however, the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive (1.85). However, 2015 returns were very low, with a CRR of 0.14, when using Butte Creek snorkel survey numbers, the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02.

Table 4. Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2015) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.55	4,795	1.63	1.22
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,533	6,746	23,787	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24
2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,865	4,135	12,730	9,916	0.54	2.09	14,300	0.55	1.30
2002	17,212	4,189	13,023	12,238	2.13	2.35	16,730	1.75	1.46
2003	17,691	8,662	9,029	9,287	1.63	2.17	14,161	1.92	1.43
2004	13,612	4,212	9,400	9,945	0.74	1.79	14,916	0.81	1.37
2005	16,096	1,774	14,322	11,701	1.10	1.23	16,295	0.94	1.19
2006	10,828	2,061	8,767	10,908	0.97	1.31	15,088	0.61	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,591	0.71	1.00
2008	6,162	1,418	4,744	8,857	0.33	0.78	11,285	0.38	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,323	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.53	6,862	0.39	0.49
2011	5,033	1,969	3,064	3,961	0.65	0.47	5,703	0.82	0.53
2012	14,724	3,738	10,986	4,747	3.91	1.10	6,702	3.87	1.16
2013	18,384	4,294	14,090	6,617	6.61	2.36	9,147	4.85	2.06
2014	8,434	2,776	5,658	7,186	1.85	2.66	10,073	1.68	2.32
2015	3,074	1,586	1,488	7,057	0.14	2.63	9,930	0.21	2.28
Median	9,775	3,616	6,159	6,541	1.97	1.89	10,220	1.00	1.46

[a] NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries. [b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

Spatial Structure

Spatial structure refers to the arrangement of populations across the landscape, the distribution of spawners within a population, and the processes that produce these patterns. Species with a restricted spatial distribution and few spawning areas are at a higher risk of extinction from catastrophic environmental events (*e.g.*, a single landslide) than are species with more widespread and complex spatial structure. Species or population diversity concerns the phenotypic (*i.e.*, morphology, behavior, and life-history traits) and genotypic (DNA) characteristics of populations. Phenotypic diversity allows more populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genotypic diversity, on the other hand, provides populations with the ability to survive long-term changes in the environment. To meet the objective of representation and redundancy, diversity groups need to contain multiple populations to survive in a dynamic ecosystem subject to unpredictable stochastic events, such as pyroclastic events or wild fires.

The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (**Figure 3**) (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks, tributaries to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998).

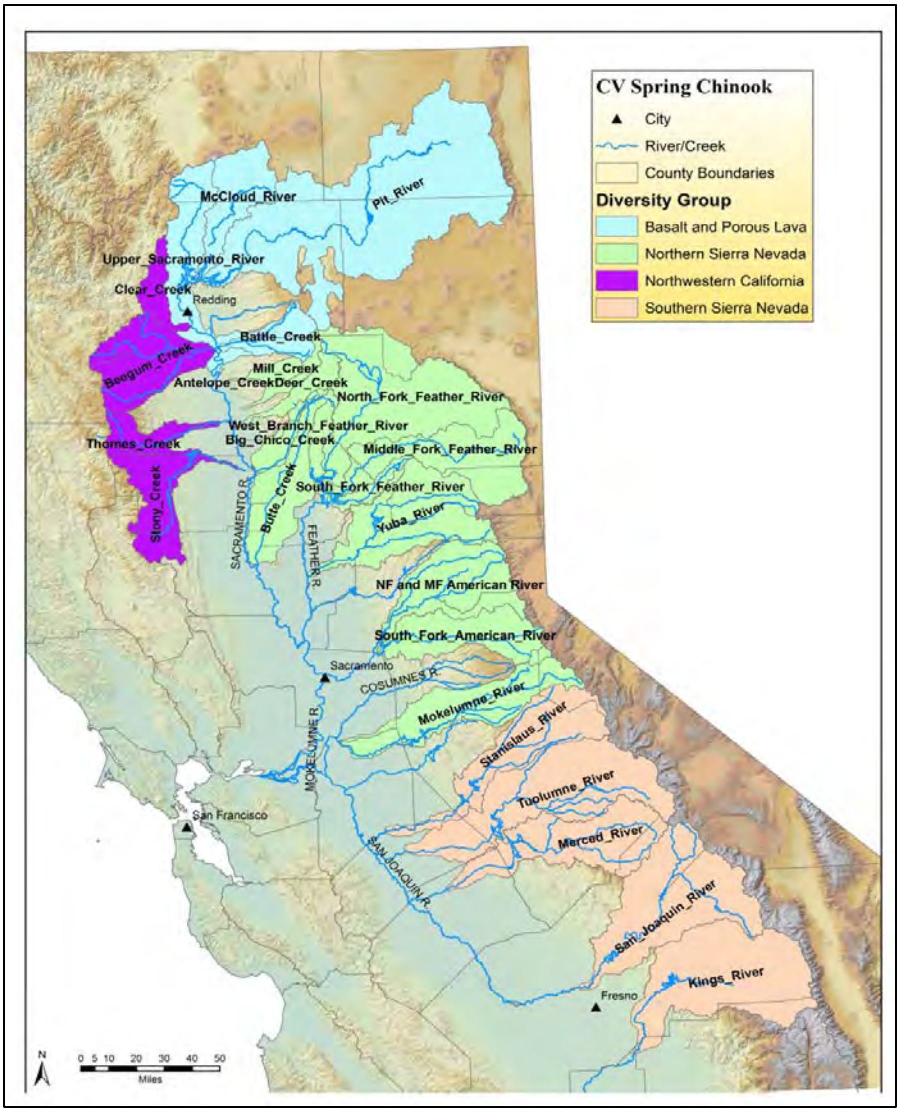


Figure 3. Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

Most historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated; Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the river mainstem as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence. Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014).

With only one of four diversity groups currently containing independent populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon adult returns are currently utilizing all available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration projects completed and more underway, are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the spring-run Chinook salmon ESU would still be lacking due to the extirpation of all San Joaquin River basin spring-run Chinook salmon populations; however, recent information suggests that perhaps a self-sustaining population of spring-run Chinook salmon is occurring in some of the San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne rivers.

A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (78 FR 79622; December 31, 2013). Pursuant to ESA Section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. The rule includes protective regulations under ESA section 4(d) that provide specific exceptions to prohibitions for taking CV spring-run Chinook salmon within the experimental population area, and in specific instances elsewhere. The first release of CV spring-run Chinook salmon juveniles into the San Joaquin River occurred in April 2014. Releases have continued annually during the spring. The SJRRP's future long-term contribution to the CV spring-run Chinook salmon ESU has yet to be determined.

Snorkel surveys (Kennedy & Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December 2003, which would indicate spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009 has indicated upstream migration of adult spring-run Chinook salmon (Anderson *et al.* 2007), and 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FishBio 2015). Finally, rotary screw trap data provided by Stockton U.S. Fish and Wildlife Service (USFWS) corroborates the spring-run Chinook salmon adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration (Franks 2014). Although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams. Genetic assessment or natal stream analyses of hard tissues could inform our understanding of the relationship of these fish to the ESU.

Lindley *et al.* (2007) described a general criteria for "representation and redundancy" of spatial structure, which was for each diversity group to have at least two viable populations. More specific recovery criteria for the spatial structure of each diversity group have been laid out in the NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014). According to the criteria, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, in addition to maintaining dependent populations, are needed for recovery. It is clear that further efforts will need to involve more than restoration of currently accessible watersheds to make the ESU viable. The NMFS Central Valley Salmon and Steelhead Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams, such as the reintroduction of a population upstream of Shasta Dam, and to facilitate passage of fish upstream of Englebright Dam on the Yuba River (NMFS 2014).

Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics (including rate of gene-flow among populations). Criteria for the diversity parameter are that human-caused factors should not alter variation of traits. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The CV spring-run Chinook salmon ESU is comprised of two known genetic complexes. Analysis of natural and hatchery CV spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised. The Feather River spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon, and it appears that the Yuba River spring-run Chinook salmon population may have been impacted by FRFH fish straying into the Yuba River (and likely introgression with wild Yuba River fall-run has occurred). Additionally, the diversity of the spring-run Chinook salmon ESU has been further reduced with the loss of the majority if not all of the San Joaquin River basin spring-run Chinook salmon populations. Efforts like the SJRRP, to reintroduce a spring-run population below Friant Dam, which are underway, are needed to improve the diversity of CV spring-run Chinook salmon.

Summary of ESU Viability

Since the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Lindley *et al.* (2007) indicated that the spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run

Chinook salmon ESU failed to meet the "representation and redundancy rule" since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them, or out of the four diversity groups as described in the NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014). Over the long-term, these three remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other.

In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review conducted in 2015 (NMFS 2016a) looked at promising increasing populations in 2012-2014; however, the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality reaching record highs.

The recent drought impacts on Butte Creek can be seen from the lethal water temperatures in traditional and non-traditional spring-run Chinook salmon holding habitat during the summer. Pre-spawn mortality was observed during the 2007 to 2009 drought with an estimate of 1,054 adults dying before spawning (Garman 2015, *pers*. *comm*.). A large number of adults (903 and 232) also were estimated to have died prior to spawning in the 2013 and 2014 drought, respectively (Garman 2015, *pers*. *comm*.). In 2015, late arriving adults in the Chico vicinity experienced exceptionally warm June air temperatures coupled with the PG&E flume shutdown resulting in a fish die off. Additionally, adult spring-run Chinook salmon in Mill, Deer, and Battle creeks were exposed to warm temperatures, and pre-spawn mortality was observed. Thus, while the independent CV spring-run Chinook populations have generally improved since 2010, and are considered at moderate (Mill and Deer) or low (Butte Creek) risk of extinction, these populations are likely to deteriorate over the next three years due to drought impacts, which may in fact result in severe declines.

In summary, the status of the CV spring-run Chinook salmon ESU, until 2015, has probably improved since the 2010 status review. The largest improvements are due to extensive restoration, and increases in spatial structure with historically extirpated populations trending in the positive direction. Improvements, evident in the moderate and low risk of extinction of the three independent populations, however, are certainly not enough to warrant the delisting of the ESU. The recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2015 drought, uncertain juvenile survival during the drought, and ocean conditions, as well as the level of straying of FRFH spring-run Chinook salmon to other CV spring-run Chinook salmon populations are all causes for concern for the long-term viability of the CV spring-run Chinook salmon ESU.

2.2.2 California Central Valley Steelhead

CCV steelhead were listed as threatened on March 19, 1998, (63 FR 13347). In classifying the threatened listing of CCV steelhead DPS, NMFS highlighted the historical loss and degradation of spawning and rearing habitat as one of the major factors leading to the current low population abundances. This habitat loss and degradation is due to a combination of water development projects and operations that include, but are not limited to: (1) impassable dams, water diversions, and hydroelectric operations on almost every major river in the Central Valley; (2)

antiquated fish screens, fish ladders, and diversion dams on streams throughout the Sacramento River Basin; and (3) levee construction and maintenance projects that do not incorporate fish-friendly designs. All of those projects and operations reduce the habitat quality and/or quantity for steelhead. The massive alterations to river channels from the gold mining era continue to impact aquatic habitats throughout much of the Central Valley. Busby *et al.* (1996) cited other land use practices that have degraded steelhead habitat in the Central Valley including forestry, agriculture, and urbanization of watersheds.

Good *et al.* (2005) described the threats to Central Valley salmon and steelhead as falling into three broad categories: loss of historical spawning habitat, degradation of remaining habitat, and genetic threats from the stocking programs. Cummins *et al.* (2008) attributed the much reduced biological status of Central Valley anadromous salmonid stocks to the construction and operation of the Central Valley Project (CVP) and the State Water Project (SWP):

> *"Construction and operation of the CVP and SWP have altered flows, reduced water quality, and degraded environmental conditions and reduced habitat for fish and wildlife in the Central Valley from the headwaters to the Delta. This includes the native anadromous fish of the Central Valley -- winter, spring, fall and late-fall chinook, steelhead and sturgeon. Adult runs that once numbered in the millions have been reduced to thousands or less.*
>
> *The transformation of the natural Sacramento/San Joaquin river systems into a massive water storage and delivery system includes dams and diversions that have blocked access for anadromous salmonids to much of their historical habitat. Development of the CVP and SWP has significantly modified the natural hydrologic, geomorphic, physical and biological systems. The modified river system significantly impacts the native salmon and steelhead production as a result of fragmented habitats, migration barriers, and seasonally altered flow and habitat regimes."*

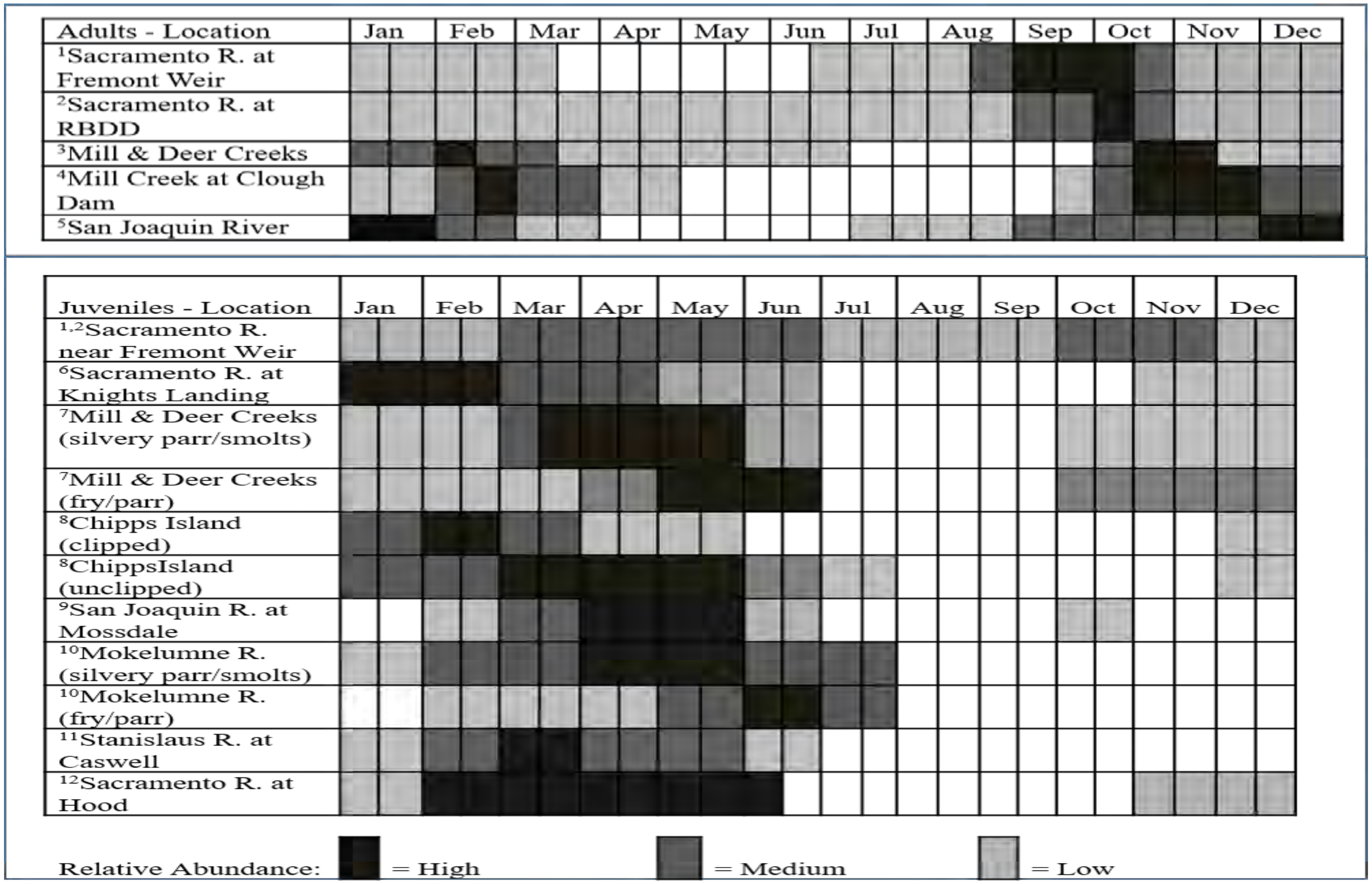
However, in the last 5-10 years, some habitat restoration programs and conservation plans have been implemented that, in aggregate, should provide a benefit to the habitat of Central Valley steelhead, or are expected to do so in the future.

The Central Valley experienced a severe drought during 2012 through 2015, which likely reduced the already limited habitat quality and range for CCV steelhead during this period. The very low numbers of adults seen at the Nimbus Fish Hatchery during the last few years may be related to the drought, as water temperatures in the lower American River at Hazel Avenue reached the low 70's (°F), well above the 65°F limit set in the NMFS 2009 opinion on the long-term operations of the Central Valley Project and State Water Project, likely impacting survival of wild steelhead parr. Steelhead populations in the Central Valley historically dealt with periodic drought. The concern is that at current low levels of abundance and productivity, some populations may go extinct during long dry spells, and the re-establishment of these populations may be difficult due to the degraded habitat conditions.

There are indications that natural production of steelhead continues to decline and is now at very low levels. Their continued low numbers in most hatcheries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced steelhead a concern. The most recent 5-year status review completed by NMFS recommends that CCV steelhead remain listed as threatened, as the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (NMFS 2016b).

The distribution and timing of steelhead varies depending on the life stage, and are shown in **Table 5** below.

Table 5. 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.



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 & 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) summarized by John Hannon (Reclamation) ; [12](Schaffter 1980).

Critical Habitat: Physical and Biological Features for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River (up to the confluence with the Merced River), including its tributaries, and the waterways of the Delta. Following is a description of the condition of the inland habitat types used as PBFs for CCV steelhead critical habitat.

Spawning Habitat

Tributaries to the Sacramento and San Joaquin rivers with year-round flows have the primary spawning habitat for CCV steelhead. Most of the available spawning habitat 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. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat

Tributaries to the Sacramento and San Joaquin rivers with year-round flows have the primary rearing habitat for CCV steelhead. 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. Freshwater rearing habitat has a high conservation value even if the current conditions are significantly degraded from their natural state.

Freshwater Migration Corridors

Migration corridors contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks, which augment juvenile and adult mobility, survival, and food supply. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value even if the migration corridors are significantly degraded compared to their natural state.

Estuarine Areas

This PBF is outside of action area for the proposed action. 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. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

Description of VSP Parameters

<u>*Abundance*</u>

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 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 for the period 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 & Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and 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 escapement monitoring plan is being planned (Eilers *et al*. 2010).

Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is 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 National Fish Hatchery (CNFH) 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. Steelhead returns to CNFH have fluctuated greatly over the years. From 2003 to 2012, the number of hatchery origin adults has ranged from 624 to 2,968. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose clipped). Natural-origin adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200-500 fish each year, although numbers the past five years have been lower, ranging from 185 to 334 (NMFS 2016b).

Redd counts are conducted in the American River, with an average of 142 redds counted on the American River from 2002-2015 (data from Hannon & Deason 2008, Hannon *et al.* 2003, Chase 2010), with only 58 counted in 2015, a new low for this survey (NMFS 2016b).

The East Bay Municipal Utilities District 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 (2000 to 2010). However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite *et al.* 2010), which are not part of the CCV steelhead DPS.

The returns of steelhead to the Feather River Hatchery have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009, and 2010, respectively. This is despite the fact that almost all of these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. Data that is more recent shows a slight increase in the annual returns, which averaged 1,134 fish from 2011 to 2015 (CDFW 2015).

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. The average redd index from 2001 to 2011 is 157, representing somewhere between 128 and 255 spawning adult steelhead on average each year.

From 2011 through 2015, an average of 231 redds has been observed in Clear Creek. The vast majority of these steelhead are natural-origin fish, as no hatchery steelhead are stocked in Clear Creek, and adipose fin clipped steelhead are rarely observed in Clear Creek (NMFS 2016b).

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. The overall catch of steelhead at these facilities has been highly variable since 1993. 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.

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2016 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960's and 1970's, 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.

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. In addition, 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.

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural steelhead production has continued to decline, and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Beginning in 1998, all hatchery-produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. The proportion of hatchery fish exceeded 90 percent in 2007, 2010, and 2011. Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities also indicates a reduction in the natural production of steelhead. The percentage of unclipped juvenile steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (NMFS 2011b).

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011b). Since 2003, fish returning to the CNFH 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 200-300 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. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production.

Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* 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.

Steelhead are well distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005; NMFS 2011b). Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* 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 *O. mykiss* compared to the Sacramento River and its tributaries.

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.

The NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014), includes recovery criteria for the spatial structure of the DPS which provide one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, in addition to maintaining dependent populations, are needed for recovery.

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 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 CV spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011b).

Diversity

a. Genetic Diversity: 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 *O. mykiss* 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 (CNFH, 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.

b. Life-History Diversity: Steelhead in the Central Valley historically consisted of both summer-run and winter-run 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.

Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002; McEwan & Jackson 1996). 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 one to three years before migrating to the ocean as smolts (Moyle 2002). 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 two to four years (Hallock *et al.* 1961, McEwan & Jackson 1996). 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 DPS 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 2011b); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish. Continued decline in the ratio between naturally-produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. 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 several years.

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, as described in the recent 5-year Status Review (NMFS 2016b), most wild CCV populations are very small, are not monitored, 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, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

2.2.3 Southern DPS of North American Green Sturgeon

The following section entails the status of the species for the southern distinct population segment (sDPS) of North American green sturgeon. This section establishes the life history and viability for sDPS green sturgeon, and discusses their critical habitat. The critical habitat analysis is approached by examining the PCEs of that critical habitat, and this analysis considers separately freshwater and estuarine environments. Throughout this analysis of life history, viability, and critical habitat, the focus is upon the CV of California. Therefore, not all aspects of sDPS green sturgeon are presented; for example, the PCEs for the critical habitat in the marine environment are not included.

Summary of sDPS Green Sturgeon Viability

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2010b). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany *et al.* 2000). The best available scientific information does not indicate that the extinction risk facing sDPS green sturgeon is negligible over a long-term (~100 year) time horizon; therefore the sDPS is not believed to be viable. To support this statement, the PVA that was done for sDPS green sturgeon in relation to stranding events (Thomas *et al.* 2013b) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (NMFS 2010b).

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their habitat needs.

Southern DPS of North American Green Sturgeon Critical Habitat

Critical habitat was designated for the sDPS green sturgeon on October 9, 2009 (74 FR 52300). A full and exact description of all sDPS green sturgeon critical habitat, including excluded areas, can be found at 50 CFR § 226.219. Critical habitat includes the stream channels and waterways in the Delta to the OHWL. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, the Feather River upstream to the Fish Barrier Dam adjacent to the FRFH, and the Yuba River upstream to Daguerre Dam. Coastal marine areas include waters out to a depth of 60 fathoms, from Monterey Bay in California, to the Strait of Juan de Fuca in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for sDPS green sturgeon.

Critical habitat for sDPS green sturgeon includes PBFs within the defined area that are essential to the conservation of the species. PBFs for sDPS green sturgeon have been designated for freshwater riverine systems, estuarine habitats, and nearshore coastal areas. In keeping with the focus on the CV, we will limit our discussion to freshwater riverine systems and estuarine habitats.

<u>Freshwater Riverine Systems</u>

Food Resources

Abundant food items for larval, juvenile, subadult, and adult life stages for sDPS green sturgeon should be present in sufficient amounts to sustain growth, development, and support basic metabolism. Although specific information on food resources for green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey as other sturgeons (Israel and Klimley 2008). Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items of shovelnose and pallid sturgeon in the Missouri River (Wanner *et al.* 2007a), lake sturgeon in the St. Lawrence River (Nilo *et al.* 2006), and white sturgeon in the lower Columbia River (Muir *et al.* 2000). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of lake sturgeon (Nilo *et al.* 2006), pallid sturgeon (Gerrity *et al.* 2006), and white sturgeon (Muir *et al.* 2000).

Substrate Type or Size

Critical habitat in the freshwater riverine system should include substrate suitable for egg deposition and development, and the development of larval, subadult, and adult life stages. For example, spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett *et al.* 1991; Moyle *et al.* 1995). Eggs are likely to adhere to substrates or settle into crevices between substrates (Van Eenennaam *et al.* 2001; Deng *et al.* 2002). Larvae exhibited a preference for benthic structure during laboratory studies (Van Eenennaam *et al.* 2001; Deng *et al.* 2002; Kynard *et al.* 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2006).

Water Flow

An adequate flow regime is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11 – 19°C) (Mayfield and Cech 2004; Van Eenennaam *et al.* 2005; Allen *et al.* 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cubic feet per second (cfs) (Brown 2007). The average daily water flow during spawning months ranges from 6,900 – 10,800 cfs (Brown 2007). In Oregon's Rogue River, the northern DPS (nDPS) green sturgeon have been shown to emigrate to sea during the autumn and winter when water temperatures dropped below 10°C and flows increased (Erickson *et al.* 2002). On the Klamath River, the fall outmigration of nDPS green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al.* 2006). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics are necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures would include: stable water temperatures within spawning reaches; temperatures within 11 – 17°C (optimal range is 14 – 16°C) in spawning reaches for egg incubation (March – August) (Van Eenennaam *et al.* 2005); temperatures below 20°C for larval development (Werner *et al.* 2007); and temperatures below 24°C for juveniles (Mayfield and Cech 2004; Allen *et al.* 2006). Suitable salinity levels range from fresh water (< 3 ppt) for larvae and early juveniles to brackish water (10 ppt) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Adequate levels of dissolved oxygen (DO) are needed to support oxygen consumption by early life stages, ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1} for juveniles (Allen and Cech 2007). Suitable water quality would also include water with acceptably low levels of contaminants (*e.g.*, pesticides, organochlorines, selenium, elevated levels of heavy metals, *etc*.) that may disrupt normal development of embryonic, larval, and juvenile stages of green sturgeon. Poor water quality can have adverse effects on growth, reproductive development, and reproductive success. Studies on the effects of water contaminants upon green sturgeon are needed; studies performed upon white sturgeon have clearly demonstrated the negative impacts contaminants can have upon white sturgeon biology (Foster *et al.* 2001a; 2001b; Feist *et al.* 2005; Fairey *et al.* 1997; Kruse and Scarnecchia 2002). Legacy contaminants, such as mercury, still persist in the watershed and pulses of pesticides have been identified in winter storm discharges throughout the Sacramento River basin, CV, and the Delta.

Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning and rearing habitats within freshwater rivers to rearing habitats within the estuaries. Unobstructed passage throughout the Sacramento River up to Keswick Dam (RM 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

Depth

Deep pools of ≥ 5 m depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River upstream of GCID. The significance and purpose of these aggregations are unknown at the present time, but may be a behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al.* 2002; Benson *et al.* 2006). As described above, approximately 54 pools with adequate depth have been identified in the Sacramento River upstream of the GCID location.

Sediment Quality

Sediment should be of the appropriate quality and characteristics necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*i.e.*, elevated levels of heavy metals such as mercury, copper, zinc, cadmium, and chromium, polycyclic aromatic hydrocarbons, and organochlorine pesticides) that can result in negative effects on any life stage of green sturgeon or their prey. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may similarly have a negative affect the growth, reproductive development, and reproductive success of green sturgeon. The Sacramento River and its tributaries have a long history of contaminant exposure from abandoned mines, separation of gold ore from mine tailings using mercury, and agricultural practices with pesticides and fertilizers which result in deposition of these materials in the sediment horizons in the river channel. The San Joaquin River is a source for many of these same contaminants, although pollution and runoff from agriculture are the predominant driving force. Disturbance of these sediment horizons by natural or anthropogenic actions can liberate sequestered contaminants into the river. This is a continuing concern throughout the watershed.

Estuarine Habitats

This PBF is outside of action area for the proposed action. 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. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

2.2.4 Climate Change

One major factor affecting the rangewide status of the threatened and endangered anadromous fish in the Central Valley and aquatic habitat at large is climate change.

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 & 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 – July has been decreasing since about 1950 (Roos 1987, 1991). Increased 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% in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) 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 CV, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Projected warming is expected to affect CV Chinook salmon, because the runs are restricted to low elevations as a result of impassable rim dams. If climate warms by 5°C (9°F), 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 – 1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the CV are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally-producing fall-run Chinook salmon are thermally acceptable. This would particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

Spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson *et al.* 2011). Spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser *et al.* 2013).

CCV steelhead will 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, however, the effects may be even greater in some cases, as juvenile 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 14°C to 19°C (57°F to 66°F). 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 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), 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 the species (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 increases 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 action area is not the same as the project boundary area because the action area must delineate all areas where federally listed fishes and their habitats may be affected by the implementation of the proposed action. For the purposes of addressing potential direct and indirect effects of the proposed action on listed fish species and their designated critical habitat, the action area encompasses the section of levee erosion on the left bank of the Feather River at RM 1.0 and the adjacent riparian zone. More specifically, it encompasses the upper extent of the project footprint along the mainstem Feather River, the adjacent riparian zone, and approximately 300 feet downstream to capture turbidity impacts. Since the proposed action includes the purchase of mitigation credits from a conservation bank, the Action Area also includes the areas affected by the two mitigation banks that have service areas relevant to the project area. These include the Fremont Landing Conservation Bank, which is a 100-acre floodplain site along the Sacramento River (Sacramento River Mile 106) and the Bullock Bend Mitigation Bank, a 119.65-acre floodplain site along the Sacramento River at the confluence of the Feather River (Sacramento River Mile 80).

Areas affected directly will be those in the immediate project footprint and immediately downstream. Indirect effects of the Project are those effects that are caused by, or will result from, the proposed action and may occur later in time, but are still reasonably certain to occur (50 CFR §402.02). Indirect effects associated with the project are those related to noise, dust, and turbidity above ambient levels. To include indirect effects from noise and dust, the action area extends 100 feet beyond the construction footprint. During installation rock revetment and the creation of the riparian bench, the action area also includes the extent to which instream turbidity may extend downstream, which is approximately 300 feet. In Section 401 of the Clean Water Act's Water Quality Certification, the CV Water Board typically requires measuring of turbidity levels 300 feet downstream of in-water activities to ensure they do not exceed turbidity thresholds for water quality.

2.4 Environmental Baseline

The *Environmental Baseline* is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species within the action area. 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).

The *Environmental Baseline* describes the status of listed species and critical habitat in the action area, to which we add the effects of the proposed erosion repair, to consider the effects of the proposed actions within the context of other factors that impact the listed species. The effects of the proposed action are evaluated along with the aggregate effects of all factors that have contributed to the status of listed species and those actions that are likely to affect listed species in the future, to determine if implementation of the proposed erosion repairs are likely to cause an appreciable reduction in the likelihood of both survival and recovery or result in destruction or adverse modification of critical habitat.

In this section we narrow our geographic scope further, applying the same analysis as was done in Section 2.2, but considering just the Feather River, especially that portion of the Feather River from its downstream end where it joins the Sacramento River at Verona and at the upstream end terminating at the Fish Barrier Dam, marking the upstream extent of habitat available to anadromous, federally-listed fishes. The proposed action is located on the west bank of the Feather River between the Thermalito Afterbay and SR 70. The action area, which encompasses the Feather River and associated riparian areas at and adjacent to the project site, functions primarily as a rearing and migratory habitat for CV spring-run Chinook salmon and CCV steelhead. Southern DPS of North American green sturgeon use the area primarily as a migration corridor and secondarily for adult feeding. Due to the life history timing of spring-run Chinook salmon, steelhead, and North American green sturgeon, it is possible for one or more of the following life stages to be present within the action area throughout the year: adult migrants or rearing and emigrating juveniles.

The action area is within designated critical habitat for CV spring-run Chinook salmon and CCV steelhead. Habitat requirements for these species are similar. The PBFs of salmonid habitat within the action area include: freshwater rearing habitat and freshwater migration corridors. The essential features of these PBFs include adequate substrate, water quality, water quantity, water temperature, water velocity, shelter, food, riparian vegetation, space, and safe passage conditions. The intended conservation roles of these habitats are to provide appropriate freshwater rearing and migration conditions for juveniles and unimpeded freshwater migration conditions for adults.

The action area is also within designated critical habitat for sDPS of North American green sturgeon. The PBFs of green sturgeon habitat within the action area include freshwater riverine systems. The essential features of this PBFs include adequate food resources, substrate type or size, water flow, water quality, migratory corridor, depth, and sediment quality.

The conservation condition and function of this habitat has been severely impaired through several factors discussed in the *Rangewide Status of the Species and Critical Habitat* section of this opinion. The result has been the reduction in quantity and quality of several essential features of migration and rearing habitat required by juveniles to grow and survive. In spite of the degraded condition of this habitat, the intrinsic conservation value of the action area is high because the entire length is used for extended periods of time by a large proportion of all federally listed anadromous fish species in the CV.

1) The Feather River

The Feather River today is very much changed from its historical condition. These changes began in earnest with the California Gold Rush, and continued with the development of manmade dams and other structures to control the flow, storage, and transport of water, and the development of hydroelectric power. The largest dam on the Feather River, and in fact the United States, is Oroville Dam. It is such a focal point of river alteration that the Feather River can effectively be divided into two parts; the Upper Feather River, including all streams, tributaries, and headwaters of the Feather River, and the Lower Feather River from Oroville Dam to the confluence with the Sacramento River at Verona (**Figure 4**).

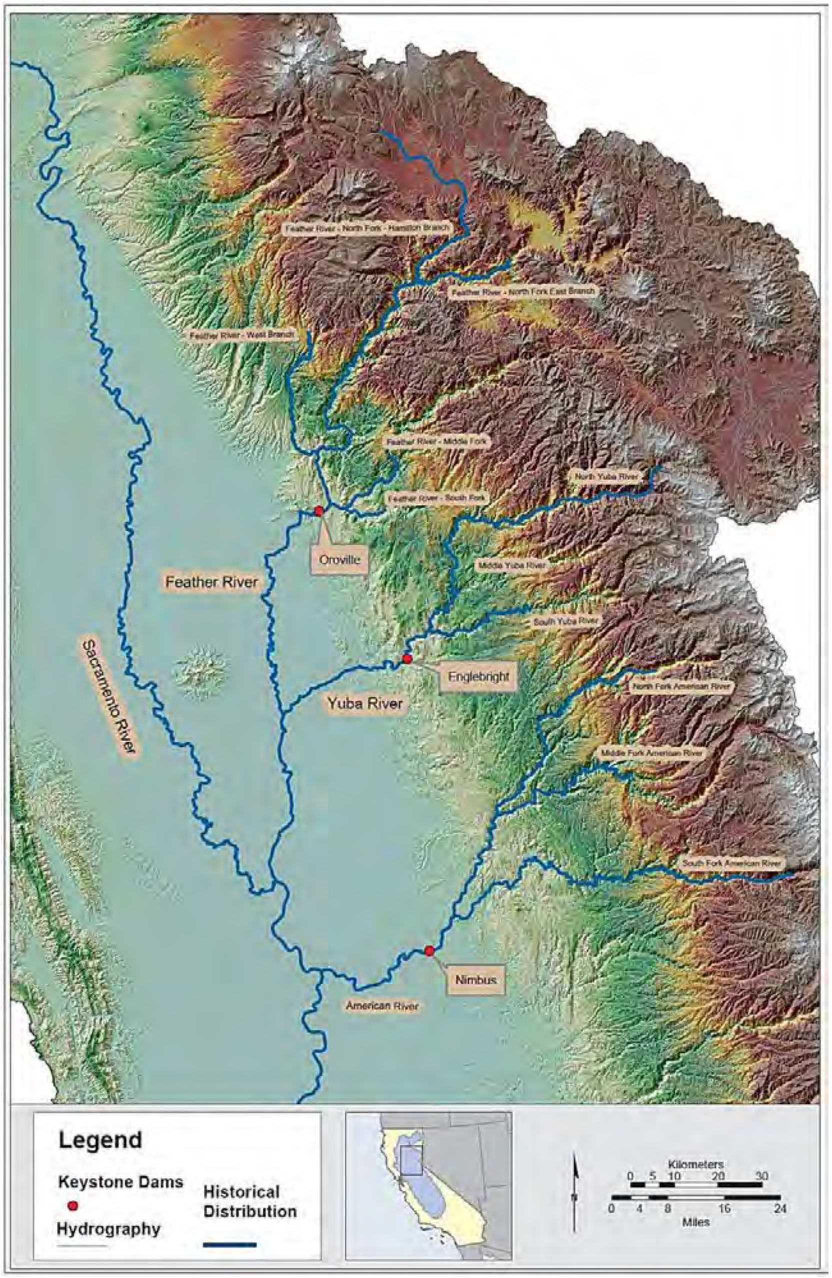


Figure 4. Map of the Feather River watershed.

2) Upper Feather River

The Upper Feather River includes the headwaters and the major tributaries that are: the West Branch, the North Fork Hamilton Branch, the North Fork East Branch (collectively the North Branch), the Middle Fork, and the South Fork.

3) Lower Feather River

The Lower Feather River is generally considered as that portion of the Feather River and its watershed that lies below Oroville Dam, extending to the confluence with the Sacramento River at Verona. The Lower Feather River watershed encompasses about 803 square miles. There are approximately 190 miles of major creeks and rivers, 695 miles of minor streams, and 1,266 miles of agricultural water delivery canals. The river flows approximately 60 miles north to south before entering the Sacramento River at Verona. The river is almost entirely contained within a series of levees as it flows through the agricultural lands of the Sacramento Valley. Oroville Dam is a major component of the SWP, and it provides virtually all the water delivered by the California SWP. Flows are regulated for water supply and flood control through releases at Oroville Dam, and to a lesser extent flows are regulated to maximize production of hydroelectric power.

Throughout this opinion, the Lower Feather River means the mainstem river between Oroville Dam and Verona. If the discussion requires a more broad definition to include the watershed, it will be noted in the context of the discussion.

2.4.1 Status of Species and Critical Habitat in the Action Area

The action area is within designated critical habitat for CV spring-run Chinook salmon and CCV steelhead. The action area is located on the west bank of the Feather River between the Thermalito Afterbay and SR 70, encompassing the Feather River and associated floodplains and riparian areas within and adjacent to OWA. It functions primarily as a migratory corridor and rearing habitat for CV spring-run Chinook salmon and CCV steelhead, and the Southern DPS of North American green sturgeon. It is adjacent to known CV spring-run Chinook salmon spawning areas along the upper reaches and secondary channels of the LFC and green sturgeon spawning areas below the Thermalito Afterbay Outlet and the deep scour hole below the Fish Barrier Dam. Due to the life history timing of spring-run Chinook salmon, steelhead, and North American green sturgeon, it is possible for one or more of the following life stages to be present within the action area throughout the year: adult migrants or rearing and emigrating juveniles.

Before the construction of Oroville Dam, the Feather River was impacted by gold mining. The effects of the dredging are still very visible just downstream of the city of Oroville, along the LFC. The effects of hydraulic mining over 100 hundred years ago still results in increased amounts of sediment in the rivers today, and modifications in stream channels also persist.

While the extent of upstream passage had been altered by earlier dams, the construction of Oroville Dam changed the amount and extent of available habitat for upstream migrating salmonids (Figure 5). Before Oroville Dam, some separation of spawning CV spring-run Chinook salmon and fall-run Chinook salmon still existed. It is likely that there was some overlap of spring-run Chinook salmon and fall-run Chinook salmon spawning at the time of construction of Oroville Dam. With the advent of Oroville Dam (without fish passage) both of these populations were spawning in the same geographical area and with overlapping spawning timing.

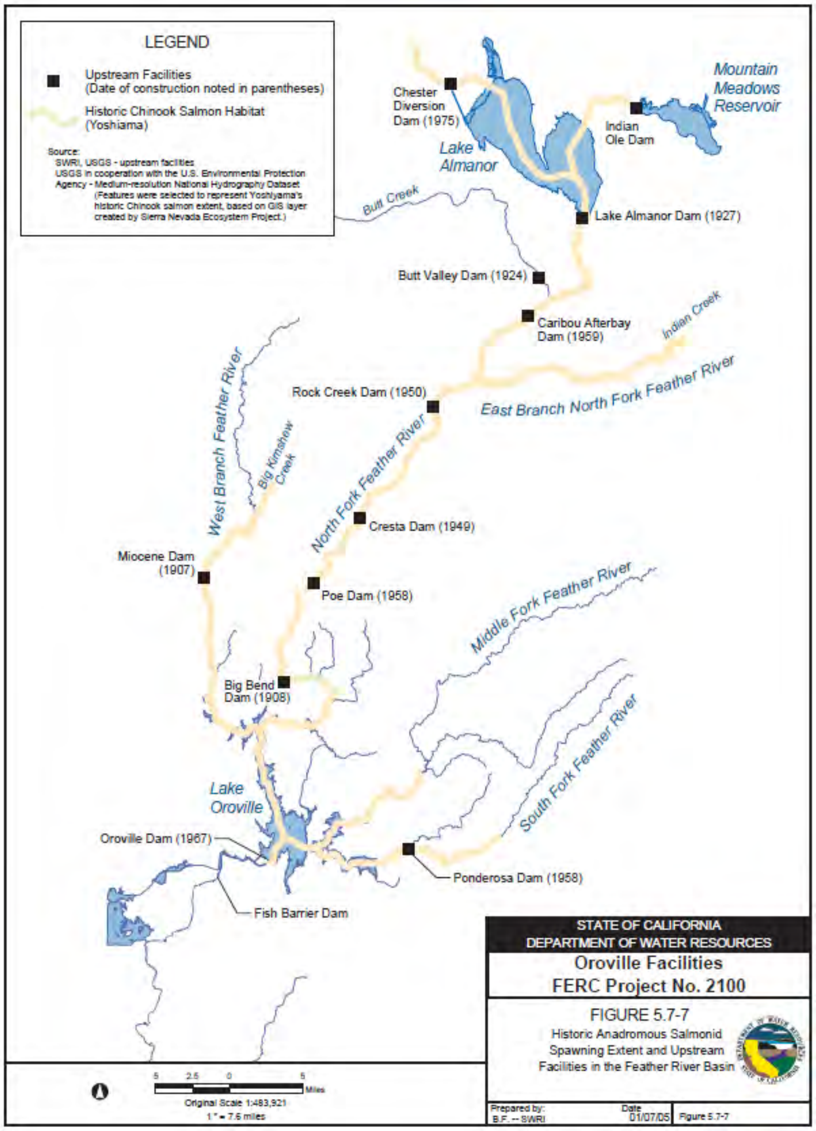


Figure 5. Historic Range of Salmonid Habitat Upstream of Oroville Dam.

Before construction of Oroville Dam, CV spring-run Chinook salmon utilized the upper tributaries of the Feather River for spawning. CV spring-run Chinook salmon would ascend the Feather River in the spring and summer as sexually immature fish, and develop to maturity by fall and then spawn. Although some overlap of CV spring-run and fall-run Chinook salmon spawning areas was already occurring before the dam was built, competition for use of the existing downstream spawning areas increased with the construction of Oroville Dam and ancillary facilities. With the construction of Oroville Dam, fish passage is halted on the Feather River at the Fish Barrier Dam just downstream of Oroville Dam. For the CV spring-run Chinook salmon that now return to the river, the options are to either spawn naturally in the river, utilizing the remaining habitat in the lower reaches of the Feather River below the Fish Barrier Dam at RM 67, or to ascend the fish ladder which begins at the Fish Barrier Dam and enters the FRFH where the fish are then artificially propagated. The amount of habitat available within the Feather River is reduced by Oroville Dam, and CV spring-run Chinook salmon are now forced to spawn in the same areas used by fall-run Chinook salmon. This leads to a number of problems, such as redd superimposition, hybridization, competition for resources, etc. Furthermore, Oroville Dam has changed the river's natural hydrology, altered the natural flow regime, and blocked the transport of sediment and the recruitment of large woody material.

Central Valley Spring-run Chinook Salmon

The CV spring-run Chinook salmon ESU includes all naturally spawned populations in the Feather River as well as fish from the FRFH CV spring-run Chinook salmon program. NMFS' Central Valley Technical Recovery Team believes that the existing CV spring-run Chinook salmon population in the Feather River, including the hatchery fish, may be the only remaining representatives of this important ESU component and that the Feather River hatchery CV spring-run Chinook salmon stock may play an important role in the recovery of CV spring-run Chinook salmon in the Feather River Basin (FERC 2007).

Adult CV spring-run Chinook salmon enter the Feather River as immature adults from March to June (Painter *et al.* 1977, Reynolds *et al.* 1993, CDFG 1998, Yoshiyama *et al.* 1998, Sommer *et al.* 2001) and spawn in the autumn during September and October (Sommer *et al.* 2001). Spawning occurs in gravel beds that are often located at the tails of holding pools (USFWS 1995a) and most CV spring-run Chinook salmon spawn in the upper reaches of the LFC (DWR 2007; Bilski 2008; Clark *et al.* 2008; Chappell 2009). Suitable water temperatures for spawning are 42 – 58°F (~5.6 - 14.4ºC). Incubation may extend through March with suitable incubation temperatures between 48 – 58°F (~8.8 - 14.4ºC) (DWR 2007). Studies have confirmed that juvenile rearing and probably some adult spawning are associated with secondary channels within the Feather River LFC. The lower velocities, smaller substrate size, and greater amount of cover (compared to the main river channel) likely make these side-channels more suitable for juvenile CV spring-run Chinook salmon rearing. Currently, this type of habitat comprises less than one percent of the available habitat in the LFC (DWR 2007).

Solid data on naturally spawning CV spring-run Chinook salmon in the Feather River does not exist. There is some natural production of CV spring-run Chinook salmon in the river, and these natural spawners are of greatest interest for conservation. DWR and CDFW have good data on CV spring-run Chinook salmon that return to the FRFH in the fall, however data on natural spawners is less clear. The escapement survey monitors for Hallprint©-tagged CV spring-run Chinook salmon and collects length, spawn condition, and other biological data, but the survey cannot estimate the number of spawners because of the overlap in spawning with fall-run. Data does indicate, however, that CV spring-run Chinook salmon do spawn successfully in the river.

There are multiple issues with both the FRFH and the naturally spawning fish in the river. The primary problem is the overlap in time and space with fall-run Chinook salmon leading to hybridization between the two runs in the river. Poor hatchery practices that historically led to mixing and interbreeding of the two runs within the hatchery also serves to exacerbate the situation. Although hatchery practices have improved, and strong efforts are made to differentiate and breed separately CV spring-run Chinook salmon from fall-run Chinook salmon in the Feather River they have nevertheless been compromised such that their genetics are something of a mix between fall-run and CV spring-run Chinook salmon. While hatchery practices may be able to alleviate some of the problems of genetic mixing of the two runs, those fish that spawn in the river are still able to mix and interbreed. For this reason, a separation weir has been proposed to physically separate CV spring-run and fall-run Chinook salmon in the river.

Juvenile Chinook salmon in the Feather River have been reported to emigrate as young of year (Seesholtz *et al.* 2004) and most appear to migrate out of the Feather River within days of emergence (DWR 2002, 2007; FERC 2007; Bilski & Kindopp 2009). Juvenile emigration from the Feather River is generally from mid-November through June, with the bulk of emigration occurring during November and December (Painter *et al.* 1977; DWR 2004a; Yuba County Water Agency (YWCA) *et al.* 2007; Bilski & Kindopp 2009). Seesholtz *et al.* (2003) speculate that because juvenile rearing habitat in the LFC of the Feather River is limited, juveniles may be forced to emigrate from the area early due to competition for resources. Rotary screw trap data for 1998 to 2000 documented emigration of CV spring-run Chinook salmon from the Feather River peaking in December, followed by another pulse of juvenile young-of-year emigrants at Live Oak in April and May (DWR 2002; Seesholtz *et al.* 2004). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December and again in March and April. However, juveniles also are observed between November and the end of May (Snider & Titus 2000).

CV spring-run Chinook salmon were impacted by a number of past human activities. Dams have eliminated access to historic holding, spawning, and rearing habitat and have resulted in CV spring-run Chinook salmon and fall-run Chinook salmon spawning and rearing in the same areas, at the same times. This has resulted in increased competition, superimposition of redds, and interbreeding of the two populations. Other anthropogenic activities that have impacted CV spring-run Chinook salmon include modification of the hydrograph, loss of sediment and large wood transport, restriction of lateral movement of the river channel, mining, unscreened water diversions, and riparian vegetation removal.

California Central Valley Steelhead

The CCV steelhead DPS final listing determination was published on January 5, 2006 (71 FR 834) and included all naturally spawned populations of CCV steelhead (and their progeny) below natural and manmade barriers in the Sacramento and San Joaquin Rivers and their tributaries, including the Feather River below the Oroville Facilities. FRFH CCV steelhead are also included in this designation. The current Feather River CCV steelhead population appears to be almost entirely supported by the FRFH and is restricted to the river reaches downstream of the Fish Barrier Dam. Because CCV steelhead have similar spawning and rearing preferences as CV spring-run Chinook salmon, the two species are believed to have occupied the same areas with the exception that CCV steelhead are thought to have migrated further upstream in the watershed (DWR 2007). Due to the construction and operation of hydropower projects, including the Oroville facilities (*i.e.*, Oroville Dam and the Fish Barrier Dam), the upper Feather River basin is no longer accessible to CCV steelhead.

CCV steelhead spawn in the Feather River between December and March, with the peak spawning occurring in late January (DWR 2007). Historically, the Feather River below the current site of Oroville Dam was likely used only as a migration corridor to upstream reaches (NMFS 2014). Presently, most of the natural CCV steelhead spawning in the Feather River occurs in the LFC, particularly in its upper reaches near the Hatchery Side Channel, a side-channel located between RM 66 and 67, and between the Table Mountain Bicycle Bridge and Lower Auditorium Riffle. Flows in the Hatchery Side Channel are fed by the discharge from the FRFH. Limited spawning has also been observed below the Thermalito Afterbay Outlet. The smaller substrate size and greater amount of cover in the side channels (compared to the main river channel) also make these areas more suitable for juvenile CCV steelhead rearing. Currently, this type of habitat comprises less than 1 percent of the available habitat in the LFC (DWR 2007). Studies have confirmed that juvenile CCV steelhead rearing, and probably adult spawning, within the Feather River is associated with secondary channels within the LFC (DWR 2005, 2007). Most naturally produced CCV steelhead rear in freshwater for two years before emigration (McEwan & Jackson 1996). Feather River CCV steelhead generally emigrate from about February through September, with peak emigration occurring from March through mid-April. However, empirical and observational data show that juvenile CCV steelhead potentially emigrate during all months of the year from the Feather River. Water temperatures of 54°F or less are considered optimal for smolting and emigrating CCV steelhead.

The number of CCV steelhead entering the FRFH each year generally increased between 1967 and 2003 (Figure 6). CCV steelhead returns to the FRFH have varied substantially over the past several years, with very low returns in some years (2009), and above average returns in others (2013 and 2014). Because almost all returning fish are of hatchery origin and stocking levels have remained fairly constant over the years, the data suggest that adverse freshwater or ocean survival conditions have caused or at least contribute to variability in hatchery returns. The CV experienced three consecutive years of drought (2007-2009) which would likely have impaired survival of naturally produced parr and smolts. However, hatchery origin CCV steelhead are reared and released as one-year olds so drought conditions would likely not have significantly affected this life stage. There may have been a drought effect during freshwater migration. However, poor ocean conditions are known to have occurred in at least 2005 and 2006 (which impacted Chinook populations in the CV) and may well have also impacted CCV steelhead populations of both hatchery and natural origin. The current drought (2012-2015) has also likely impacted CCV steelhead populations.

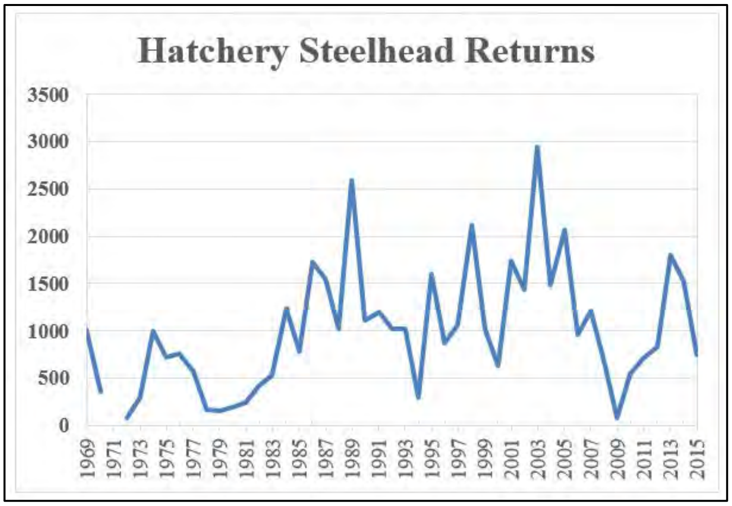


Figure 6. Adult CCV Steelhead Returns to FRFH, 1969-2015.

The FRFH was designed and is operated to replace CCV reduced steelhead production, attributable to the construction of the Oroville Facilities. The population of fish produced in the FRFH is artificially maintained. The FRFH has an annual production goal of 400,000 yearling CCV steelhead to mitigate for construction of the Oroville Facilities. The FRFH also has a goal of raising an additional 50,000 CCV steelhead for the Delta Fish Agreement (also known as the Four Pumps Agreement) between DWR and DFW, which addresses impacts from SWP pumping in the Delta. More than 99 percent of the CCV steelhead that enter the FRFH fish are of direct hatchery origin (Brown *et al.* 2004). The NMFS 2011 status review of CCV steelhead discussed that currently, nearly all the CCV steelhead that return to the Feather River Hatchery are hatchery fish. Ideally, hatcheries and management programs could seek to foster viable, independent populations of CCV steelhead across the CV, with the Feather River playing an integral role. Improved water management practices and habitat restoration may help to better establish a viable population of naturally spawning CCV steelhead in the Feather River. Currently, the population of CCV steelhead in the Feather River appears to be largely hatchery-dependent, making progress toward long-term diversity challenging.

Data on the population of naturally produced CCV steelhead in the Feather River does not exist. There is no specific target set for adult abundance. Currently, the CCV steelhead population in the Feather River appears to be almost totally dependent upon the FRFH, placing even more importance on proper hatchery management and habitat restoration. The viability of this population will remain heavily dependent upon the hatchery until hatchery genetic management plans are fully implemented and natural origin CCV steelhead are replacing themselves at a sustainable level.

Southern DPS of North American Green Sturgeon

Green sturgeon are long-lived and widely ranging across the North American west coast, but the southern distinct population segment (sDPS) breeds exclusively in the freshwater rivers of California, predominantly in the Sacramento River, and to a smaller extent in the Feather and Yuba rivers. The best available information shows that access to historic sDPS green sturgeon habitat upstream of the Fish Barrier Dam in the Feather River that may have been used by sDPS green sturgeon is now blocked due to the construction of Oroville Dam (NMFS 2005). Southern DPS green sturgeon are now limited to downstream habitat, primarily below the Thermalito Afterbay Outlet, although some usage as far upstream as the Fish Barrier Dam has been observed. This loss of potential upstream habitat, subsequent downriver limitations, altered hydrograph and temperature regime, diversions of water, degraded environmental or habitat conditions, as well as overfishing, poaching, predation, ocean survival have greatly impacted the sDPS green sturgeon in the Feather River. This has resulted in in low abundance and future uncertainty for the species. In this section we focus on sDPS green sturgeon usage of the Feather River, which contains at least one known spawning area (Figure 7) and also provides for a migratory corridor to access the Yuba River.

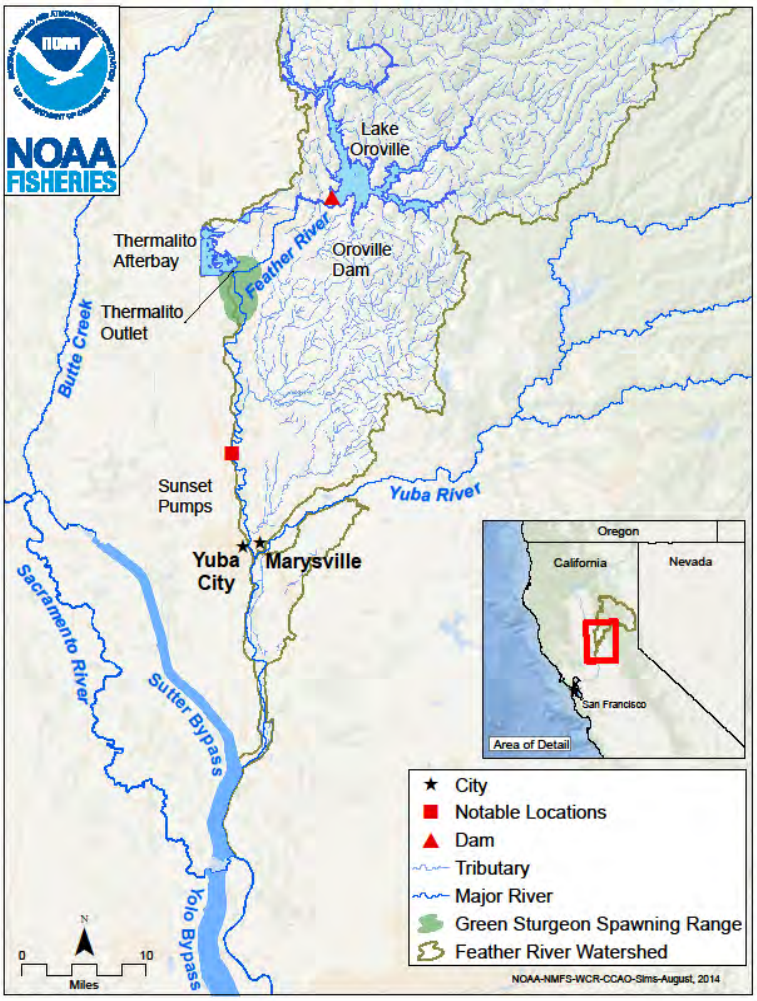


Figure 7. Feather River sDPS Green Sturgeon spawning areas.

An initial abundance estimate of the sDPS of green sturgeon was published in 2015. Several researchers (Klimey *et al.* 2015; Mora *et al.* 2015) identified estimates of an average run size of 364 adult sDPS green sturgeon to the Sacramento River, and a preliminary population estimate of 1,348 adults (± 524 individuals) (NMFS 2015) in the green sturgeon sDPS. This does not include Feather River fish. Ongoing work being conducted by UC Davis is seeking to refine the estimates. Initial indications are that the population estimate may increase. Researchers at UC

Davis, most notably Ethan Mora, have surveyed the Sacramento River for sDPS green sturgeon and have been able to determine spawning locations and abundance of adult spawners in the river. So far, the work done by UC Davis has not included the Feather River in their annual sampling for adult sDPS green sturgeon, so the population numbers derived so far may be slightly underestimating the CV sDPS green sturgeon adult population size. There is an estimated average of 364 adult fish spawning in the Sacramento River per year (Klimley *et al.* 2015; NMFS 2015) and an estimated 25 or fewer sDPS green sturgeon utilizing the Feather River per year.

Nevertheless, the Feather River is highly valuable from a sDPS green sturgeon conservation perspective because it is the *only* place outside the Sacramento River where sDPS green sturgeon spawning has been documented, giving the Feather River a prominent role in the recovery of the species. In 2011, sDPS green sturgeon spawning in the Feather River was observed at the Thermalito Afterbay Outlet (Seesholtz *et al.* 2014). There is no available data on sDPS green sturgeon productivity in the Feather River. Spawning occurs episodically and opportunistically, as a function of suitable environmental conditions that presumably do not occur every year. The population growth rate is unknown. The population structure is also unknown, and the relationship of spawner success in the Feather River to spawner returns (in the Feather River or Sacramento River) is also unknown. It will take at least a couple of decades to get this type of data, given the long life span of sDPS green sturgeon and the age at maturity. However, this would be valuable data to obtain so that a population trajectory can be determined.

Data for sDPS green sturgeon habitat in the Feather River and sDPS green sturgeon habitat interactions is limited. The number of adult green sturgeon in the Feather River is likely dependent on flow conditions and associated passage issues. In low flow years, it is likely that no sDPS green sturgeon migrate upstream of Sunset Pumps, and in the past Shanghai Bench was also a passage barrier. Within the Feather River green sturgeon require adequate food resources and a migratory corridor to access spawning grounds and to access other tributaries such as the Yuba River. Water depth available in pools appears to be important. Pool depths of greater than 5 m appear important for holding and spawning. Sediment quality must be sufficient for all life stages. Acoustic data sets should improve in the coming years as sample sizes increase and the effects of tagging are no longer factors. As fish tagged in previous years return to the river, we may begin to get a feel for the range of behaviors that sDPS green sturgeon naturally exhibit as they use the Feather River. For the time being, we must simply assume that sDPS green sturgeon may use the Feather River for as little as a few days or as long as several months, and with sufficient flow to access the entire river, especially for passage at Sunset Pumps, we may see the full range of behavioral characteristics.

Southern DPS Green sturgeon distribution in the Feather River appear to be heavily influenced by flow rates. High springtime flows may provide environmentally attractive cues to sDPS green sturgeon and may encourage their migration up the Feather River. High flows are also necessary to achieve passage at Sunset Pumps in the Sutter Extension Water District (SEWD) (Figure 8), where a manmade rock weir stretches across the entire river, denying access to upriver spawning habitat until flows are sufficient for sDPS green sturgeon to pass over and above this impediment. Discussions, unrelated to the Oroville Facilities, are ongoing to address the effects of the Sunset Pumps weir on anadromous fishes.

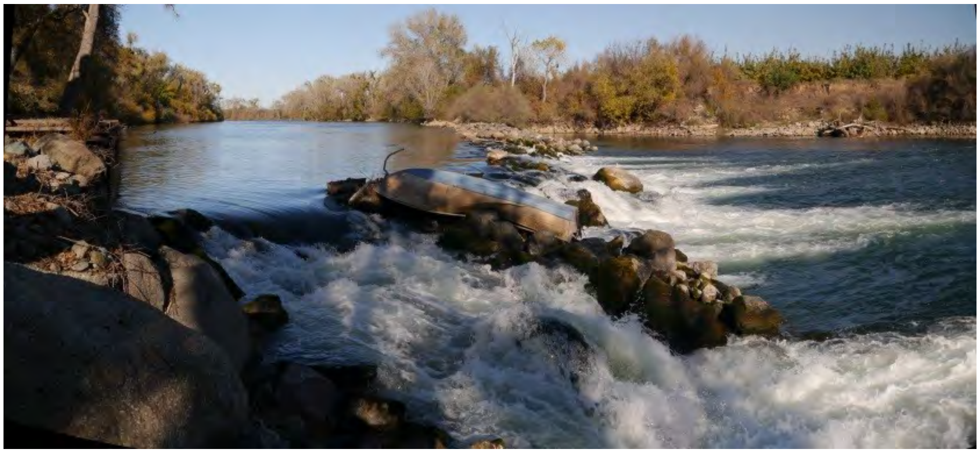


Figure 8. Photo of the Boulder Weir at Sunset Pumps.

Given that the Fish Barrier Dam is likely to persist into the foreseeable future as a total migration barrier to sDPS green sturgeon, the habitat below the Fish Barrier Dam becomes the sole focus for sDPS green sturgeon conservation in the Feather River. Unlike Chinook salmon or CCV steelhead, there is not a hatchery for sDPS green sturgeon to mitigate the impacts to the species. Therefore, the condition of the Feather River below Oroville Dam is of utmost concern for the conservation of sDPS green sturgeon. Attention is focused upon water releases from Oroville Dam sufficient to provide suitable flows and temperatures. Additionally, habitat conditions necessary to support a healthy population of sDPS green sturgeon in the Feather River are influenced by a variety of other impacts such as sport fishing regulations, water diversions, contributions from tributaries such as the Yuba River, levee maintenance and construction, and so forth. All these factors should be managed in order to promote habitat conditions in the Feather River that support a viable sDPS green sturgeon population. Presently, most, if not all, of these factors are at levels that are insufficient to achieve sDPS green sturgeon viability.

The long-term viability of sDPS green sturgeon is potentially impacted by three important types of factors: 1) catastrophic events; 2) long-term demographic processes; and 3) long-term evolutionary potential.

In terms of catastrophic event risk, sDPS green sturgeon in the Feather River are at high risk. With only one known spawning location in the Feather River at the Thermalito Afterbay Outlet, a single catastrophe or environmental change (manmade or natural) that damages this habitat or affects the fish in this location could have a significant detrimental effect on the sDPS green sturgeon using the Feather River. During site visits to the Feather River in 2014, the characteristic voluminous discharge flow of water out of Thermalito Afterbay Outlet, which creates the hydrologic conditions that sDPS green sturgeon apparently favor, was absent, raising concerns that operational changes in water flow might be precluding sDPS green sturgeon spawning. However, it is unknown whether sDPS green sturgeon would relocate to another location or return to the ocean without spawning should a catastrophic event occur.

Drought conditions in California from 2012-2015 have also taken their toll, and the flows in the Feather River have not been adequate to permit unimpeded sDPS green sturgeon passage at Sunset Pumps. We know that elevated flows in the Sacramento River are important for sDPS green sturgeon, where higher river flows have been shown to be important for triggering adult migrations, spawning and play a role in juvenile recruitment.

In the Sacramento River spawning is believed to be triggered by increases in water flow to about 14,000 cfs (average daily water flow during spawning months: 6,900 – 10,800 cfs; Brown 2007). In other rivers, post-spawning downstream migrations are triggered by increased flows. For example, in the Sacramento River migration flows range from 6,150 –14,725 cfs in the late summer (Vogel 2005), and in the Rogue, Klamath, and Trinity rivers flows greater than 3,550 cfs in the winter were identified (Erickson *et al.* 2002, Benson *et al.* 2007). Good recruitment of juvenile sDPS green sturgeon in the Delta was observed during years where the mean monthly February through May flows ranged from 3,488 – 20,505 cfs at Gridley, and 7,028 – 35,234 cfs at Nicolaus (USFWS 1995b). The current suitability of habitat in the Feather River is almost entirely dependent on releases from Oroville Dam, and the continued operations of Oroville Dam are likely to further attenuate high flow events.

Southern DPS green sturgeon critical habitat is much degraded in the action area. Within the Feather River habitat quality and quantity is an important issue for sDPS green sturgeon viability. Within this context, the most problematic issue for sDPS green sturgeon is probably flow. Oroville Dam, and to a lesser extent other upstream dams, impound flows that would otherwise have naturally flowed down the river during winter and spring storms, and with spring snow melt, flows which provided the necessary environmental cues for sDPS green sturgeon to migrate up the Feather River in search of spawning grounds. In the absence of these flows, sDPS green sturgeon appear to underutilize the Feather River. Furthermore, migration barriers such as the boulder weir at Sunset Pumps sturgeon passage at low flows, thereby exacerbating the problem of low flows.

The migratory PBF is also problematic as the habitat in the Lower Feather River is heavily impacted by unscreened water diversions that impose a potential serious mortality risk for larval and juvenile sDPS green sturgeon. Past investigations of suitable deep pools indicate that there are up to 12 deep holes over 13 miles, from the Fish Barrier Dam at RM 67 downstream to RM 54, with characteristics attractive to sDPS green sturgeon. Seven of these holes are greater than 5 meters deep, and 5 of the pools are between 3 – 5 meters. One of these holes is located directly downstream below the Thermalito Afterbay Outlet and may have been created or enhanced by releases from the Outlet. The total area of the pools is greater than 164,500 m^2.

The adequacy of other PBFs for sDPS green sturgeon is unknown because little investigation has been done thus far to look at food resources, contaminants, or sediments in the Feather River.

2.4.2 Factors Affecting Species and Critical Habitat in the Feather River

Oroville Dam, its associated structures, and the operation of these structures and facilities induce factors and effects to listed fish species and their critical habitat. Oroville Dam imposes a total barrier to migration of fish at the point of the Fish Barrier Dam structure. Operation of the dam produces thermographs and hydrographs that differ from the historical (pre-dam) condition of the Feather River. Oroville Dam retains sediment and large woody material that would otherwise wash downstream and replenish spawning and rearing habitat. The FRFH also has effects upon listed fish species through several mechanisms. These and other factors are considered below.

Blocked Habitat

Oroville Dam imposes a total barrier to fish migration. The dam's secondary downstream structure, the Fish Barrier Dam, marks the terminus of river accessibility to anadromous fish. For the fish species that historically utilized the upper Feather River, their descendants have suffered one of three fates: they are now permanently trapped above Oroville dam, they have been extirpated from the river entirely, or they are forced to use the remaining habitat below the Fish Barrier Dam.

Downstream of Oroville Dam, near the town of Live Oak, SEWD operates a pumping facility known as Sunset Pumps. In order to raise the surface elevation of the river to allow the pumps to function properly, the SEWD maintains a boulder weir that stretches across the river. This structure does not have an engineered fish ladder or fish passage chute specifically designed for the passage of CCV steelhead, Chinook salmon, or sDPS green sturgeon. Because this structure blocks, or partially blocks, fish passage at low to moderate flows, the structure impacts listed fish species and contributes to their status in the Feather River. This structure is not associated with the project or the FERC license for Oroville Dam. Numerous additional dams exist above Oroville Dam.

The amount of habitat made inaccessible by Oroville Dam varies by species. For sDPS green sturgeon, Mora *et al.* (2009) used a predictive model based on limited parameters (flow rates, gradient, and air temperatures in nearby rivers used by sDPS green sturgeon) to estimate that Oroville Dam blocks access to approximately 16 ± 4 kilometers of habitat in the Feather River. The study states the blocked habitat is probably of relatively high value due to its upstream position in the river network, but acknowledges that the accuracy of the model is limited because just a few habitat conditions were considered.

Even if fish passage were provided past the Oroville Facilities, loss of access to historical spawning and rearing habitats upstream of the Oroville Facilities would probably continue somewhat into the foreseeable future due to the significant number of upstream hydroelectric projects that start at the upstream extent of the project facilities at Oroville Reservoir and extend into the upper watersheds of all main forks of the Feather River and their tributaries (**Figure 9**). Some otherwise suitable habitat is also blocked by natural barriers in the upper tributaries.

Figure 9. PG&E dams upstream of Oroville Reservoir on the West Fork and North Fork of the Feather River.

Altered River Flow

The operation of Oroville Dam creates a hydrograph that is markedly different from historical conditions. As **Figure 10** shows, there is a consistent pattern of decreased springtime flows and increased summer flows across all water-year types. Marchetti and Moyle (2001) identified that restoration of natural flow regimes is necessary to reverse the decline of native fish populations. Healey (1991) stated that dams have probably had a much greater effect on stream-type Chinook salmon (*e.g.* CV spring-run Chinook salmon) than ocean-type Chinook (fall-run Chinook) due to longer migrations and longer resident times in rivers. The NRC (1996) stated that salmon are very sensitive to changes in streamflow and time their life-cycle movements according to local discharge regimes. For fish species (*e.g.* Chinook salmon, green sturgeon) that evolved in conditions of elevated springtime flows, such an altered hydrograph may have a negative effect. In some conditions, such as drought, the altered hydrograph can be beneficial.

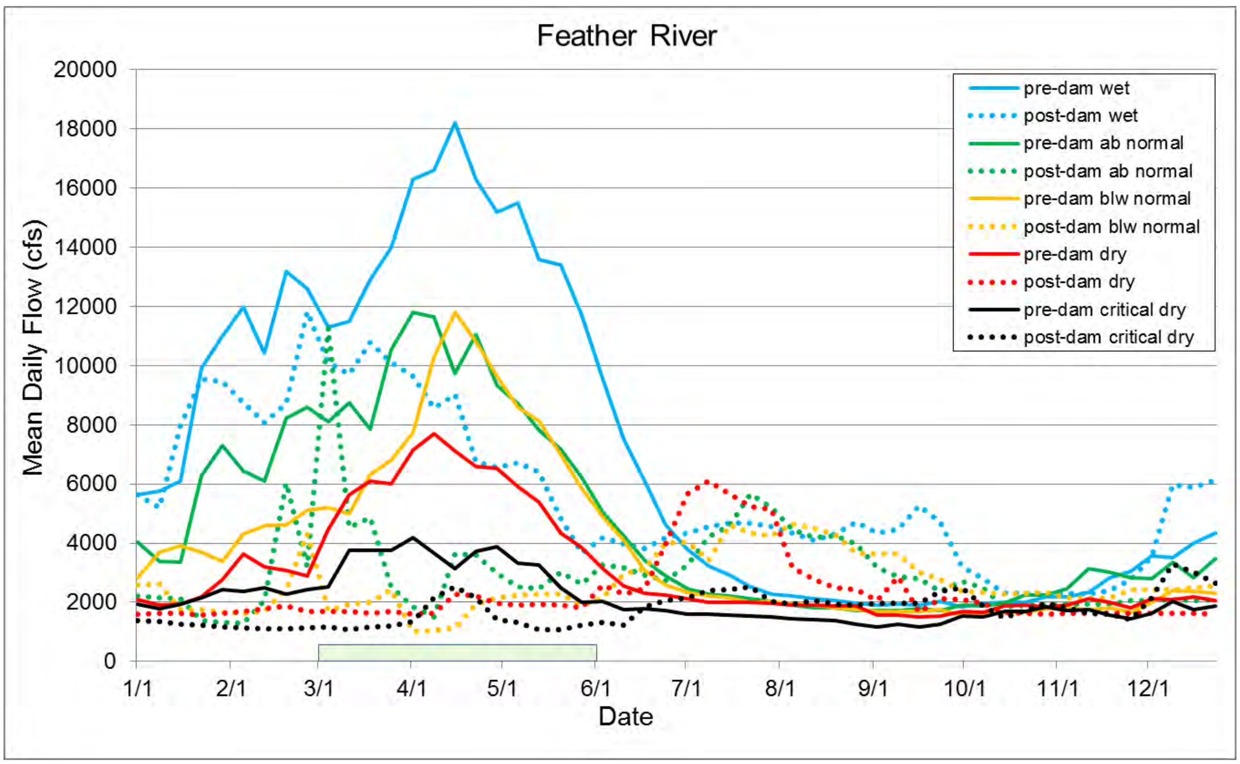


Figure 10. Median weekly water flow in critical dry water years in the Feather River during pre-dam years (Oroville gauge 1906 – 1965) and post-dam years (Gridley gauge 1969 – 2012).

Ramping Rates

Ramping rates are not required by the existing FERC license, but the rates that are proposed as part of the new license have been maintained in practice since 2004. Ramping rates are important because decreasing flows too quickly may result in stranded fish (Hunter 1992).

Instream Flows

DWR manages flows in the Feather River in a manner that reduces the potential for fish stranding and desiccation of redds. Minimum flows in the Feather River are currently set by an agreement between DWR and CDFW (DWR and CDFG 1983). The *Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife* established criteria for flow and water temperature in the LFC and the reach of the Feather River downstream of the Thermalito Afterbay Outlet to the confluence with the Sacramento River to preserve salmon spawning and rearing habitat. The agreement specifies a minimum release of 600 cfs into the Feather River LFC from the Thermalito Diversion Dam for fisheries purposes. This is the total rate of flow from the diversion dam outlet, the diversion dam power plant, and the FRFH outlet.

When Lake Oroville surface elevation is greater than 733 feet, the minimum instream flow requirements on the Feather River, downstream of the Thermalito Afterbay Outlet, range from 1,000 – 1,700 cfs depending on unimpaired run-off forecasts. These flows are requirements in the existing project license. Under the DWR/DFG agreement, if the April 1 runoff forecast in a given water year indicates that, under normal operation of the SWP, the reservoir level will be drawn down to elevation 733 feet (approximately 1.5 million acre feet [af]), releases for fish life prescribed in the agreement (*i.e.*, the minimum instream flow requirements on the Feather River downstream of the Thermalito Afterbay Outlet) may suffer monthly reductions in the same proportion as the respective monthly reductions imposed upon deliveries of water for agricultural use from the SWP. However, in no case shall the fish water releases prescribed in the agreement be reduced by more than 25 percent.

Under the DWR/DFG agreement, if the hourly flow exceeds 2,500 cfs anytime between October 15 and November 30, DWR must maintain a flow equal to that hourly flow amount less 500 cfs until the following March unless the high flow was a result of flood management operations or mechanical problems. This requirement ensures flow levels are high enough to keep the overbank areas submerged to protect any fish spawning that could occur. In practice, the flows are maintained below 2,500 cfs from October 15 to November 30 to prevent fish from spawning in the overbank areas.

Altered River Temperatures

The operation of Oroville Dam and associated facilities affects water temperature in the Feather River below Oroville Dam. Water temperatures may be colder or warmer than historic norms in the river depending upon a number of parameters including the large, naturally occurring variability in Feather River hydrology (unimpaired Feather River flow has varied from 1 million af to nearly 10 million af over the roughly 100-year gauge record), operation of dams further upstream, and a variety of operations conducted at Oroville Dam, a majority of which are not elective for DWR.

DWR releases water from Lake Oroville under a prescribed statutory and contractual hierarchy. These are, in order of priority, flood control releases, Feather River instream flow and temperature requirements that are primarily the result of biological opinions, Delta water quality requirements that are permit conditions associated with DWR's water rights on the Feather

River, contractual water supply obligations to senior Feather River water rights diverters, and lastly, SWP water supply deliveries to the 29 public agencies with SWP water supply contracts. Power generation releases through Hyatt Powerplant and releases through the River Valve Outlet System from Lake Oroville are made subordinate to the hierarchy noted above. These priorities may be adjusted in specific situations if rigid adherence to them would compromise the ability to meet legally mandated water quality, flow, or temperature requirements in other parts of the river system.

With respect to the Hyatt Powerplant intake located just upstream of the left abutment of Oroville Dam, water can be drawn from Lake Oroville over a range of depths by adding or removing shutters on the Hyatt Power Plant intake, thus permitting water to be drawn into the turbines over all or limited intervals of the upper 287 feet of Lake Oroville. Because Lake Oroville stratifies with respect to temperature, especially during summer, deeper water below the thermocline tends to be colder. The Hyatt Intake is very effective, under most operating conditions, at regulating the temperature of the water released from Oroville Dam to meet all current Oroville Facilities temperature requirements. Essentially, Lake Oroville must approach elevation 700 feet or lower for the Hyatt Intake to be ineffective in drawing cold water below the Lake Oroville thermocline. Such low elevation at Lake Oroville is typically only reached in dry or drought conditions or when such conditions persist over several years.

Oroville Dam, as required by dam safety regulations, also has a low level outlet accessing elevation 225 feet in Lake Oroville called the RVOS. The RVOS was designed to serve as a bypass around Hyatt Powerplant in the event of an outage of the plant and was also designed to serve as a low level outlet in case emergency evacuation of Lake Oroville is required. Both these operating scenarios are extreme events that are not expected to occur (especially the emergency evacuation scenario).

The two 54-inch fixed cone valves comprising the RVOS that discharge into Hyatt Tailrace Tunnel 2 have a design discharge capacity that varies with Lake Oroville elevation. Their capacity ranges from approximately 4,000 cfs at lake elevation 640 feet to about 2,000 cfs at Lake Oroville dead pool at elevation 340 feet. Lake Oroville has never been lower than elevation 645 feet. Because the two 54-inch FCVs are guarded by 72-inch spherical valves with no means to be isolated from the nearly 700 feet of head on the reservoir side, it is clear the design intent of the RVOS was for emergency or only occasional use. That said, the RVOS has been used in 5 separate years since the completion of Oroville Dam in 1967 to access cold Lake Oroville water for blending with Hyatt Powerplant releases to meet FRFH and Feather River temperature requirements deemed necessary for the protection of special status anadromous fish.

However, a malfunction and resulting accident occurred with the RVOS in 2009 that resulted in significant restrictions being placed on their operation. At this time (2016), through agreement with Division of Occupational Safety and Health, Department of Industrial Relations and others, the RVOS is approved for limited operations during the current (2016) drought emergency. DWR is working with dam safety regulatory agencies and others towards a long-term solution for use of the RVOS, which is intended to restore the full original design capacity of 4,000 cfs at lake elevation 640 feet for the RVOS.

As water flows downstream of Oroville Dam, most water is typically diverted into the Thermalito Forebay-Afterbay Complex to meet the aforementioned senior Feather River water rights obligations, which are primarily for agricultural beneficial use. A substantial portion of the April to October releases from Oroville Dam is for this purpose. By design, the water residence time in the relatively shallow 40,000-acre Thermalito Afterbay warms the water. On average, about one-third of this water flows back into the Feather River at the Thermalito Afterbay Outlet. The diversion of water through the Thermalito Complex can warm the water as much as 6°F. Thermalito Afterbay was originally designed, in part, to warm the river water downstream to mimic the warmer water temperatures that occurred in the Feather River before Oroville Dam was constructed (and before its cold water pool was established). Oroville Dam operations provide colder water to the Feather River, under a broad range of hydrologic conditions, compared to the pre-Oroville Dam conditions. Warmer river water is more conducive to rice farming, which has been identified as a beneficial use of Feather River water since before the Oroville Facilities were built as recognized in the senior water rights along the Feather River.

The operation of Oroville Dam and associated facilities produce complicated effects upon water temperature in the Feather River below Oroville Dam. Water temperatures may be colder or warmer than historic norms in the river depending upon how operations are conducted. Within Lake Oroville, water can be drawn from a variety of depths by adding or removing shutters on the Hyatt Power Plant intakes. Because deeper water tends to be colder, this type of manipulation is effective, up to a point, at regulating the temperature of the water released from Oroville Dam. The dam structure has river valves that allow deep, cold water to be released if desired. However, the diversion of water through the Thermalito Complex significantly reduces the amount of cold water habitat available in the Feather River. Furthermore, pump back operations[1] can also contribute to the artificial warming of river water.

Additionally, other FERC-licensed projects in the upper Feather River can influence the water temperature in the FRFH and the LFC. The South Feather Power Project discharges water in the Lower Feather River immediately downstream from Oroville Dam and affects water temperatures at the FRFH and the LFC. Water is diverted from the South Feather River at Ponderosa Dam and conveyed via tunnel and conduit to Miner's Ranch Reservoir and then via tunnel and penstock to the Kelly Ridge Powerhouse, through which up to 260 cfs is discharged to the Feather River downstream of Oroville Dam. Data and analyses indicate the flows diverted at Ponderosa Dam experience heating in transit to the Kelly Ridge Powerhouse, especially within Miner's Ranch Reservoir. The temperatures of the Kelly Ridge discharges are of greatest concern from summer through fall (August through October) because: (1) this interval is critical for anadromous fish holding, spawning, and incubation in the Feather River; (2) the intake of water to the Feather River Hatchery occurs from the Thermalito Diversion Pool, and cold water requirements must be maintained; (3) colder releases through the Hyatt Powerhouse (Oroville

[1]Overall, the SWP uses more energy than it produces. Pump-back operations allow DWR to minimize the cost of the power it purchases. Pump-back operations are a practice where water is pumped from an afterbay (*e.g.*, Thermalito Afterbay) up to a forebay (*e.g.*, Thermalito Forebay or the Diversion Pool) during off-peak periods when power costs are lower. The water is then sent back through the power plant to generate power when power values are higher to offset the costs of water conveyance. A side effect of this practice is the warming of the water due to its retention time in the system. When the water eventually does exit the system at the Thermalito Afterbay, it is likely warmer than it would have been had it been initially discharged from Lake Oroville.

Project) are reduced or periodically halted as Lake Oroville elevations fall in late summer and fall, and as consumptive needs and power demands lessen; and (4) late summer or fall meteorological conditions (heat storms) may cause appreciable heating in the FRFH and the LFC.

Collectively, all these operations may produce a thermograph that is similar or different to that in which ESA listed anadromous fish species evolved. Figure 11 shows the overall water temperature trends in the Feather River for a current time period (2002-2012) compared to a historical, pre-dam time period (1958-1967). A variety of temperature control devices have been engineered into the Oroville Facilities, allowing DWR to adjust river temperatures to better suit the needs of listed fish species. DWR has been able to substantially reduce river temperatures from approximately May 1 until November 1 compared to pre-dam conditions. This type of temperature control was not available before the Oroville Facilities were built.

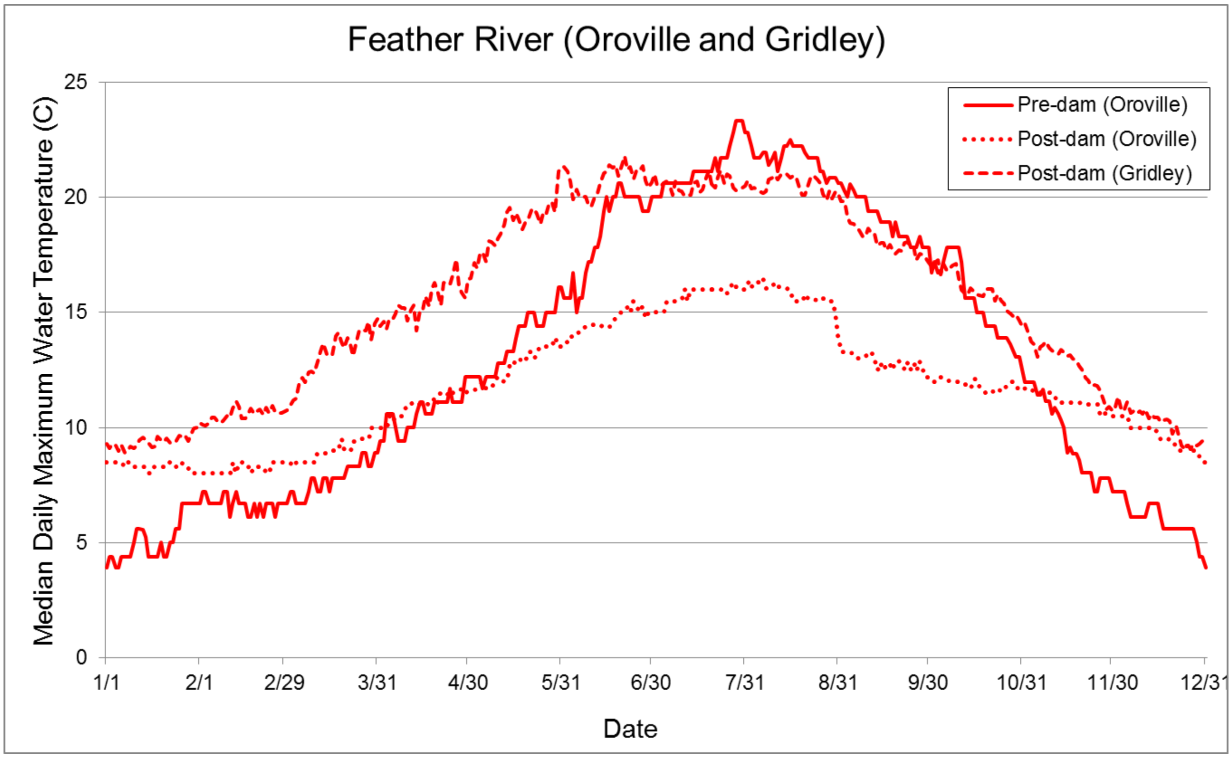


Figure 11. Median daily maximum water temperature in the Feather River at Oroville during pre-dam years 1958-1967 (solid line), at Oroville during post-dam years 1969-1992 (dotted line), and at Gridley during post-dam years 2002-2012 (dashed line).

Currently, water temperatures in the Lower Feather River are capable of supporting sDPS green sturgeon spawning during much of the spawning period, including what is considered the peak spawning period in April and May. From 1964 to 1994, water temperatures were within the optimal range for spawning 99 percent of the time from March through April from RM 67 downstream to RM 38.9 at the Sunset Pumps, a distance of approximately 28 river miles. During May, approximately 16 miles of habitat are within optimal ranges for 95 percent of the days during that period. Daily average water temperatures tend to be warmer in June, but are within optimal ranges for 88 percent of the days in June at RM 54 and up to 82 percent of the days at the Gridley Bridge (RM 51). During wet and above average years, the conditions are slightly improved when optimal spawning temperatures in June are exceeded for only 11 to 15 percent of the days downstream to RM 54 and 51, respectively (DWR 2009).

Impaired Recruitment of Large Woody Material and Sediment

Oroville Dam blocks important physical transport mechanisms, most notably the inhibition of downstream transport of gravel and large woody material. Gravel transport is important for the maintenance of favorable spawning habitat. Without human intervention, the habitat below Oroville dam becomes increasingly devoid of suitable spawning substrates as this material is washed downstream during periods of heavy flow and is not replaced naturally. Therefore, a gravel augmentation program, though expensive and labor intensive, is the only way to maintain suitable spawning habitat below Oroville Dam. The same is true for large woody material, which is important for maintaining habitat complexity, and providing refuge areas for juvenile fish (salmonids and sturgeon) and for creating habitat that encourages a complex and thriving ecosystem, ideally one that is hospitable to native fish.

Susceptibility to Disease

A number of factors, such as fish species, fish densities, the presence and amounts of pathogens in the environment, and water quality conditions (*e.g.*, temperature, DO, and pH), relate to the susceptibility of listed species to disease within the action area. Oroville Facilities, and associated programs, have affected all these factors since operations began and are expected to continue to do so into the foreseeable future.

Several endemic salmonids pathogens occur in the Feather River basin, including *Ceratomyxa shasta* (salmonids ceratomyxosis), *Flavobacterium columnare* (columnaris), the infectious hematopoietic necrosis virus (IHNV), *Renibacterium salmoninarum* (bacterial kidney disease), and *Flavobacterim psychrophilum* (cold water disease) (DWR 2004c). Although all these pathogens occur naturally in the Feather River basin, the Oroville facilities may have produced environmental conditions that are more favorable than under historical conditions. Such conditions include: 1) impediments to upstream migration altering timing, frequency, and duration of exposure of anadromous salmonids to certain pathogens; 2) inadvertent introduction of foreign diseases through out-of-basin transplants as part of the Lake Oroville Coldwater Fishery Improvement Program; 3) the transmission of disease from FRFH fish to wild or natural populations of listed salmonids; and 4) water transfers, pump-back operations, and flow manipulation resulting in changes in water quality conditions (*e.g.*, temperatures, DO, pH, etc.). Across the entire CV, including the Feather River, there is no evidence that CV spring-run Chinook salmon have experienced unusual levels of disease in the wild. There have been numerous outbreaks of IHNV in Chinook salmon at the FRFH. Although the virus has been detected in stream salmonids, there have been no reported epizootics of IHNV in Central Valley stream populations (*i.e.*, the virus was detected but the fish themselves were asymptomatic of the disease) (DWR 2009). It appears that IHNV is not readily transmitted from hatchery fish to salmon and other fish in streams, estuary, or the ocean (DWR 2009).

Water Quality

Water quality parameters that may affect fish species within the Feather River basin include: (1) DO and pH; 2) turbidity and total suspended solids (TSS) levels; (3) metals, petroleum by-products; (4) pesticide concentrations; and 5) nutrient concentrations. The CVRWQCB has listed the lower Feather River as impaired by sources of mercury, certain pesticides, and toxicity of unknown origin (DWR 2007).

Findings and other pertinent information related to monitored water quality parameters have been reported by DWR (2004c). For the most part, DO and pH levels complied with objectives established by the CVRWQCB. Turbidity and TSS levels were typically low in the upper watershed (above Lake Oroville), except during storm events. Because Lake Oroville acts as a sediment trap, turbidity and TSS levels are also generally low between Oroville dam and the Thermalito Afterbay Outlet. Downstream of the Thermalito Afterbay Outlet, turbidity and TSS concentrations generally increase, presumably related to inputs from downstream tributaries in the lower Feather River (DWR 2007).

Exceedance of water quality objectives for aluminum, iron, and copper were observed in DWR's water quality studies (DWR 2004c), but could not be associated with project operations or recreational activities. Petroleum products and pesticides were largely undetected in water samples collected for DWR's studies (DWR 2007). Nutrient concentrations measured in the Feather River were consistently below most Basin Plan objectives for the protection of beneficial uses (which includes freshwater habitat, fish migration and spawning) (DWR 2007).

It is expected that water quality parameters will continue to be monitored by the CVRWQCB and may remain at current levels into the foreseeable future.

Bank Modification and Riparian Habitat Loss

Bank modification (the construction of levees and bank armoring) changes the geomorphic processes affecting the lower Feather River. Continued deprivation of the sediment load in the lower Feather River is expected to result in reduced formation of sediment benches important to the colonization and succession of riparian vegetation (DWR 2007). Riparian vegetation is important to aquatic habitats because it provides overhanging cover for rearing fish, stream side shading, and a source of terrestrial and aquatic invertebrate contributions to the fish food base (DWR 2007). Riparian vegetation is also an important source of future LWM contributions to the aquatic system.

Water Diversions

DWR has settlement agreements with six local agencies along the Feather River (including the Thermalito Afterbay) from Lake Oroville to the confluence with the Sacramento River. They receive water according to the terms of settlement stemming from the original construction of the Oroville Facilities. These settlements recognized the senior water rights of those agencies and that DWR would provide them certain quantities of water from storage in Lake Oroville in accordance with those senior water rights. Four of these agencies are allowed to divert up to 955,000 AF during the irrigation season (April 1 – October 31), subject to provisions for reduction in supply under certain specific low-inflow conditions. The agreements with these agencies also indicate that an unspecified amount may be diverted for beneficial use outside of the contract irrigation season (November 1 – March 31). The remaining two agencies are allowed to divert up to 19,000 af annually, subject to provisions for reduction in supply under certain specific low-inflow conditions.

The actual amount diverted varies from year to year depending on the local hydrology. These diversions are made at one location in Lake Oroville, one location in the Thermalito Power Canal, four locations in Thermalito Afterbay, and five locations on the Feather River below Thermalito Afterbay. The agencies that divert directly from the Thermalito Afterbay are collectively referred to as the Feather River Service Area water users and are responsible for most of the local diversions.

DWR has also executed a number of contracts with riparian landowners along the Feather River downstream of Oroville Dam. Riparian owners are entitled to divert unimpaired flow for use on riparian land, but are not entitled to augmented flow made available as a result of project storage. Although the quantities of water are relatively small and do not ordinarily influence SWP operations, in certain years, riparian diversions can affect Oroville releases.

Water diversions have the potential to affect listed fish species in two ways: first by entraining fish directly and second by altering the habitat through changes to water flow, temperature, hydrology, or by creating predation hotspots. Entrainment risk is primarily a concern for water diversions that are unscreened and the fry or juvenile life stages are most vulnerable. An unscreened water diversion can entrain a fish by sucking it up into the pump, where it might be killed or injured by the pump, or, should the fish survive transport through the pump, it will be transported to a canal or ditch where long-term survival is probably impossible. Entrainment experiments have shown that a juvenile Chinook salmon's entrainment risk ranges from 0.3 to 2.3 percent and a juvenile green sturgeon's entrainment risk ranges from 4.2 to 22.3 percent when encountering a single unscreened pump (Mussen *et al.* 2014).

Risk of entrainment varies by year and location and can be significantly affected by river velocity, the rate of water diversion, and the number of pumps encountered during migration (Mussen *et al.* 2014). On the Feather River there are 120 diversion pumps downstream of the Fish Barrier Dam, only four of which are screened (Figure 12). The unscreened diversions pose a potential entrainment risk to both larval and juvenile fish. The combined effect of all unscreened water diversions is unknown and requires further study. Additionally, NMFS should develop screen criteria for green sturgeon because the current application of salmonid criteria may not be sufficient to protect sDPS green sturgeon.

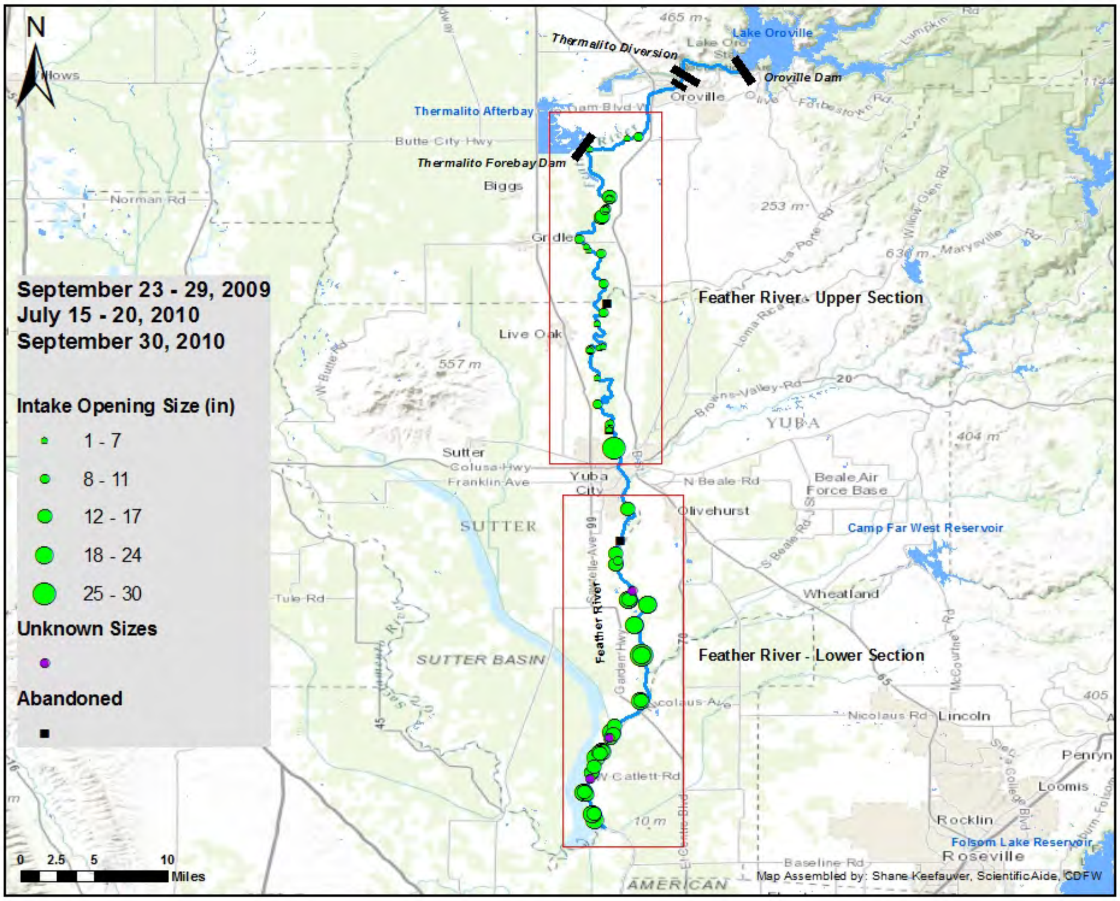


Figure 12. Locations of water diversions in the Feather River. Of the approximately 120 water diversions in the lower Feather River, only 4 are screened.

Periods of high water diversion may result in low flows along the Feather River. Salmon, steelhead, and green sturgeon are attracted by increased flows, so low flows in the Feather River may be insufficient to provide attraction cues to these fish species, thereby inhibiting spawner returns. Low flows may also lead to higher in-river water temperatures, perhaps to sub-optimal levels. Low flows may also expose barriers to migration at locations such as the Sunset Pumps, where a boulder weir stretches across the river, inhibiting fish passage at low to moderate flows (the exact flow thresholds that pose a fish passage problem at the Sunset Pumps boulder weir is not yet clearly defined).

The cumulative impact of water diversions to listed fish species in the Feather River is not well understood. The SWRCB Division of Water Rights regulates water diversions through their Water Rights Permitting program in coordination with CDFW. Recently, the SWRCB has stepped up monitoring requirements due to the drought, requiring reporting of diversion amounts and ceasing diversions when precipitation and other factors limit available flows. Also, there are currently proposed emergency regulations for measuring and monitoring water diversions through Senate Bill no. 88 (SB88). SB88 authorizes SWRCB to adopt regulations requiring measurement for water right holders and claimants who divert 10 af of water or more per year. Currently, the effects are not being analyzed. Therefore, this topic presents an opportunity to engage in better management, and thereby improve habitat conditions in the Feather River which may help to bolster spawner success, recruitment, escapement and overall abundance of salmon, CCV steelhead, and sDPS green sturgeon in the Feather River.

Water Management

As an integral part of the California SWP, the Oroville Facilities are operated in coordination with the Federal CVP to provide water deliveries to a large portion of California. SWP water flow management activities must comply with the State/Federal Coordinated Operations Agreement (COA); SWRCB water quality control plans (which include Delta flow and water quality standards to be met); previous salmon, CCV steelhead, sDPS green sturgeon, and delta smelt biological opinions issued by either NMFS or USFWS; and other agreements.

Many early restrictions placed on project operations primarily focused on Sacramento River winter-run Chinook salmon because this was the first species to be listed in the action area. More recent restrictions on combined CVP/SWP operations have also considered CV spring-run Chinook salmon, CCV steelhead, and the sDPS of green sturgeon.

Flood Control

The Oroville Facilities are also operated as an integral component of the flood management system for areas along the Feather and Sacramento Rivers downstream of Oroville Dam. This flood management system is called the Sacramento River Flood Control Project. From September to June, the Oroville Facilities are operated under flood control requirements specified by the Corps, the agency primarily responsible for flood control operations. Historically, flood control releases have not been necessary every year. When they are necessary, however, they can be substantial. Peak flood control releases during major spill events between January 1970 and December 1996 ranged from 77,000 – 160,000 cfs (FERC 2007).

Flood control operations have simplified the hydrograph by reducing the frequency of bankfull and greater flows that shape and maintain the morphology of the river channel and associated fish habitats. This has simplified habitat conditions for fish and reduced the inundation of floodplain habitats that when inundated are known to improve the growth and survival of juvenile salmonids when compared to rearing conditions in the main channel (Jeffres *et al.* 2008).

Recreational Fishing

Fishing regulations currently prohibit fishing of any type above the Table Mountain Bridge on the Feather River, but limited fishing for CCV steelhead, salmon, and sturgeon is permitted below this bridge. While hatchery CCV steelhead, Chinook salmon, and white sturgeon are targeted, incidental catch of protected species such as naturally produced CCV steelhead, CV spring-run Chinook salmon, and sDPS green sturgeon does occur. The areas open to fishing includes some of the best spawning habitat for listed salmonids on the Feather River, introducing the possibility that spawning redds might be disturbed by anglers.

Since 1998, all hatchery CCV steelhead have been marked with an adipose fin clip, allowing anglers to tell the difference between hatchery and wild CCV steelhead. Current regulations restrict anglers from keeping unmarked CCV steelhead in CV streams, except in the upper Sacramento River.

Current sport fishing regulations do not prevent wild CCV steelhead from being caught and released many times over while on the spawning grounds, where they are more vulnerable to fishing pressure. Recent studies on hooking mortality based on spring-run Chinook salmon have found a 12 percent mortality rate for the Oregon in-river sport fishery (Lindsay *et al.* 2004). Applying a 30 percent contact rate for CV rivers (*i.e.*, the average of estimated CV harvest rates), approximately 3.6 percent of adult steelhead die before spawning from being caught and released in the recreational fishery. Studies have consistently demonstrated that hooking mortality increases with water temperatures. Mortality rates for steelhead may be lower than those for Chinook, due to lower water temperatures.

In addition, survival of CCV steelhead eggs is reduced by fishermen walking on redds in spawning areas while targeting hatchery CCV steelhead or salmon. Roberts and White (1992) identified up to 43 percent mortality from a single wading over developing trout eggs, and up to 96 percent mortality from twice daily wading over developing trout eggs. Salmon and trout eggs are sensitive to mechanical shock at all times during development (Leitritz and Lewis 1980). Typically, CCV steelhead and salmon eggs are larger than trout eggs, and are likely more sensitive to disturbance than trout eggs. Currently, there are no regulations restricting river access to provide protection for spawning areas in the Feather River.

2.4.3 Mitigation Banks and the Environmental Baseline

The Feather River Mile 1.0L levee repair project occurs within the service areas of two conservation or mitigation banks approved by NMFS. These include:

Fremont Landing Conservation Bank: Established in 2006, the Fremont Landing Conservation Bank is a 100-acre floodplain site along the Sacramento River at the confluence of the Feather River (Sacramento River Mile 80) and is approved by NMFS to provide credits for impacts to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. There are off-channel shaded aquatic habitat credits, riverine shaded aquatic habitat credits, and floodplain credits available. To date, there have been 23.32 of 100 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. All features of this bank are designated critical habitat for the species analyzed in this opinion.

Bullock Bend Mitigation Bank: Established in 2016, the Bullock Bend Mitigation Bank is a 119.65-acre floodplain site along the Sacramento River (Sacramento River Mile 106) and is approved by NMFS to provide credits for impacts to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead. There are salmonid floodplain restoration, salmonid floodplain enhancement, and salmonid riparian forest credits available. To date, there have been 12.5 of 119.65 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. Additional transactions are pending but given the uncertainty associated benefits are not considered part of the environmental baseline. All features of this bank are designated critical habitat for the species analyzed in this opinion.

2.4.4 Survival and Mortality

The survival prospects for listed fish species in the Feather River are not particularly good (Figure 15). Many of the above factors are the cause, plus a few additional topics, such as predation, that have not been covered thus because of insufficient information. In a recent study of spring-run Chinook salmon smolts released in the Feather River, smolts generally survived at a lower rate while traveling through the Feather River than the Sacramento River or Delta (Amman *et al.* 2014) (**Figure 13**).

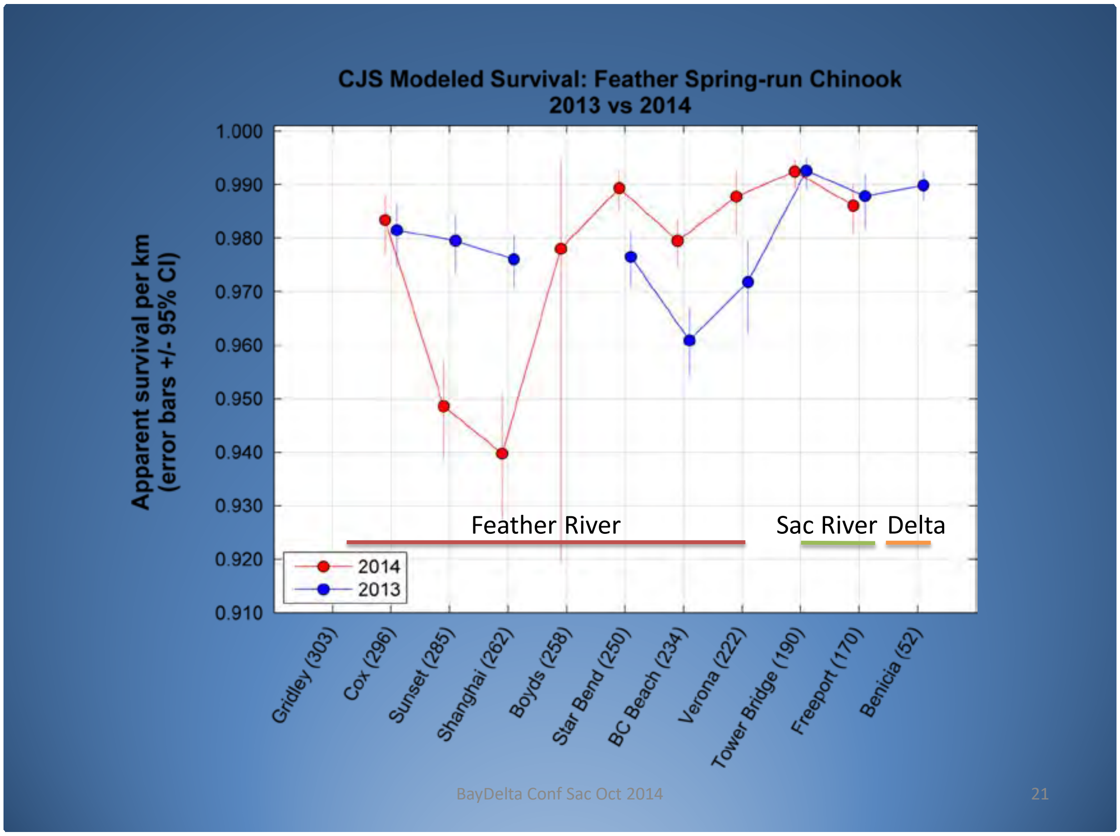


Figure 13. Study results of CV spring-run Chinook salmon smolt survival (2013-2014) where smolts were released in the Feather River, and survival tracked through the Feather River, Sacramento River, and the Delta. Survival was lowest in the Feather River. Source: presentation by Arnold Amman, NMFS/SWFSC, at the Bay Delta Science Conference, 2014.

Specific reaches of the Feather River were identified by the investigators as trouble areas, or "mortality hotspots" (Figure 14) and may warrant further investigation. However, CWT data from paired releases of CV spring-run Chinook salmon smolts released in the river and in San Pablo Bay reveal relatively equal return rates as adults to the Feather River. Data from other years show that smolts released in the bay perform better, suggesting there are no clear answers regarding the survival of hatchery smolts released in the lower river

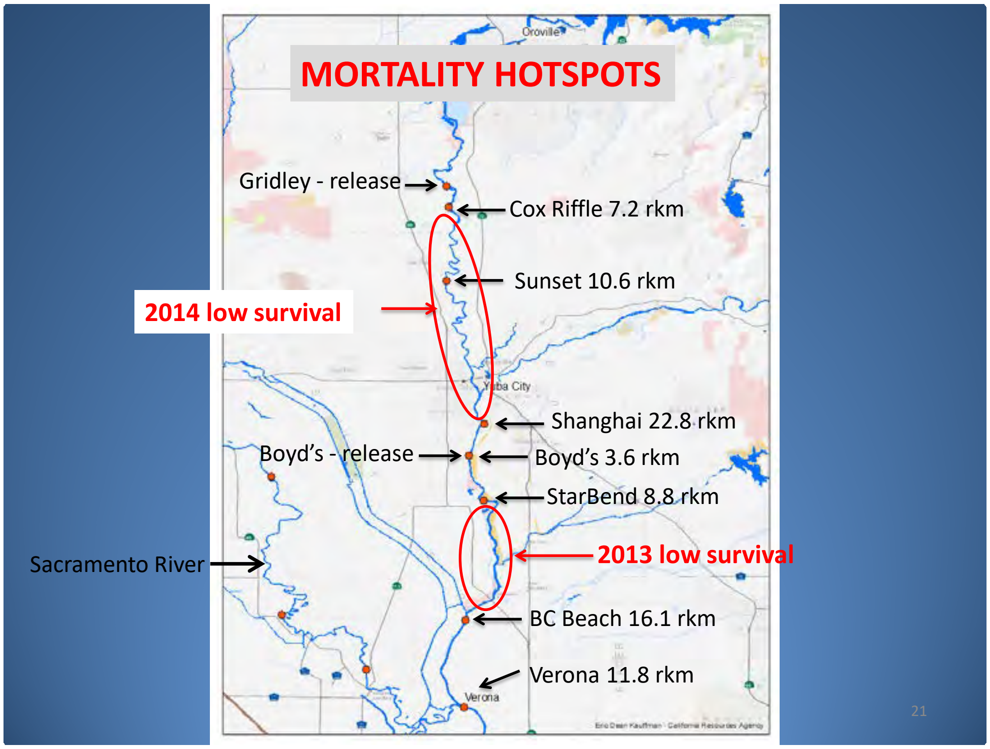


Figure 14. Mortality Hotspots in the Feather River, 2013-2014.

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 will 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 effects assessment will consider the nature, duration, and extent of the effects of the proposed action relative to the migration timing, behavior, and habitat requirements of federally listed CV spring-run Chinook salmon, and CCV steelhead, and the sDPS of North American green sturgeon and the magnitude, timing, frequency, and duration of project impacts to these listed species. Due to the life history timing of spring-run Chinook salmon, steelhead, and green sturgeon, it is possible for the following life stages to be present in the action area: rearing and emigrating juveniles, and spawning and migrating adults.

To evaluate the effects of the Feather River Mile 1.0 Left Bank Erosion Repair Site Project, NMFS examined the proposed actions in the designated action area. We analyzed construction-related impacts and the expected short- and long-term fish response to habitat modifications using the SAM. We also reviewed and considered the Corps proposed conservation and mitigation measures. This assessment relied heavily on the information from the Corps BA project description, SAM analysis, and discussions with consulting biologists and project engineers.

Specifically, the assessment will consider the potential short- and long-term impacts related to these species resulting from the construction impacts of the proposed action, including:

(1) potential for contaminants hazardous materials entering the water;
(2) increased turbidity and suspended sediment;
(3) temporal loss of riparian vegetation;
(4) loss of benthic habitat along the river channel; and
(5) direct injury or death from in-water construction work.

2.5.1 Construction Impact Analysis

NMFS expects that adult and juvenile CV spring-run Chinook salmon, adult and juvenile CCV steelhead, and adult and juvenile sDPS green sturgeon may be present in the action area, and therefore exposed to the effects of construction activities. Spawning habitat does not occur within the action area; therefore, adverse effects to incubating eggs are not expected to occur. Construction activities will likely cause localized, temporary disturbance of aquatic habitat, with turbidity and noise being the major effects for 300 feet upstream and downstream. Short-term effects are assessed based on the potential for exposure of listed species to construction-related effects and general knowledge of the impact mechanisms and species responses to these effects.

Those fishes that are exposed to the effects of construction activities will encounter short-term (*i.e.*, minutes to hours) construction-related noise, physical disturbance, and water quality impacts that may cause injury or harm by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors and affecting sheltering abilities.

Only those fish that are holding adjacent to or migrating past the construction site will be directly exposed or affected by construction. Adult salmonids and adult green sturgeon will likely respond to construction activities by quickly swimming away from the construction sites, and will escape injury. Furthermore, adult fishes are not expected to sustain any physical damage due to construction because preference for deep water and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance that occurs during typical daylight construction hours. Juveniles salmonids and green sturgeon may be exposed construction activities, but NMFS expects relatively few juvenile fishes are expected to be injured or killed by in-river construction activities as construction will be suspended under high flow conditions, when the largest numbers of fish are migrating.

Accidental Spill of Hazardous Materials (Contaminants)

Operation of construction equipment in or adjacent to the river presents the risk of a spill of hazardous materials into the river (*e.g.*, construction equipment leaking fluids). Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the waterway and have deleterious effects on listed salmonids and their prey. Potential effects of contaminants on fish include direct injury and mortality (*i.e.*, damage to gill tissue causing asphyxiation) or delayed effects on growth, reproduction, and survival (*e.g.*, increased stress or reduced feeding), depending on the type of contaminant and exposure concentrations. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. In addition, accidental spill of petroleum products would adversely affect EFH and PBFs for Chinook salmon, steelhead, and green sturgeon through degraded habitat.

The risk of such effects will be highest during in-water construction activities because of the proximity of construction equipment to the creek channel. However, this risk will be minimized by the implementation of a hazardous materials management plan, which the contractor will develop and implement prior to initiation of construction, which is intended to prevent any discharge of oil into navigable water or adjoining shorelines. The plan will include BMPs that would reduce the potential for spills of toxic chemicals and other hazardous materials during construction. Additionally, the plan will include a specific protocol for the proper handling and disposal of materials and contingency procedures to follow in the event of a hazardous materials spill. Any spills of hazardous materials to the river will be cleaned up immediately and reported immediately to the RWQCB, NMFS, and USFWS.

NMFS expects that the preparation of a spill control plan and a SWPPP will ensure that the potential for the release and exposure of construction-related contaminants will be avoided and/or minimized. These factors are expected to reduce the likelihood or severity of fuel spills or toxic compound releases to a point where they are not expected to cause adverse effects to any life stages of spring-run Chinook salmon, steelhead, or green sturgeon.

Increased Turbidity and Suspended Sediment

Activities related to vegetation removal, the construction of the riparian bench, and placement of riprap from the levee toe up to approximately the MSWSE will disturb the existing levee and riverbed. All of these activities will result in temporary increases in turbidity and suspended sediments in the action area.

The short-term increases in turbidity and suspended sediment levels associated with construction may negatively impact fish populations temporarily through reduced availability of food, reduced feeding efficiency, and exposure to sediment released into the water column. Fish responses to increased turbidity and suspended sediment can range from behavioral changes (*e.g.*, alarm reactions, abandonment of cover which could lead to predation, and avoidance) to sublethal effects (*e.g.*, reduced feeding rate), and, at high suspended sediment concentrations for prolonged periods, lethal effects (Newcombe & Jensen 1996). Temporary spikes in suspended sediment may result in behavioral avoidance of the site by fishes; several studies have documented active avoidance of turbid areas by juvenile and adult salmonids (Bisson & Bilby 1982, Lloyd *et al.* 1987, Servizi & Martens 1992, Sigler *et al.* 1984). Individual salmonids that encounter increased turbidity or sediment concentrations will likely move away from affected areas into suitable surrounding habitat.

High turbidity and suspended sediment levels can lead to reduced growth, survival, and reproductive success through a number of potential mechanisms such as reduced foraging ability, impaired disease resistance, and interference with cues necessary for orientation in homing and migration (Lloyd *et al.* 1987). Laboratory studies have demonstrated that chronic or prolonged exposure to high turbidity and suspended sediment levels can lead to reduced growth rates in juvenile salmonids. For example, Sigler *et al.* (1984) found that juvenile Coho salmon and steelhead trout exhibited reduced growth rates and higher emigration rates in turbid water (25-50

NTU) compared to clear water. Reduced growth rates in salmonids in turbid water have generally been attributed to their reliance on sight to effectively feed (Waters 1993).

Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to utilize visual cues (Sillman *et al.* 2005). Green sturgeon, which can occupy waters containing variable levels of suspended sediment and thus turbidity, are not expected to be impacted by the slight increase in the turbidity levels anticipated from the proposed project. Increases in turbidity can disrupt feeding and migratory behavior activities of salmonids, but NMFS anticipates that adherence to BMPs will greatly minimize the risk of injury or death caused by increases in turbidity.

2.5.2 Project Effects on Salmonids Using Standard Assessment Methodology

Methodology for the SAM analysis

The SRBPP Feather River Mile 1.0L Erosion Repair Project impacts to salmonids were analyzed using SAM. The Corps provided the background data, assumptions, analyses, and assessment of habitat compensation requirements for the Federally protected fish species relevant to this consultation. The SAM allows agencies to quantitatively assess the potential effects of bank protection and stream restoration projects to ensure that these activities do not jeopardize Chinook salmon and steelhead and do not destroy or adversely modify their critical habitat.

In general, the SAM quantifies habitat values in terms of bankline-weighted or area-weighted species responses. These responses are calculated by combining indices of habitat quality (*i.e.*, fish response indices) with quantity (bank length or wetted-area) for each season, target year, and relevant species/life stage. The SAM employs six habitat variables to characterize near-shore and floodplain habitats of listed fish species:

1) **Bank slope —** average bank slope of each average seasonal water surface elevation;

2) **Floodplain availability —** ratio of wetted channel and floodplain area during the 2-year flood to the wetted channel area during average winter and spring flows;

3) **Bank substrate size —** the median particle diameter of the bank (*i.e.*, D50) along each average seasonal water surface elevation;

4) **Instream structure —** percent of shoreline coverage of instream woody material along each average seasonal water surface elevation;

5) **Aquatic vegetation —** percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal water surface elevation; and

6) **Overhanging shade —** percent of the shoreline coverage of shade.

The SAM does not directly model changes in the above variables. Instead, habitat changes are estimated separately by the user and entered into an input data file to an Electronic Calculation Template (ECT) developed within a Microsoft Access database to track species responses to project actions over time. Changes in habitat variables may be fixed in time, such as installation of revetment at a particular slope and substrate size. In other circumstances, habitat evolution over time may be represented by more gradual changes in variables such as changes in floodplain inundation due to meander migration or changes in shade due to growth of planted vegetation. Typically, habitat evolution modeling is restricted to shade estimates from riparian growth models, but the SAM accommodates any number of other habitat modeling approaches such as meander migration modeling or LWD recruitment modeling.

Once a particular time series of habitat variable estimates is developed and entered into an ECT input file, fish responses are calculated using previously developed relationships between habitat variables and species/life stage responses (USACE 2012). The response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival, growth, and/or reproduction. For a given site and scenario (*e.g.*, with-project or without-project), the ECT uses these relationships to determine the responses of individual species and life stages to the measured or predicted values of each variable, for each season and target year; the ECT then multiplies these values together to generate an overall species response index. This index is then multiplied by the linear distance or area of bank to which it applies; the product is then integrated through time, generating a weighted species response index (expressed as feet or square feet) in each year of the analysis. The weighted species response index provides a common metric that can be used to quantify habitat values over time, compare project designs to existing conditions, and evaluate the effectiveness of onsite and off-site habitat compensation actions.

Following the procedures outlined in the SAM Users Manual (USACE 2012), the ECT (Version 4.0) was used to quantify the responses of the focus fish species and life stages to with-project conditions over 50 years. The SAM model utilizes water years (WY) rather than traditional calendar years; SAM WY also differ from traditional hydrologic water years. SAM WY are as follows: Fall (September – November), Winter (December – February), Spring (March – May), Summer (June – August). The ECT was used to calculate a time series of the relative response indices for each pre-project and with-project scenario developed below. Biological responses of each focus fish species life stage were predicted within each habitat unit and for each time step, based on habitat variable values and fish residency determined from region-specific timing tables (USACE 2012). In general, as calculated using the ECT, positive differences between the existing and with-project responses are assessed as a net benefit for the focus fish species (*i.e.*, the bank repair action produced superior conditions than pre-project conditions). Negative differences indicate the bank repair actions produced inferior conditions when compared with pre-project conditions; they generally require additional habitat compensation.

The SAM evaluates the response of focus fish species and their critical life-stages to bank protection measures over a 50 year period of analysis. Results are output as either bankline or wetted area WRI. The maximum negative WRI for a juvenile life stage are identified and used as a proxy for offsetting project effects. Although the SAM results are presented as bankline weighted and wetted area weighted WRIs, this analysis will focus on wetted area WRIs because they provide a more relevant representation of project effects than bankline WRIs. Wetted-area weighted results incorporate consideration of loss of wetted area due to construction of project features. The SAM incorporates the value of onsite mitigative features; therefore, the maximum negative WRI should be interpreted as the remaining potential effect that must be mitigated through additional onsite or offsite features, or through the purchase of offsite mitigative credits.

Identifying the maximum negative WRI over the 50 year period of analysis ensures that potential temporal losses are sufficiently considered.

The site-specific timing by year (WY) and season of installed bank protection features, including rock placement, soil and instream woody material installation, and vegetation plantings, were considered in this analysis for the with-project conditions. The pre-project and project conditions at Feather RM 1.0L used in the SAM analyses are presented in Tables E-9 and E-10 of Appendix E of the BA. Descriptions of the habitat variables used in the analysis are discussed below.

1) Shoreline length

Shoreline length is used as a quantitative attribute by which the qualitative attributes of a site are weighted to achieve a relative response factor. Shoreline lengths at a bank protection site are defined as the total length of continuous shoreline corresponding to each average seasonal flow (USACE 2012). Shoreline lengths were determined by assessing water surface elevations modeled across the breadth of the action area. Pre-project and with-project modeled water surface elevations were used to estimate seasonal shoreline lengths.

2) Wetted areas

Wetted area is used as a quantitative attribute by which the qualitative attributes of a site are weighted to achieve a relative response factor. Wetted areas at average flow conditions are defined as the wetted channel area of each site (the area between seasonal MWSE and centerline of the river). River centerline was determined through satellite imagery analysis. Seasonal MWSEs were determined by referencing digital elevation models created for each site.

3) Bank slope

In the SAM, bank slope serves as an indicator of the availability of shallow-water habitat and is obtained from point estimates of bank slope (horizontal change to vertical change, dH:dV) along each seasonal shoreline (*i.e.*, the line where the water surface intersects the bank on average fall, winter, spring, and summer) (USACE 2012). Bank slope for pre-project conditions were derived from the 2009 SAM analysis. The existing bank slope values were originally estimated from onsite survey data or by using GIS software with the topography at each site to determine a bank slope extending from each seasonal shoreline to a depth of approximately 3 ft. With-project bank slopes were estimated by referencing designs.

4) Floodplain inundation ratio

In the SAM, floodplain habitat availability is considered important for juvenile life stages and is defined by areas that are flooded by the 2-year flood event (Q2), and measured by calculating a Floodplain Inundation Ratio (USACE 2012). This ratio is calculated by dividing the wetted channel and inundated floodplain areas during the 2-year flood event (AQ2) by the wetted channel area (AQavg) during average winter and spring flows. For this analysis, pre-project and with-project values for floodplain inundation ration were derived from the 2009 SAM analysis. The amount of available floodplain habitat is consequently proportional to the ratio’s positive deviation from unity (i.e., values greater than 1). In the absence of a levee setback actions, the amount of available floodplain areas and channel cross sections would not be greatly altered during bank protection activities and thus have minimal impact in a SAM analysis.

5) Bank Substrate Size

Bank substrate size is directly affected by bank revetment and is considered an important determinant of predation risk and growth for nearly all life stages of the focus fish species (USACE 2012). Therefore, the relevant life stages are positively affected by smaller sizes of bank substrate and negatively affected by larger sizes of bank substrate. For this assessment, bank substrate size represents the median particle size (D50 in inches) within the submerged portion of the bank immediately below (0–3 feet) the seasonal MWSE. The pre-project bank substrate size used in this SAM analysis is consistent with the 2009 SAM value of 0.25 inches for all seasons. Determination of with-project bank substrate size was made by updating values based on changes in design.

6) Instream Structure

Instream structure is defined as instream woody material (IWM, excluding live bank vegetation) that is partially or fully submerged during average seasonal flows (USACE 2012). IWM is included in nearly all bank protection designs because it provides hiding and resting cover for focus fish and their predators, in addition to affecting invertebrate food production. Within the SAM (USACE 2012), bankline cover of IWM along the shorelines is assumed to be proportional to habitat quality for most life stages of the focus fish species. Pre-project and with-project IWM values were determined using site visit estimates along with vegetation planning designs developed by the Corps.

7) Aquatic Vegetation

Aquatic vegetation is defined as aquatic or inundated bank vegetation that is partially or fully submerged during average seasonal flows (USACE 2012). Floating, submerged, and emergent aquatic vegetation serve as hiding cover, and as an invertebrate food production base for both focus fish and their predators. Habitat quality is therefore considered to benefit proportionally with the relative amount of aquatic vegetation along a shoreline. Determination of the cover from aquatic vegetation under with-project conditions was determined by updating values based on changes in design. Aquatic vegetation is not typically planted at the summer/fall MWSE. Installation of fascine bundles is expected to provide some value to both aquatic vegetation and shade habitat components; however, the successful establishment of fascine bundles at erosion repair sites has varied greatly and cannot be relied upon to contribute to habitat benefits. Aquatic vegetation at winter/spring MWSE is expected to follow a typical growth model, originally developed by Stillwater Sciences in the 25 sites EA SAM analysis (USACE 2009) and augmented for this SAM analysis based on the planting plan cover objectives. Specifically, the objective when designing planting plans for all vegetative cover is 80%; therefore, the expectation of maximum cover for all seasons was modified from 100% to 80%.

8) Shade

Shade is represented by overhead canopy cover and is measured by estimating the percent of shoreline in which riparian vegetation extends over the water during average seasonal flows. Overhanging shade is considered to benefit habitat quality by providing hiding cover and food availability for the focus fish species. Values for pre-project shade were derived from the 2009 SAM analysis. Determination of with-project shade cover was made by updating values based on changes in design (protecting all trees in place). Values for shade in winter and spring were modified by 25% and 75% of the existing values, respectively, to incorporate consideration of annual winter defoliation and spring leafing out.

Results of the SAM Analysis

The Corps utilizes a reasonable worst-case scenario approach when evaluating the SAM results. This approach errs on the side of caution so that bank protection actions and onsite mitigation are more likely to meet or exceed modeled expectations, while limiting temporal and permanent effects. The SAM results presented below in **Table 6** and are based on such a worst case scenario analysis. **Table 6** shows negative WRI values, but there are several areas where the action will result in improved conditions. These are discussed below, and are summarized in Appendix E to the BA – *Fisheries Effect Analysis for the Bank Protection Measures at Feather River 1.0L Using the Standard Assessment Methodology*, here after referred to as the FHR 1.0L SAM Analysis. In **Table 6**, year 0 refers to the year of construction.

Table 6. FHR 1.0L SAM Analysis Results – Wetted Area Weighted Relative Response

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Spring-run Chinook																				
2018 - Year 0			0	0				0	0				0	0				0	0	
2019 - Year 1			0	0				-564	-4,072				-504	-2,675				-5,032	-33,933	
2020 - Year 2			-1,905	-12,311				-476	-11,180				-1,455	-11,924				-7,098	-46,580	
2021 - Year 3			-3,809	-24,622				-207	-16,974				-2,127	-19,928				-7,272	-47,468	
2022 - Year 4			-4,762	-30,778				737	-18,033				-1,270	-20,693				-7,359	-47,912	
2023 - Year 5			-5,333	-34,471				2,174	-16,637				687	-18,065				-7,411	-48,179	
2024 - Year 6			-5,714	-36,934				3,576	-14,575				2,918	-15,128				-7,445	-48,357	
2025 - Year 7			-5,986	-38,692				4,981	-12,103				5,306	-12,015				-7,470	-48,483	
2026 - Year 8			-6,141	-39,909				6,262	-9,648				7,492	-9,104				-7,440	-48,476	
2027 - Year 9			-6,175	-40,671				7,336	-7,463				9,277	-6,607				-7,329	-48,287	
2028 - Year 10			-6,123	-41,117				8,265	-5,464				10,783	-4,396				-7,162	-47,971	
2029 - Year 11			-6,009	-41,332				9,091	-3,597				12,087	-2,399				-6,953	-47,563	
2030 - Year 12			-5,849	-41,374				9,838	-1,829				13,236	-555				-6,715	-47,085	
2031 - Year 13			-5,653	-41,283				10,526	-135				14,273	1,168				-6,452	-46,555	
2032 - Year 14			-5,429	-41,087				11,167	1,503				15,217	2,798				-6,171	-45,983	
2033 - Year 15			-5,183	-40,808				11,772	3,097				16,089	4,353				-5,875	-45,377	
2043 - Year 25			-3,080	-37,728				15,837	14,469				21,714	15,042				-3,496	-40,469	
2068 - Year 50			-1,425	-35,253				18,951	23,264				26,014	23,274				-1,633	-36,624	
Fall-run Chinook																				
2018 - Year 0			0					0	0				0	0						
2019 - Year 1			0					-564	-4,072				-504	-2,675						
2020 - Year 2			-1,905					-476	-11,180				-1,455	-11,924						
2021 - Year 3			-3,809					-207	-16,974				-2,127	-19,928						
2022 - Year 4			-4,762					737	-18,033				-1,270	-20,693						
2023 - Year 5			-5,333					2,174	-16,637				687	-18,065						
2024 - Year 6			-5,714					3,576	-14,575				2,918	-15,128						
2025 - Year 7			-5,986					4,981	-12,103				5,306	-12,015						
2026 - Year 8			-6,141					6,262	-9,648				7,492	-9,104						
2027 - Year 9			-6,175					7,336	-7,463				9,277	-6,607						
2028 - Year 10			-6,123					8,265	-5,464				10,783	-4,396						
2029 - Year 11			-6,009					9,091	-3,597				12,087	-2,399						
2030 - Year 12			-5,849					9,838	-1,829				13,236	-555						
2031 - Year 13			-5,653					10,526	-135				14,273	1,168						
2032 - Year 14			-5,429					11,167	1,503				15,217	2,798						
2033 - Year 15			-5,183					11,772	3,097				16,089	4,353						
2043 - Year 25			-3,080					15,837	14,469				21,714	15,042						
2068 - Year 50			-1,425					18,951	23,264				26,014	23,274						
Winter-run Chinook																				
2018 - Year 0			0	0				0	0				0	0				0		
2019 - Year 1			0	0				-564	-4,072				-504	-2,675				-5,032		
2020 - Year 2			-1,905	-12,311				-476	-11,180				-1,455	-11,924				-7,098		
2021 - Year 3			-3,809	-24,622				-207	-16,974				-2,127	-19,928				-7,272		
2022 - Year 4			-4,762	-30,778				737	-18,033				-1,270	-20,693				-7,359		
2023 - Year 5			-5,333	-34,471				2,174	-16,637				687	-18,065				-7,411		
2024 - Year 6			-5,714	-36,934				3,576	-14,575				2,918	-15,128				-7,445		
2025 - Year 7			-5,986	-38,692				4,981	-12,103				5,306	-12,015				-7,470		
2026 - Year 8			-6,141	-39,909				6,262	-9,648				7,492	-9,104				-7,440		
2027 - Year 9			-6,175	-40,671				7,336	-7,463				9,277	-6,607				-7,329		
2028 - Year 10			-6,123	-41,117				8,265	-5,464				10,783	-4,396				-7,162		
2029 - Year 11			-6,009	-41,332				9,091	-3,597				12,087	-2,399				-6,953		
2030 - Year 12			-5,849	-41,374				9,838	-1,829				13,236	-555				-6,715		
2031 - Year 13			-5,653	-41,283				10,526	-135				14,273	1,168				-6,452		
2032 - Year 14			-5,429	-41,087				11,167	1,503				15,217	2,798				-6,171		
2033 - Year 15			-5,183	-40,808				11,772	3,097				16,089	4,353				-5,875		
2043 - Year 25			-3,080	-37,728				15,837	14,469				21,714	15,042				-3,496		
2068 - Year 50			-1,425	-35,253				18,951	23,264				26,014	23,274				-1,633		

Focus Fish Species and Water Year	Fall					Winter					Spring					Summer				
	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence	Adult migration	Spawning and egg incubation	Fry and juvenile rearing	Juvenile migration	Adult residence
Steelhead																				
2018 - Year 0			0	0	0			0	0	0			0	0	0			0		0
2019 - Year 1			0	0	0			-953	-2,276	-1,373			-799	-1,275	-1,161			-9,000		-29,000
2020 - Year 2			-3,079	-12,040	-5,17			-933	-9,185	-4,359			-2,446	-10,446	-6,493			-12,342		-34,171
2021 - Year 3			-6,157	-24,081	-10,342			-612	-15,380	-6,923			-3,645	-18,897	-11,209			-12,333		-29,675
2022 - Year 4			-7,697	-30,101	-12,927			741	-16,740	-8,120			-2,531	-20,239	-13,394			-12,328		-27,427
2023 - Year 5			-8,620	-33,713	-14,478			2,799	-15,717	-8,653			79	-18,324	-14,263			-12,326		-26,078
2024 - Year 6			-9,236	-36,121	-15,512			4,761	-14,131	-8,703			2,949	-16,064	-14,105			-12,324		-25,179
2025 - Year 7			-9,676	-37,841	-16,251			6,694	-12,206	-8,476			5,969	-13,606	-13,361			-12,323		-24,537
2026 - Year 8			-9,920	-39,025	-16,678			8,435	-10,330	-8,162			8,714	-11,325	-12,496			-12,236		-23,928
2027 - Year 9			-9,958	-39,758	-16,784			9,885	-8,717	-7,867			10,949	-9,427	-11,771			-12,016		-23,228
2028 - Year 10			-9,850	-40,174	-16,665			11,132	-7,288	-7,585			12,827	-7,796	-11,143			-11,703		-22,465
2029 - Year 11			-9,638	-40,361	-16,383			12,232	-5,993	-7,313			14,446	-6,361	-10,586			-11,322		-21,656
2030 - Year 12			-9,347	-40,376	-15,976			13,222	-4,797	-7,048			15,672	-5,070	-10,083			-10,891		-20,812
2031 - Year 13			-8,995	-40,258	-15,479			14,127	-3,677	-6,789			17,149	-3,892	-9,620			-10,420		-19,941
2032 - Year 14			-8,595	-40,035	-14,906			14,966	-2,616	-6,534			18,309	-2,801	-9,189			-9,918		-19,049
2033 - Year 15			-8,157	-39,730	-14,274			15,754	-1,603	-6,282			19,377	-1,780	-8,784			-9,392		-18,141
2043 - Year 25			-4,444	-36,458	-8,862			20,991	5,386	-4,452			26,217	4,985	-6,079			-5,185		-11,182
2068 - Year 50			-1,521	-33,835	-4,599			35,012	10,770	-3,034			31,441	10,173	-4,002			-1,892		-5,759
Green Sturgeon																				
2018 - Year 0			0					0					0					0		
2019 - Year 1			0					0					0					-3,127		
2020 - Year 2			11,211					7,660					7,660					8,084		
2021 - Year 3			22,422					15,321					15,321					20,337		
2022 - Year 4			28,028					19,151					19,151					26,464		
2023 - Year 5			31,391					21,449					21,449					30,140		
2024 - Year 6			33,633					22,981					22,981					32,591		
2025 - Year 7			35,235					24,076					24,076					34,341		
2026 - Year 8			36,436					24,896					24,896					35,654		
2027 - Year 9			37,370					25,535					25,535					36,675		
2028 - Year 10			38,118					26,045					26,045					37,492		
2029 - Year 11			38,729					26,463					26,463					38,161		
2030 - Year 12			39,239					26,811					26,811					38,718		
2031 - Year 13			39,670					27,106					27,106					39,189		
2032 - Year 14			40,040					27,359					27,359					39,593		
2033 - Year 15			40,360					27,577					27,577					39,943		
2043 - Year 25			42,154					28,803					28,803					41,904		
2068 - Year 50			43,489					29,722					29,722					42,374		

The impacts will occur along approximately 997 feet of the left bank of the Feather River. For salmon and steelhead the main factor driving SAM deficits is the reduction in riparian habitat.

Certain life stages of salmonids have been omitted from the SAM analysis, as their responses to bank stabilization projects cannot be accurately modeled by SAM. These life stages include the following: adult migration for salmon and steelhead, outmigration of post spawning adult steelhead, and spawning and egg incubation for salmon and steelhead.

SAM modeled results for the adult migration life stages of salmon and steelhead were omitted since migrating adult salmonids are not expected to utilize the area near the shore where the project will occur or be influenced by the shoreline habitat features modeled by SAM, as they prefer deeper water. Furthermore, these fish are unlikely to be affected by the project because there will be no increase in predation and their upstream migration will not be impeded by any structural features. The site is 997 feet in length and migrating adult salmonids are likely to continue moving past the site if it does not provide habitat conditions that they prefer. Therefore, the project is not expected to impact the quality of the area as an adult migration corridor. The adult steelhead that are outmigrating as post spawning adults are not expected to be negatively impacted by the project for the same reasons. The salmon and steelhead adult spawning and egg incubation life stages were not included in the SAM analysis as the impacts of bank modifications on these life stages has not been modeled for use in SAM analyses. Furthermore, these life stages do not occur in the RM 1.0L action area, and thus they are not expected to be impacted by the proposed project.

It is important to note that the SAM results are not the sole factor to consider in the determination of appropriate compensation and that the SAM is performed and interpreted on a case by case basis. The results of the SAM analysis are summarized in **Table 7** The largest negative value for all species, life stages, and seasons occurs for the juvenile migrating spring-run Chinook salmon with a magnitude of -48,483 ft^2 (1.1 acres). Purchase of appropriate mitigation credits in the amount of -48,483 ft^2 would provide compensatory mitigation for short and long-term effects from construction at FHR 1.0L to CV spring-run chinook salmon, fall-run chinook salmon, late fall-run chinook salmon, winter-run chinook salmon, and CCV steelhead.

Summary of effects by water surface elevation:

At fall water surface elevations:

Reductions in riparian vegetation and placement of rock-revetment along 997 feet of the left bank of the Feather River, leading to reduced growth and survival of fry and juvenile rearing CV spring-run chinook salmon and CCV steelhead are expected to last at least 50 years after any construction activities associated with the bank repair actions at FHR 1.0L. The amount and extent of these effects are quantified in **Table 6** and **Table 7**. These adverse effects are greatest in Year 9 with a magnitude of -6,175 ft^2 WRI for all chinook runs and -9,958 ft^2 WRI for CCV steelhead, and continue for at least 50 years.

Table 7. Summary of SAM Results for the Proposed Levee Erosion Repair at FHR 1.

Season	Life Stage	Maximum Negative WRI (ft^2)	Duration of Adverse Effect (Years after Construction)	Max benefit (ft^2 at Year 50)
Spring-run Chinook Salmon				
Fall	Fry & Juvenile Rearing	-6,175	50+	-
	Juvenile Migration	-41,374	50+	-
Winter	Fry & Juvenile Rearing	-564	3	18,961
	Juvenile Migration	-18,033	13	23,264
Spring	Fry & Juvenile Rearing	-2,127	4	26,014
	Juvenile Migration	-20,693	12	23,274
Summer	Fry & Juvenile Rearing	-7,470	50+	-
	Juvenile Migration	-48,483	50+	-
Fall-run Chinook Salmon				
Fall	Fry & Juvenile Rearing	-6,175	50+	-
Winter	Fry & Juvenile Rearing	-564	3	18,961
	Juvenile Migration	-18,033	13	23,264
Spring	Fry & Juvenile Rearing	-2,127	4	26,014
	Juvenile Migration	-20,693	12	23,274
Winter-run Chinook Salmon				
Fall	Fry & Juvenile Rearing	-6,175	50+	-
	Juvenile Migration	-41,374	50+	-
Winter	Fry and Juvenile Rearing	-564	3	18,961
	Juvenile Migration	-18,033	13	23,264
Spring	Fry & Juvenile Rearing	-2,127	4	26,014
	Juvenile Migration	-20,693	12	23,274
Summer	Fry & Juvenile Rearing	-7,470	50+	-
Central Valley Steelhead				
Fall	Fry & Juvenile Rearing	-9,958	50+	-
	Juvenile Migration	-40,376	50+	-
	Adult Residence	-16,784	50+	-
Winter	Fry & Juvenile Rearing	-953	3	25,010
	Juvenile Migration	-16,740	16	10,770
	Adult Residence	-8,703	50+	-
Spring	Fry & Juvenile Rearing	-3,645	4	31,441
	Juvenile Migration	-20,239	16	10,173
	Adult Residence	-13,394	50+	-
Summer	Fry & Juvenile Rearing	-12,342	50+	-
	Adult Residence	-34,171	50+	-
Green Sturgeon				
Fall	Fry & Juvenile Rearing	-	-	43,499
Winter	Fry & Juvenile Rearing	-	-	29,722
Spring	Fry & Juvenile Rearing	-	-	29,722
Summer	Fry & Juvenile Rearing	-3,127	1	43,374

Maximum Negative WRI results are presented as wetted-area Weighted Response Indices (WRI)

Reduced growth and survival of juvenile out-migrating (smolts) CV spring-run chinook salmon, late fall-run chinook salmon, winter-run chinook salmon, and CCV steelhead due to reductions in riparian vegetation and placement of rock-revetment along 997 feet of the left bank of the Feather River is expected for at least 50 years after any construction activities associated with the bank repair actions at FHR 1.0L. The amount and extent of these adverse effects is quantified in **Table 7** These adverse effects are greatest in Year 12 following construction, with a magnitude of -41,374 ft^2 WRI for all chinook runs and -40,376 ft^2 WRI for CCV steelhead, and continue for at least 50 years.

Reduced survival of adult resident CCV steelhead (kelts) is expected for at least 50 years after any construction activities associated with the bank repair actions at FHR 1.0L due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. The amount and extent of this adverse effect is quantified in **Table 7** These adverse effects are greatest in Year 9 following construction, with a magnitude of -16,784 ft^2 WRI, and continue for at least 50 years.

Rearing Juvenile Sturgeon

Improved growth and survival of fry and juvenile rearing sDPS green sturgeon is expected as the result of reduction in slope and placement of IWM along 997 feet of the left bank of the Feather River. The amount and extent of this beneficial effect is quantified in **Table 7**. The reduction in riparian vegetation along 997 feet of the left bank of the Feather River leading to reduced growth and survival of fry and juvenile rearing green sturgeon is expected to last at least 50 years after any construction activities associated with the bank repair actions at RM 1.0L. The amount and extent of this effect are quantified in **Table 7**. These adverse effects are greatest in Year 1 with a magnitude of -3,127 ft^2 WRI, and continue for at least 50 years.

Improved growth and survival of fry and juvenile rearing sDPS green sturgeon is expected as the result of reduction in slope and placement of IWM along 997 feet of the left bank of the Feather River. The amount and extent of this beneficial effect is quantified in **Table 7**. Beneficial effects for the juvenile rearing life stage of sDPS green sturgeon are expected immediately following construction, and would increase to a magnitude of 43,499 ft^2 by Year 50.

At winter water surface elevations:

Reduced survival of fry and juvenile rearing CV spring-run chinook salmon, fall-run chinook salmon, late fall-run chinook salmon, winter-run chinook salmon, and CCV steelhead is expected for at least 3 years after any construction activities associated with the bank repair actions at FHR 1.0L due to short term reductions in vegetation and associated shade along 997 feet of the left bank of the Feather River. The amount and extent of this adverse effect is quantified in **Table 7**. These adverse effects are greatest in Year 1 following construction, with a magnitude of -564 ft^2 WRI for all chinook runs and -953 ft^2 WRI for CCV steelhead. Beneficial effects are expected by Year 4 for all chinook runs and Year 4 for CCV steelhead; by Year 50, beneficial effects would increase to a magnitude of 18,961 ft^2 WRI and 25,010 ft^2 for all chinook runs and CCV steelhead respectively.

Reduced growth and survival of juvenile migrating (smolts) CV spring-run chinook salmon, fall-run chinook salmon, late fall-run chinook salmon, and winter-run Chinook salmon is expected for at least 13 years after any construction activities associated with FHR 1.0L due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. Reduced growth and survival of juvenile migrating (smolts) CCV steelhead is expected for at least 16 years after any construction activities due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. The amount and extent of these adverse effects are quantified in **Table 7**. For all chinook runs, these adverse effects are greatest in Year 4 following construction, with a magnitude of -18,033 ft^2 WRI. For CCV steelhead, these adverse effects are greatest in Year 4 following construction, with a magnitude of -16,740 ft^2 WRI. Beneficial effects are expected by Year 14 for all chinook runs and Year 17 for CCV steelhead; by Year 50, beneficial effects would increase to a magnitude of 23,264 ft^2 WRI and 10,770 ft^2 for all chinook runs and CCV steelhead respectively.

Reduced survival of adult resident CCV steelhead (kelts) is expected for at least 50 years after any construction activities associated with the bank repair actions at FHR 1.0L due to reductions in riparian vegetation along 990 feet of the left bank of the Feather River. The amount and extent of this adverse effect is quantified in **Table 7**. These adverse effects are greatest in Year 6 following construction with a magnitude of -8,703 ft^2 WRI, and continue for at least 50 years.

Improved growth and survival of fry and juvenile rearing sDPS green sturgeon is expected as the result of construction of a riparian bench and installation of IWM along 997 feet of the left bank of the Feather River. The amount and extent of this beneficial effect is quantified in **Table 7**. Beneficial effects for the juvenile rearing life stage of sDPS green sturgeon are expected immediately following construction, and would increase to a magnitude of 29,722 ft^2 by Year 50.

<u>*At spring water surface elevations:*</u>

Reduced survival of fry and juvenile rearing CV spring-run chinook salmon, fall-run chinook salmon, late fall-run chinook salmon, winter-run chinook salmon, and CCV steelhead is expected for at least 4 years after any construction activities associated with the bank repair actions at FHR 1.0L due to short term reductions in vegetation and associated shade along 997 feet of the left bank of the Feather River. The amount and extent of this adverse effect is quantified in **Table 7**. These adverse effects are greatest in Year 3 following construction, with a magnitude of -2,127 ft^2 WRI for all chinook runs and -3,645 ft^2 WRI for CCV steelhead. Beneficial effects are expected by Year 5 for all chinook runs and Year 5 for CCV steelhead; by Year 50, beneficial effects would increase to a magnitude of 26,014 ft^2 WRI and 31,441 ft^2 for all chinook runs and CCV steelhead respectively.

Reduced growth and survival of juvenile migrating (smolts) CV spring-run chinook salmon and winter-run chinook salmon is expected for at least 12 years after any construction activities associated with FHR 1.0L due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. Reduced growth and survival of juvenile migrating (smolts) CCV steelhead is expected for at least 16 years after any construction activities due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. The amount and extent of these adverse effects are quantified in **Table 7**. For all chinook runs, these adverse effects are greatest in Year 4 following construction, with a magnitude of -20,693 ft^2 WRI. For CCV steelhead, these adverse effects are greatest in Year 4 following construction, with a magnitude of -20,239 ft^2 WRI. Beneficial effects are expected by Year 13 for all chinook runs and Year 17 for CCV steelhead; by Year 50, beneficial effects would increase to a magnitude of 23,274 ft^2 WRI and 10,173 ft^2 for all chinook runs and CCV steelhead respectively.

Reduced survival of adult resident CCV steelhead (kelts) is expected for at least 50 years after any construction activities associated with bank repair actions at FHR 1.0L due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. The amount and extent of this adverse effect is quantified in Table 7. These adverse effects are greatest in Year 5 following construction, with a magnitude of -14,263 ft^2 WRI, and continue for at least 50 years.

Improved growth and survival of fry and juvenile rearing sDPS green sturgeon is expected as the result of construction of a riparian bench and installation of IWM along 997 feet of the left bank of the Feather River. The amount and extent of this beneficial effect is quantified in Table 7. Beneficial effects for the juvenile rearing life stage of sDPS green sturgeon are expected immediately following construction, and would increase to a magnitude of 29,722 ft^2 by Year 50.

At summer water surface elevations:

Reduced growth and survival of fry and juvenile rearing CV spring-run chinook salmon, fall-run chinook salmon, late fall-run chinook salmon, winter-run chinook salmon, and CCV steelhead are expected to last at least 50 years after any construction activities associated with bank repair actions at FHR 1.0L due to reductions in riparian vegetation and placement of rock-revetment along 997 feet of the left bank of the Feather River. The amount and extent of these adverse effects are quantified in Table 6. For all chinook runs, these adverse effects are greatest in Year 7 following construction, with a magnitude of -7,470 ft^2 WRI, and would last for at least 50 years. For CCV steelhead, these adverse effects are greatest in Year 2 following construction, with a magnitude of -12,342 ft^2 WRI, and would last for at least 50 years.

Reduced growth and survival of juvenile migrating (smolts) CV spring-run chinook salmon, is expected for at least 50 years after any construction activities associated with bank repair actions at FHR 1.0L due to reductions in riparian vegetation and placement of rock-revetment along 990 feet of the left bank of the Feather River. The amount and extent of these adverse effects are quantified in Table 7. These adverse effects are greatest in Year 7 following construction, with a magnitude of -48,483 ft^2 WRI for spring-run chinook, and would continue for at least 50 years.

Reduced survival of adult resident CCV steelhead (kelts) is expected for at least 50 years after any construction activities associated with the bank repair actions at FHR 1.0L due to reductions in riparian vegetation along 997 feet of the left bank of the Feather River. The amount and extent of these adverse effects are quantified in Table 7. These adverse effects are greatest in Year 2 following construction, with a magnitude of -34,171 ft^2 WRI, and would continue for at least 50 years.

Short term reductions to the growth and survival of fry and juvenile rearing sDPS green sturgeon are expected from initial construction of the bank repair actions along 997 feet of the left bank of the Feather River. After completion of the construction action, including features that reduce near shore bank slope and increase available IWM, habitat for fry and juvenile rearing sDPS green sturgeon would improve. The amount and extent of construction related effects are quantified in Table 7. Adverse effects for the juvenile rearing life stage of sDPS green sturgeon would occur in Year 1 following construction with a magnitude of -3,127 ft^2 WRI. Beneficial effects for the juvenile rearing life stage of sDPS green sturgeon are expected to begin in Year 2 and would increase to a magnitude of 43,374 ft^2 by Year 50.

2.5.3 Project Effects to sDPS Green Sturgeon Using Habitat Loss as an Analytical Surrogate

The SAM is somewhat limited in its ability to predict a complete range of potential project impacts on all focus fish species and life stages, as it is focused primarily on changes to nearshore/bank habitat. The SAM does not adequately assess potential impacts to deeper benthic habitat where green sturgeon are more likely to be present. Although the SAM model does have a green sturgeon component, NMFS has determined that the model may not have the precision to accurately index green sturgeon responses to changes in modeled habitat attributes and that a more rigorous modeling approach needs development.

Critical habitat for green sturgeon in the action is designated in the Feather River below the OHWM. For this opinion, NMFS has determined the amount of critical habitat covered by rock revetment would serve as the best analytical surrogate for impacts to all life stages of green sturgeon. However, the OHWM could not be collected at the time of this consultation due to the unusually high flows that occurred during the winter of 2017. Therefore, the amount of bare rock revetment will serve as the analytical surrogate for project effects. The amount of bare rock revetment (no vegetation) installed serves as the best analytical surrogate since it represents a direct quantification of the loss of soft benthic substrate where green sturgeon forage, described in greater detail below.

The proposed project will result in a loss of benthic substrate where adult green sturgeon forage for invertebrates to consume, as a total of 15,596 ft^2 will be permanently covered with bare rock revetment. Thus, adult green sturgeon utilizing the Feather RM 1.0L action area are expected to be adversely affected by the proposed project due to the reduction in food availability. Juvenile green sturgeon rearing and migrating in the Feather RM 1.0L action area are expected to be impacted by the permanent reduction in available habitat for the same reasons. However, the increase in IWM resulting from the project is expected benefit to juvenile green sturgeon by providing underwater structure.

The green sturgeon adult spawning and egg incubation life stages are not expected to be impacted by the proposed bank repair at RM 1.0L, as there is no evidence to support the presence of spawning or egg incubation in the Feather River within the action area for RM 1.0L. Spawning and egg incubation have been documented to occur farther upstream. Thus, these life stages are not expected to be impacted by the proposed project.

2.5.4 Project Effects on Critical Habitat

CV spring-run Chinook salmon and CCV steelhead Critical Habitat

The SAM model, which models fish response, serves as a good proxy for measuring impact to CV spring-run Chinook salmon and CCV steelhead, and because the model evaluates changes to important attributes of PBFs and essential features including overhanging shade, substrate size, instream woody material, bank slope, and instream aquatic vegetation. Therefore the SAM can serve to identify appropriate mitigation for short- and longer-term losses and modifications to PBFs of critical habitat.

SAM modeled impacts to PBFs for these species generally will last for 1 to at least 50 years and result from loss or modification of riparian vegetation. These losses and modifications affect juvenile rearing and migration PBFs by reducing in-stream cover, food production, and the quantity of sediment that allow for normal physiological and behavioral responses to the environment. However, impacts to critical habitat and PBFs will be addressed through the purchase of compensatory, off-site mitigation, planting of riparian habitat onsite, and the implementation of conservation measures. The purchase of credits at a mitigation bank would occur concurrently with implementation of the proposed action, which would ensure that no temporal loss to habitat is experienced. For these reasons we do not expect project impacts to the quality and availability of PBFs of critical habitat in this reach of the river to impact the current function of the action area or affect its ability to reestablish essential features that have been impacted by past and current actions. Therefore, we do not expect project-related impacts to reduce the conservation value of designated critical habitat CV spring-run Chinook salmon and CCV steelhead.

Southern DPS of the North American Green Sturgeon Critical Habitat

The bank repair at Feather RM 1.0L is expected to cause a reduction in critical habitat by permanently replacing up to 15,596 ft^2 of the natural river bed with bare rock revetment. The project is expected to adversely impact several of the essential features of critical habitat for sDPS green sturgeon. The PBF of food resources, which refers to the availability of prey items for juvenile, subadult, and adult life stages, is expected be adversely affected by the installation of 15,596 ft^2 bare rock revetment at the toe of the bank repair. The rock revetment will permanently cover green sturgeon foraging habitat, thereby reducing the availability of prey. Similarly the PBF of substrate type and size will also be adversely affected, as part of the natural river bed will be permanently covered with large rocks and will no longer be available as foraging habitat.

The SRBPP Feather RM 1.0L Erosion Repair Project is not expected to impact the PBFs of water flow or water quality, migration corridors (*i.e.*, migratory pathways necessary for the safe and timely passage of all life stages), or depth (*i.e.*, availability of deep pools for use as holding habitat).

2.5.5 Mitigation/Conservation Bank Credit Purchases

To address permanent impacts to riparian and aquatic habitats, the proposed action includes purchase of mitigation bank credits at a 3:1 ratio for long-term SAM modeled deficits (*i.e.*, largest modeled negative WRI value for all species, life stages, and seasons) and a 3:1 ratio for permanent loss of benthic habitat. Both the SAM modeled deficits and benthic habitat impacts are on designated critical habitat. The purchase of mitigation credits will address the loss of ecosystem functions due to the modification of the riverbank. These credit purchases are ecologically relevant to the impacts and the species affected because both banks include shaded riparian aquatic, riparian forest, and floodplain credits with habitat values that are already established and meeting performance standards. Also, the banks are located in areas that will provide benefit the ESUs/DPSs affected.

The purchase of credits provides a high level of certainty that these benefits will be realized because each of the NMFS-approved banks considered in this opinion have mechanisms in place to ensure credit values are met over time. Such mechanisms include legally binding conservation easements, long-term management plans, detailed performance standards, credit release schedules that are based on meeting performance standards, monitoring plans and annual monitoring reporting to NMFS, non-wasting endowment funds that are used to manage and maintain the bank and habitat values in perpetuity, performance security requirements, a remedial action plan, and site inspections by NMFS. In addition, each bank has a detailed credit schedule and credit transactions and credit availability are tracked on the Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS). RIBITS was developed by the USACE with support from the Environmental Protection Agency, the U.S. Fish and Wildlife Service, the Federal Highway Administration, and NMFS to provide better information on mitigation and conservation banking and in-lieu fee programs across the country. RIBITS allows users to access information on the types and numbers of mitigation and conservation bank and in-lieu fee program sites, associated documents, mitigation credit availability, service areas, as well information on national and local policies and procedures that affect mitigation and conservation bank and in-lieu fee program development and operation.

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 climate change section (Section 2.2.4).

Non-Federal actions that may affect the action area include aquaculture and fish hatcheries, recreational fishing, habitat restoration activities, agricultural practices (*i.e.*, water withdrawals and diversions), adjacent mining activities, and increased population growth resulting in urbanization and development of floodplain habitats. These actions will occur without respect to whether the Restoration project is implemented, and there are statutes in place to control all these activities to minimize their detrimental impacts. No reasonably foreseeable future projects within the current project action area are known at this time. Implementation of the proposed action is not expected to result in significant cumulative effects, in combination with other projects, within or outside of the Action Area.

2.6.1 Aquaculture and Fish Hatcheries

More than 32-million fall-run Chinook salmon, 2-million spring-run Chinook salmon, 1-million late fall-run Chinook salmon, 0.25-million winter-run Chinook salmon, and 2-million steelhead are released annually from six hatcheries producing anadromous salmonids in the CV. All of these facilities are currently operated to mitigate for natural habitats that have already been permanently lost as a result of dam construction. The loss of historical habitat and spawning grounds upstream of dams results in dramatic reductions in natural population abundance, which is mitigated for through the operation of hatcheries. Salmonid hatcheries can, however, have additional negative effects on ESA-listed salmonid populations.

The high level of hatchery production in the CV can result in high harvest-to-escapements ratios for natural stocks. California salmon fishing regulations are set according to the combined abundance of hatchery and natural stocks, which can lead to over-exploitation and reduction in the abundance of wild populations that are indistinguishable and exist in the same system as hatchery populations. Releasing large numbers of hatchery fish can also pose a threat to wild Chinook salmon and steelhead stocks through the spread of disease, genetic impacts, competition for food and other resources, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production.

Impacts of hatchery fish can occur in both freshwater and the marine ecosystems. Limited marine carrying capacity has implications for naturally produced fish experiencing competition with hatchery production. Increased salmonid abundance in the marine environment may also decrease growth and size at maturity, and reduce fecundity, egg size, age at maturity, and survival (Bigler *et al.* 1996). Ocean events cannot be predicted with a high degree of certainty at this time. Until good predictive models are developed, there will be years when hatchery production may be in excess of the marine carrying capacity, placing depressed natural fish stocks at a disadvantage by directly inhibiting their opportunity to recover.

2.6.2 Recreational Fishing

While hatchery Chinook salmon and steelhead are targeted, incidental catch of protected species such as naturally produced CV spring-run Chinook salmon and CCV steelhead does occur. Since 1998, all hatchery CCV steelhead have been marked with an adipose fin clip, allowing anglers to tell the difference between hatchery and wild CCV steelhead. Current regulations restrict anglers from keeping unmarked CCV steelhead in CV streams, except in the upper Sacramento River.

Current sport fishing regulations do not prevent wild CCV steelhead from being caught and released many times over while on the spawning grounds, where they are more vulnerable to fishing pressure. Recent studies on hooking mortality based on spring-run Chinook salmon have found a 12 percent mortality rate for the Oregon in-river sport fishery (Lindsay *et al.* 2004). Applying a 30 percent contact rate for CV rivers (*i.e.*, the average of estimated CV harvest rates), approximately 3.6 percent of adult steelhead die before spawning from being caught and released in the recreational fishery. Studies have consistently demonstrated that hooking mortality increases with water temperatures. Mortality rates for steelhead may be lower than those for Chinook, due to lower water temperatures.

In addition, survival of steelhead eggs is reduced by anglers walking on redds in spawning areas while targeting hatchery steelhead or salmon. Roberts and White (1992) identified up to 43 percent mortality from a single wading over developing trout eggs, and up to 96 percent mortality from twice daily wading over developing trout eggs. Salmon and trout eggs are sensitive to mechanical shock at all times during development (Leitritz & Lewis 1980). Typically, Chinook salmon and steelhead eggs are larger than trout eggs, and are likely more sensitive to disturbance than trout eggs. While state angling regulations have moved towards restrictions on selected sport fishing to protect listed fish species, hook and release mortality of steelhead and trampling of redds by wading anglers may continue to cause a threat.

2.6.3 Agricultural Practices

Non-Federal actions that may affect the action area include water diversions for irrigated agriculture, ongoing agricultural activities in the Lower Clear Creek action area. Farming and ranching activities within or adjacent to the action area may have negative effects on water quality due to runoff laden with agricultural chemicals. Stormwater and irrigation discharges related to agricultural activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, Daughton 2003). 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 then flow into the receiving waters of the associated watersheds.

Water withdrawals and diversions may result in entrainment of individuals into unscreened or improperly screened diversions, and may result in depleted river flows that are necessary for migration, spawning, rearing, flushing of sediment from spawning gravels, gravel recruitment, and transport of LWM. Agricultural practices in and upstream of Clear Creek may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow. Water withdrawals and diversions may result in entrainment of fishes into unscreened or improperly screened diversions, and may result in depleted river flows that are necessary for migration, spawning, rearing, sediment flushing from spawning gravels, gravel recruitment, and transport of large woody debris. Depending on the size, location, and season of operation, these unscreened agricultural diversions entrain and kill many life stages of aquatic species, including juvenile salmonids and green sturgeon. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a CV database were either unscreened or screened insufficiently to prevent fish entrainment (Herren & Kawasaki 2001).

2.6.4 Urban Development

Future urban and/or rural residential development may adversely affect water quality, riparian function, and aquatic productivity. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will 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 that are situated away from waterbodies, will not require Federal permits, and thus will 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. Recreational activities can potentially disturb the current riparian vegetation and/or listed fishes in the active channel. 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 will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially re-suspension of contaminated sediments and degrading areas of submerged vegetation. This in turn will 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.

2.7 Integration and Synthesis

The *Integration and Synthesis* section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of the proposed action. In this section, NMFS performs two evaluations: whether, given the environmental baseline and status of the species and critical habitat, as well as future cumulative effects, it is reasonable to expect the proposed action is not likely to: (1) reduce the likelihood of both survival and recovery of the species in the wild; and (2) result in the destruction or adverse modification of designated critical habitat (as determined by whether the critical habitat will remain functional to serve the intended conservation role for the listed anadromous species or retain its current ability to establish those features and functions essential to the conservation of the species).

The *Analytical Approach* described the analyses and tools we have used to complete this analysis. This section is based on analyses provided in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Action*.

In our *Status of the Species* section, NMFS summarized the current likelihood of extinction of each of the listed species. We described the factors that have led to the current listing of each species under the ESA across their ranges. These factors include past and present human activities and climatological trends and ocean conditions that have been identified as influential to the survival and recovery of the listed species. Beyond the continuation of the human activities affecting the species, we also expect that ocean condition cycles and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover. The *Environmental Baseline* reviewed the status of the species and the factors that are affecting their survival and recovery in the action area. The *Effects of the Action* reviewed the exposure of the species and critical habitat to the proposed action and interrelated and interdependent actions, cumulative effects. NMFS then evaluated the likely responses of individuals, populations, and critical habitat. The *Integration and Synthesis* will consider all of these factors to determine the proposed action's influence on the likelihood of both the survival and recovery of the species, and on the conservation value of designated critical habitat.

The criteria recommended for low risk of extinction for Pacific salmonids are intended to represent a species and populations that are able to respond to environmental changes and withstand adverse environmental conditions. Thus, when our assessments indicate that a species or population has a moderate or high likelihood of extinction, we also understand that future adverse environmental changes could have significant consequences on the ability of the species to survive and recover. Also, it is important to note that an assessment of a species having a moderate or high likelihood of extinction does not mean that the species has little or no chance to survive and recover, but that the species faces moderate to high risks from various processes that can drive a species to extinction. With this understanding of both the current likelihood of extinction of the species and the potential future consequences for species survival and recovery, NMFS will analyze whether the effects of the proposed action are likely to in some way increase the extinction risk each of the species faces.

In order to estimate the risk to CV spring-run Chinook salmon, CCV steelhead, and green sturgeon as a result of the proposed action, NMFS uses a hierarchical approach. The condition of the ESU or DPS is reiterated from the *Status of the Species* section of this opinion. We then consider how the status of populations in the action area, as described in the *Environmental Baseline*, is affected by the proposed action. Effects on individuals are summarized, and the consequence of those effects is applied to establish risk to the diversity group, ESU, or DPS.

In designating critical habitat, NMFS considers the PBFs within the designated areas that are essential to the conservation of the species and that may require special management considerations or protection. Such requirements of the species include, but are not limited to: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring, and generally; and (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species [see 50 CFR § 424.12(b)]. In addition to these factors, NMFS also focuses on the PBFs within the defined area that are essential to the conservation of the species. PBFs may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

The basis of the “destruction or adverse modification” analysis is to evaluate whether the proposed action results in negative changes in the function and role of the critical habitat in the conservation of the species. As a result, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential to the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality.

2.7.1 Status of the CV Spring-Run Chinook Salmon ESU

In the 2016 status review, NMFS found, with a few exceptions, CV spring-run Chinook salmon populations have increased through 2014 returns since the last status review (2010/2011), which has moved the Mill and Deer creek populations from the high extinction risk category, to moderate, and Butte Creek has remained in the low risk of extinction category. Additionally, the Battle Creek and Clear Creek populations have continued to show stable or increasing numbers the last five years, putting them at moderate risk of extinction based on abundance. Overall, the Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run Chinook salmon (through 2014) has probably improved since the 2010/2011 status review and that the ESU’s extinction risk may have decreased, however the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized (NMFS 2016b).

2.7.2 Status of the CCV Steelhead DPS

The 2016 status review (NMFS 2016a) 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 populations. There are some encouraging signs, as several hatcheries in the Central Valley 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 percentage of wild fish in those data remains much higher than at Chipps Island. The new video counts at Ward Dam show that Mill Creek likely supports one of the best wild steelhead populations in the Central Valley, though at much reduced levels from the 1950's and 60's. Restoration and dam removal efforts in Clear Creek continue to benefit CCV steelhead. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.

2.7.3 Status of the North American Green Sturgeon southern DPS

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2015).

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (NMFS 2015).

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their micro- and macro-habitat ecology.

2.7.4 Status of the Environmental Baseline and Cumulative Effects in the Action Area

The action area is used by most diversity groups and populations of the salmon, steelhead and green sturgeon ESUs and DPSs that are the subject of this opinion. Salmon, steelhead and green sturgeon use the action area as an upstream and downstream migration corridor and for rearing.

Within the action area, the essential features of freshwater rearing and migration habitats for salmon, steelhead and green sturgeon have been transformed from a meandering waterway lined with a dense riparian vegetation, to a highly leveed system under varying degrees of constraint of riverine erosional processes and flooding. Levees have been constructed near the edge of the river and most floodplains have been completely separated and isolated from the Feather River. Severe long-term riparian vegetation losses have occurred in this part of the Feather River, and there are large open gaps without the presence of these essential features due to the high amount of riprap. The change in the ecosystem as a result of halting the lateral migration of the river channel, the loss of floodplains, the removal of riparian vegetation and IWM have likely affected the functional ecological processes that are essential for growth and survival of salmon, steelhead, and green sturgeon in the action area.

The *Cumulative Effects* section of this opinion describe how continuing or future effects such as the discharge of point and non-point source chemical contaminant discharges, aquaculture and hatcheries 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 rearing and migratory corridors.

2.7.5 Summary of Project Effects on Listed Species - Individuals

1) Construction and O&M-related Effects

During construction and O&M, direct injury or death to individual fishes could result from rock placement (crushing), or predation related to displacement of individuals away from the shoreline or at the margins or turbidity plumes. Construction-related turbidity may extend up to 100 feet from the shoreline, and 300 feet downstream, along the project reach for levee construction activities. These construction type actions will occur during summer and early fall months, when the abundance of individual salmon, steelhead, and sturgeon is low and should result in correspondingly low levels of injury or death.

2) Long-term Effects Related to the Presence of Project Features

For juvenile and outmigrating salmon and steelhead, the proposed action will result in some short term and long-term adverse effects to individual salmon and steelhead that are exposed to the project features along the Feather River. These project features include the placement of up to 4,674 yd^3 of quarry stone and 12,712 yd^3 of soil filled quarry stone along 997 linear feet of the left bank of the Feather River as well as temporal loss of riparian vegetation.

These adverse effects are indexed by SAM model results and expressed as WRI deficits. The project results in long-term WRI deficits for rearing and migrating juvenile salmon and steelhead at summer and fall water surface elevations, and do not recover over the 50 years modeled by the SAM analysis. In winter and spring, outmigrating salmon and steelhead will generally experience initial adverse effects in the years following the levee repair, but long-term WRI values are positive. For juvenile and fry salmon and steelhead, both short term and long-term WRI values in spring and winter are positive.

Migrating Chinook and steelhead residents (outmigrating post-spawning adults) will likely not be impacted because adult salmonids are unlikely to use the nearshore habitat that will be affected by this project, as they prefer deeper water instead. Furthermore, the project is not anticipated to cause an increase in predation or install any structural features that might impede adult migration.

Although the project will result in a loss of benthic substrate where juvenile green sturgeon forage for food (15,596 ft^2), the project will result in an increase in IWM, which is expected benefit to juvenile green sturgeon by providing underwater structure. Similarly, adult green sturgeon will also be adversely affected by the loss of benthic habitat due to the reduction in food availability. However, the amount of benthic substrate lost is small compared to the amount of available habitat in the Feather River.

Because of the relatively small size of the project, the favorable response of many life stages to integrated conservation measures, the installation of riparian habitat onsite, and the Corps' proposal to purchase compensatory mitigation credits, the action is not likely to appreciably reduce the survival or recovery of anadromous salmonids or green sturgeon.

2.7.6 Summary of Project Effects on Listed Species Critical Habitat

Within the action area, the relevant PBFs of the designated critical habitat for listed salmonids are migratory corridors and rearing habitat, and for green sturgeon the six PBFs include food resources, substrate type/size, flow, water quality, migration corridor free of passage impediments, depth (holding pools), and sediment quality.

Based on SAM modeled WRIs, we expect reductions in the value of PBFs for salmon and steelhead freshwater rearing, but these reductions are at fall and summer water surface elevations and not at water surface elevations when the habitat use is the highest and most significant. Green sturgeon PBFs of substrate type/size and food resources are expected to both be impacted by the proposed project, as project features will cover the soft benthic substrate where green sturgeon forage for food with riprap. Because of the relatively small size of the project, the favorable response of many life stages to integrated conservation measures, the installation of riparian habitat onsite, and the Corps' proposal to purchase compensatory mitigation credits, the action is not likely to appreciably reduce the conservation value of designated critical habitat.

As compensatory mitigation for these impacts, the Corps plans to purchase credits from a NMFS-approved conservation bank at a 1:1 ratio equal to the largest WRI deficit for all life stages and seasons for salmonids and green sturgeon (1.1 acres) and at a 3:1 ratio for permanent impacts to benthic habitat. Although the conservation banks within the service area are located on the Sacramento River, they benefit the same juvenile CV spring-run and CCV steelhead that use the project footprint of the action area by providing suitable rearing habitat. Bullock Bend Mitigation Bank and Fremont Landing Conservation Bank have adequate mechanisms in place to track credits and debits and ensure that more debits are not sold then credits that are available, and overall habitat improvement for CV spring-run Chinook salmon and CCV steelhead is expected. Although the banks technically do not include green sturgeon credits (only salmonid credits), we expect that individual green sturgeon critical habitat will benefit from the purchase of these credits, as the banks provide areas with soft benthic substrate where juvenile and adult green sturgeon can forage. The purchase of credits at these banks benefit green sturgeon in the same DPS. A description of these tracking mechanisms can be found in the respective banking instruments for Bullock Bend (Westervelt Ecological Services 2016) and Fremont Landing (Wildlands Inc. 2006).

2.7.7 Summary

Although there are some short-term and SAM modeled WRI deficits, the effects of these deficits, when added to the environmental baseline and cumulative effects in the action area are small, and in some cases occur during seasons when fish abundance is low. To mitigate for some of the impacts of the RM 1.0L levee repair, the Corps plans install a riparian bench on the waterside levee slope and purchase 2.2 acres of mitigation credits off-site at a NMFS-approved mitigation bank with an applicable service area for the project site. The project is not expected to increase the extinction risk of CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon or reduce the conservation value of their designated critical habitat.

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, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CV spring-run Chinook salmon, CCV steelhead, or the sDPS of North American green sturgeon 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.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any licenses issued, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activities covered by this Incidental Take Statement. If the Corps: (1) fails to assume and implement the terms and conditions; or (2) fails to require the contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the license, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the

Corps must report the progress of the action and its impact on the species to NMFS as specified in this Incidental Take Statement (50 CFR §402.14(I)(3)).

2.9.1 Amount or Extent of Take

NMFS anticipates incidental take of CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon in the action area through the implementation of the proposed action. NMFS cannot, using the best available information, quantify the anticipated incidental take of these species because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the general programmatic conditions and ecological surrogates using negative SAM WRI values. Accordingly, NMFS is quantifying take of CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon incidental to the action resulting from short-term construction impacts, as well as long-term impacts as indexed by the SAM model.

The amount and extent of take described below is in the form of harm due to habitat impacts that will reduce the growth and survival of individuals from predation, or by causing fish to relocate and rear in other locations and reduce the carrying capacity of the existing habitat. This SAM values represent the extent of habitat impacts that will harm fish. As described in the *Analytical Approach* and the *Effects of the Action* sections of this opinion, the SAM values represent an index of fish response to habitat variables to which fish respond including bank slope, bank substrate size, instream structure, overhanging shade, aquatic vegetation and floodplain availability. Positive SAM values represent a positive growth and survival response and negative values index negative growth and survival. There is not a stronger ecological surrogate based on the information available. Due to a lack of site-specific fish data, the exact number of fish that will be affected is not known. The take related to project monitoring is not included below, because it was already described and exempted in the programmatic BO for Phase II of the SRBPP. The following level of incidental take from program activities is anticipated:

Incidental Take Associated with Construction:

1) Take of CV spring-run Chinook salmon, CCV steelhead, and sDPS of North American green sturgeon in the form of injury and death from predation caused by construction-related turbidity that extends up to 100 feet from the shoreline, and 300 feet downstream, along the project reach for levee construction activities.

2) Take of CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon, in the form of harm or injury of fish is expected from habitat-related disturbances from the placement of up to 4,674 yd^3 of quarry stone and 12,712 yd^3 of soil filled quarry stone along 997 linear feet of the left bank of the Feather River. Take will be in the form of harm to the species through modification or degradation of the PBFs for rearing and migration that reduces the carrying capacity of habitat.

Incidental Take Associated with Operations and Maintenance

1) Take of CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon, in the form of harm from O&M actions is expected from habitat-related disturbances from the placement of up to 600 yd^3 of material per year under the programmatic BO for the extent of the project life (*i.e.*, 50 years). Take will be in the form of harm to the species through modification or degradation of the PBFs for rearing and migration that reduces the carrying capacity of habitat.

Incidental Take Associated with Exposure to Project Facilities:

CV spring-run Chinook salmon and CCV steelhead

At fall water surface elevations:

1) Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon and CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 6 for each species at -6,175 ft^2 and -9,958 ft^2 WRI respectively, and continue for at least 50 years.

2) Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon and CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 12 for each species at -41,374 ft^2 and -40,376 ft^2 WRI, respectively, and continue for at least 50 years.

3) Take in the form of harm to resident adult CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year following construction, with a magnitude of -16,784 ft^2 WRI, and continue for at least 50 years.

At winter water surface elevations:

1) Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon and CCV steelhead is expected for at least 3 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 1 for each species at -554 ft^2 and -953 ft^2 WRI respectively, and continue for at least 3 years.

2) Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon is expected for at least 13 years after any construction due to reductions in riparian vegetation. Take in the form of harm to juvenile migrating (smolts) CCV steelhead is expected for at least 15 years post-construction. The amount and extent of this adverse effect is quantified in Table 7. These adverse effects are greatest in Year 4 following construction, with a magnitude of -18,033 ft^2 WRI for CV spring-run Chinook salmon and -16,740 ft^2 WRI for CCV steelhead. Following Year 13 for spring-run and Year 15 steelhead, the SAM modelled habitat conditions exceed baseline conditions and harm from habitat modification is not expected.

3) Take in the form of harm to resident adult CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 6 following construction, with a magnitude of -8,703 ft^2 WRI, and continue for at least 50 years.

At spring water surface elevations:

1) Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon and CCV steelhead is expected for at least 4 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 3 for each species at -2,127 ft^2 and -3,645ft^2 WRI respectively, and continue for at least 4 years post-construction.

2) Take in the form of harm to juvenile migrating (smolts) CV spring-run Chinook salmon, and winter-run Chinook salmon is expected for at least 3 years after construction and take of juvenile migrating (smolts) CCV steelhead is expected for at least 5 years after any construction due to reductions in riparian vegetation. The amount and extent of harm is quantified in Table 3 of this opinion. These adverse effects are greatest in Year 1 following construction, with a magnitude of –3,598 ft^2 WRI for all Chinook runs and -4,732 ft^2 WRI for CCV steelhead. Following Year 4 for all Chinook runs and Year 6 for CCV steelhead, the SAM modelled habitat conditions exceed baseline conditions and harm from habitat modification is not expected.

3) Take in the form of harm to resident adult CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 5 following construction, with a magnitude of -14,263 ft^2 WRI, and continue for at least 50 years.

At summer water surface elevations:

1) Take in the form of harm to fry and juvenile rearing CV spring-run Chinook salmon is expected for at least 12 years after project construction due to reductions in riparian habitat. Take in the form of harm to juvenile migrating (smolts) CCV steelhead is expected for at least 15 years post-construction. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 4 for both species with a magnitude of -20,693 ft^2 and -20,239 ft^2 respectively.

2) Take in the form of harm to juvenile migrating (smolt) CV spring-run Chinook salmon, for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 7 following construction, with a magnitude of -48,483 ft^2 WRI, and continue for at least 50 years.

3) Take in the form of harm to resident adult CCV steelhead is expected for at least 50 years after project construction due to reductions in riparian habitat. The amount and extent of harm is quantified in Table 7 of this opinion. These adverse effects are greatest in Year 2 following construction, with a magnitude of -37,171 ft^2 WRI, and continue for at least 50 years.

<u>Southern DPS of North American Green Sturgeon</u>

1) Take in the form of harm to juvenile rearing, juvenile migrating, and adult sDPS green sturgeon due to permanent replacement of 15,596 ft^2 of benthic habitat with bare quarry stone.

2.9.2 Effect of the Take

In this 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 the CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon or destruction or adverse modification of their 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 maintain, monitor, and adaptively manage all conservation measures throughout the life of the proposed project to ensure their effectiveness.

2) Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and off-site conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the sDPS of North American green sturgeon.

3) Measures shall be taken to ensure that contractors, construction workers, and all other parties involved with these projects implement the projects as proposed in the BA and this opinion.

4) Measures shall be taken to ensure that the Corps levee vegetation management policies that influence SRBPP repair design are based on best available science and consider the potential benefits of levee vegetation to levee integrity, public safety, and ESA-listed fish species.

5) Measures shall be taken to minimize the amount and duration of placement of rock revetment below the OHWM of the Feather River.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps 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 incidental take statement (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) Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the proposed project to ensure their effectiveness.

   a. The Corps shall continue to coordinate with the IWG agencies and the Technical Team of the Interagency Collaborative Flood Management Program during the implementation and monitoring of this repair.

   b. The Corps shall update their O&M Manual to ensure that the self-mitigating efforts and repair designs meet the expectation of the SAM values.

   c. The Corps shall provide additional annual reports, as necessary, to describe the implementation of O&M actions, and summarize monitoring results.

   d. The Corps shall increase the duration of project-specific monitoring from 5 to 10 years for all SAM-modeled measures. This requirement is based on the need to help validate that projects with SAM-modeled results are on a positive trajectory and successfully reaching or exceeding baseline values. Monitoring the effectiveness of the measures installed to meet SAM values may require scientific inquiry that extends beyond in-stream data collection. Tools such as computer modeling and hydraulic models, as well as tagging studies should be used as necessary to assess the relative value of each element of the SAM model. Instream studies must include sampling procedures to determine species composition and abundance together with physical observations and measurements at selected construction and control sites.

   e. The Corps shall ensure that, for the life of the project, future maintenance actions ensure performance of the site to a level necessary to retain the SAM-modeled habitat values.

   f. The Corps shall begin implementation of a Green Sturgeon Habitat Mitigation and Monitoring Program (HMMP). At a minimum, this shall include developing a work plan for implementation of the HMMP elements that have been described in the NMFS 2015 biological opinions for the West Sacramento and American River GRRs. This work plan should a plan for conducting pre- and post-project hydraulic monitoring of the action area, conducting benthic sampling in order to evaluate green sturgeon food availability, and developing a compensatory mitigation strategy for offsetting the spatial footprint of permanently lost benthic habitat that will occur as a result of project construction. The compensatory mitigation strategy shall account for temporal effects between project implementation and implementation of the mitigation measures. If the mitigation occurs offsite, the initial compensatory mitigation rate shall be at a 3:1 ratio to the project footprint. The Corps shall send this work plan to NMFS within 60 days of receiving this opinion. Benthic sampling and green sturgeon diet studies shall be conducted in collaboration with the Interagency Ecological Program (IEP).

2) Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and off-site conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the sDPS of North American green sturgeon.

a. The Corps shall minimize the removal of existing riparian vegetation and IWM to the maximum extent practicable, and where appropriate, removed IWM will be anchored back into place. The trunks of trees left in place shall be protected from construction damage by wrapping them with coir fiber, jute fabric, 2X4s or other mechanisms that prevent trunk damage while minimizing the risk or levee scour.

b. In addition to the mitigation credits proposed by the Corps as compensatory mitigation for SAM modeled deficits, (*i.e.*, the largest modeled negative WRI value for all species, life stages, and seasons of -48,483 ft^2 or 1.1 acres), the Corps shall purchase additional credits at a NMFS-approved mitigation bank with an applicable service area for the project site, at a 3:1 ratio for the spatial extent of 15,596 ft^2 of bare rock that will cover benthic habitat below the OHWM. Adjusting 15,596 ft^2 to a 3:1 mitigation ratio yields 46788 ft^2 or an additional 1.1 acre, therefore, the Corps shall purchase a total of 2.2 acres of compensatory mitigation credits for the impacts of this project.

3) Measures shall be taken to ensure that contractors, construction workers, and all other parties involved with this project implement the project as proposed.

a. The Corps shall provide a copy of the programmatic BO and this opinion to the prime contractor, making the prime contractor responsible for implementing all requirements and obligations included in these documents and to educate and inform all other contractors involved in the project as to the requirements of the programmatic BO and this opinion. A notification that contractors have been supplied with this information will be provided to the reporting address below.

b. A NMFS-approved Worker Environmental Awareness Training Program for construction personnel shall be conducted by the NMFS-approved biologist for all construction workers prior to the commencement of construction activities. The program shall provide workers with information on their responsibilities with regard to Federally-listed fish, their critical habitat, an overview of the life-history of all the species, information on take prohibitions, protections afforded these animals under the ESA, and an explanation of the relevant terms and conditions of this opinion and the programmatic BO. Written documentation of the training must be submitted to NMFS within 30 days of the completion of training.

4) Measures shall be taken to ensure that the Corps levee vegetation management policies that influence the SRBPP are based on best available science and consider the potential benefits of levee vegetation to levee integrity, public safety, and ESA-listed fish species.

a. The Corps shall sponsor an independently facilitated workshop, inviting NMFS, USFWS, CDFW, DWR, local maintainers such as Sacramento Area Flood

Control Agency, and the authors of the Synthesis of Levee Vegetation Research Results (2007-2014) to discuss the conclusions of this report and how local tree risk models that incorporate the best available science can be used in future risk assessments for levee repair programs.

   b. The Corps tree risk assessments for SRBPP shall consider the benefits of levee vegetation to levee integrity, public safety, and ESA-listed fish species.

5) Measures shall be taken to minimize the amount and duration of placement of rock revetment below the OHWM the Feather River.

   a. Construction involving the placement of rock revetment below the OHWM will occur in accordance with BMPs and conservation measures described in the programmatic BO.

   b. Updates and reports required by these terms and conditions shall be submitted to:

Maria Rea
Central Valley Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento CA 95814
FAX: (916) 930-3629
Phone: (916) 930-3600

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 Corps should complete a study of potential rock revetment removal sites on the Feather River where rock revetment does not serve a flood risk reduction benefit and can be removed for the purpose of enhancing green sturgeon and salmonid habitat. The Corps should consider remediating one of these sites as mitigation for the next consultation to be completed under the SRBPP programmatic if there are impacts to green sturgeon habitat.

2) The Corps should make set-back levees integral components of their authorized bank protection or ecosystem restoration efforts.

3) The Corps should engage with NMFS on opportunities for implementing actions under the Sacramento River Bank Protection Program - 80,000 linear feet (SRBPP 80,000 lf) that avoid, minimize and effectively offset impacts to fish species and critical habitat. The Corps should collaborate with NMFS to develop a prioritization framework that identifies and implements site-level and system improvements that avoid in-water work to the maximum extent practicable. This should include the following, but not necessarily limited to:

a. Developing a prioritization framework for SRBPP 80,000 lf with a project design hierarchy the starts with set-back levees and landside levee repairs.

b. Proactively seeking variance solutions ahead of consultation requests and/or project planning and implementation.

c. Proactively conducting real-estate investigations for landside work before consultation requests and/or project planning and implementation.

d. Proactively investigating and identifying riparian corridor enhancement opportunities that could be implemented in the vicinity of future projects that impact fish species and critical habitat.

e. Proactively investigating and planning rock removal projects to mitigate future placement of revetment in critical habitat. For example, the Corps' Chico Landing to Red Bluff project has legacy rock placement areas that are not serving any purpose toward protecting human safety and could be removed to facilitate riverine function such as side channel and floodplain inundation.

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

2.11 Reinitiation of Consultation

This concludes formal consultation for the Sacramento River Bank Protection Project (SRBPP) Feather River Mile 1.0L.

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 CONSULTATION

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 Corps and descriptions of EFH for Pacific Coast Salmon (PFMC 2014) contained in the Fishery Management Plans (FMP) developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

EFH designated under the Pacific Coast Salmon Fisheries Management Plan (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 channels and floodplain habitats, **(2)** thermal refugia.

3.2 Adverse Effects on Essential Fish Habitat

Construction activities would result in increased sedimentation, turbidity, and the potential for contaminants to enter the waterway. Installation of revetment would result in adverse effects to Pacific coast salmon EFH due to losses of riparian habitat and natural substrate. 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 2.5 and subsections. Effects to ESA-listed critical habitat and EFH HAPCs are appreciably similar, therefore no additional discussion is included. A list of temporary and permanent adverse effects to EFH HAPCs is included in this EFH consultation. Affected HAPCs are indicated by number, corresponding to the list in Section 3.1:

<u>Sedimentation and Turbidity</u>

- Reduced habitat complexity (1)
- Degraded water quality (1, 2)
- Reduction in aquatic macroinvertebrate production (1)

Contaminants and Pollution-related Effects

- Degraded water quality (1, 2)
- Reduction in aquatic macroinvertebrate production (1)

Installation of Revetment

- Permanent loss of natural substrate at levee toe (1)
- Reduced habitat complexity (1)
- Increased bank substrate size (1)
- Increased predator habitat (1)

Removal of Riparian Vegetation

- Reduced shade (2)
- Reduced supply of terrestrial food resources (1)
- Reduced supply of IWM (1)

The terms and conditions and conservation recommendations in the preceding opinion contain adequate measures to avoid, minimize, or otherwise offset the adverse effects to EFH. Therefore, NMFS has no additional EFH conservation recommendations to provide.

3.3 Supplemental Consultation

The Corps 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 Corps is the intended user of this opinion. Other interested users could include DWR, USFWS, or CDFW. Individual copies of this opinion were provided to the Corps. This opinion will be posted on the Public Consultation Tracking System web site (Go to 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 3 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*.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion 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

Allendorf, F. W., D. Bayles, D. L. Bottom, K. P. Currens, C. A. Frissell, D. Hankin, J. A. Lichatowich, W. Nehlsen, P. C. Trotter, and T. H. Williams. 1997. Prioritizing Pacific salmon stocks for conservation. Conservation Biology 11(1):140-152.

Anderson, J. T., C. B. Watry, and A. Gray. 2007. Upstream fish passage at a resistance board weir using infrared and digital technology in the Lower Stanislaus River, California: 2006-2007 Annual Data Report.

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

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

Berntssen, M. H., Aatland, A., and Handy, R. D. 2003. Chronic dietary mercury exposure causes oxidative stress, brain lesions, and altered behaviour in Atlantic salmon (*Salmo salar*) parr. Aquatic Toxicology 65(1): 55-72.

Bigler, B. S., D. W. Wilch, and J. H. Helle. 1996. A review of size trends among North Pacific salmon (*Oncorynchus spp.*). Canadian Journal of Fisheries and Aquatic Sciences 53:455-465.

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

Brown, M. R. 1996. Benefits of increased minimum instream flows on Chinook salmon and steelhead in Clear Creek, Shasta County, California 1995-6. U.S. Fish and Wildlife Service. Red Bluff Fish and Wildlife Office, Red Bluff, California.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, W. Waknitz, and I. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon and California.

California Department of Fish and Game. 1990. Status and management of spring-run Chinook salmon. Inland Fisheries Division, 33 pp.

California Department of Fish and Game. 1998. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. Candidate Species Status Report 98-01. California Department of Fish and Game.

California Department of Fish and Wildlife. 2015. GrandTab Spreadsheet of Adult Chinook Escapement in the Central Valley.

California Department of Fish and Wildlife. 2016. Appendix 2-A: Invasive Species Management Plan, Oroville Wildlife Area D Unit. Available: http://sutterbutteflood.org/wp-content/uploads/2016/05/app_2a_invasive_species_plan.pdf. Accessed on 19 September 2017.

Chase, R. 2010. Lower American River steelhead (*Oncorhynchus mykiss*) spawning surveys - 2010. Shasta Lake, CA.

Clark, G. H. 1929. Sacramento-San Joaquin salmon (*Oncorhynchus tschawytscha*) fishery of California. Fish Bulletin 17.

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.

Cummins, K., Furey, C., Giorgi, A., Lindley, S., Nestler, J. and Shurts, J. 2008. Listen to the river: an independent review of the CVPIA Fisheries Program. Prepared under contract with Circlepoint for the US Bureau of Reclamation and the US Fish and Wildlife Service.

Daughton, C. G. 2003. Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health. I. Rationale for and avenue toward a green pharmacy. Environmental Health Perspectives 111:757-774.

Dettinger, M. D. 2005. From Climate-Change Spaghetti to Climate-Change Distributions for 21st Century California. San Francisco Estuary and Watershed Science 3(1):14.

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., D. R. Cayan, M. K. Meyer, and A. E. Jeton. 2004. Simulated Hydrologic responses to climate variations and changes in the Merced, Carson and American River basins, Sierra Nevada, California, 1900-2099. Climatic Change 62(62):283-317.

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

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.

Feyrer, F., M. L. Nobriga, and T. R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64(4):723-734.

FishBio, L.L.C. 2015. Adult Chinook salmon adults observed in the video weir and provided in Excel tables during the spring on the Stanislaus River, unpublished data.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8(3):870-873.

Franks, S. E. 2014. Possibility of natural producing spring-run Chinook salmon in the Stanislaus and Tuolumne rivers. Unpublished Work. National Oceanic Atmospheric Administration.

Franks, S. E. 2015. Spring-running salmon in the Stanislaus and Tuolumne Rivers and an overview of spring-run Recovery. National Marine Fisheries Service, Sacramento, California.

Fry, D. H., Jr. 1961. King salmon spawning stocks of the California Central Valley, 1940–1959 California Fish and Game 47(1):55-71.

Fukushima, M., T. J. Quinn, and W. W. Smoker. 1998. Estimation of eggs lost from superimposed pink salmon (*Oncorhynchus gorbuscha*) redds. Canadian Journal of Fisheries and Aquatic Sciences 55(3):618-625.

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. Santa Cruz, California.

Giovannetti, S. L., R.J. Bottaro, and M. R. Brown. 2013. Adult steelhead and late-fall Chinook salmon monitoring on Clear Creek, California: 2011 Annual report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

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.

Graham Mathews and Associates. 2006. Clear Creek Gravel Management Plan, 2006 Update. Prepared for Western Shasta Resource Conservation District.

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 (*Salmo gairdnerii gairdnerii*) in the Sacramento River System. Fish Bulletin 114.

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.

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.

Harvey, C. D. 1995. Adult steelhead counts in Mill and Deer Creeks, Tehama County, October 1993-June 1994. Inland Fisheries Administrative Report Number 95-3.

Hedgecock, D., M. A. Banks, V. K. Rashbrook, C. A. Dean, and S. M. Blankenship. 2001. Applications of population genetics to conservation of Chinook salmon diversity in the Central Valley. Fish Bulletin 179 1:26.

Herren, J. R. and S. S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. Pages 343-355. In: Contributions to the Biology of Central Valley Salmonids. R. L. Brown, editor. Volume 2. California Fish and Game. Fish Bulletin 179.

Hoblitt, R. P., C. D. Miller, and W. E. Scott, 1987. Volcanic hazards with regard to siting nuclear-power plants in the Pacific Northwest (pp. 1-194). Reston, VA: U.S. Geological Survey.

Jeffres, C. A., J. J. Opperman, and P. B. Moyle. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes 83(4):449-458.

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.

Kennedy, T. and T. Cannon. 2005. Stanislaus River Salmonid Density and Distribution Survey Report (2002-2004). Fishery Foundation of California. Sacramento.

Leitritz, E. and R. C. Lewis. 1980. Trout and Salmon Culture: Hatchery Methods. UCANR Publications.

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, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESUs in California's Central Valley Basin in U.S. Department of Commerce, editor.

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.

Lindsay, R. B., R. K. Schroeder, K. R. Kenaston, R. N. Toman, and M. A. Buckman. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24(2):367-378.

Lloyd, D. S., J. P. Koenings, and J. D. Laperriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7(1):18-33.

McClure, M. M. 2011. Climate change. p. 261-266 In: Ford, M. J. (ed.). Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281 p. Document is found at: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2011s_s__pnw_tm113webfinal.pdf

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 K. Van Houtan. 2013. Incorporating climate science in applications of the U.S. Endangered Species Act for aquatic species. Conservation Biology 27(6):1222-1233.

McCullough, D. A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. U.S. Environmental Protection Agency, EPA-910-D-01-005.

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.

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

McEwan, D. R. 2001. Central Valley Steelhead. Fish Bulletin 179(1):1-44.

Mosser, C. M., L. C. Thompson, and J. S. Strange. 2013. Survival of captured and relocated adult spring-run Chinook salmon *Oncorhynchus tshawytscha* in a Sacramento River tributary after cessation of migration. Environmental Biology of Fishes 96(2-3):405-417.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles.

Muir, W. D., G. T. McCabe, M. J. Parsley, and S. A. Hinton. 2000. Diet of first-feeding larval and young-of-the-year white sturgeon in the lower Columbia River. Northwest Science 74(1):25-33.

National Marine Fisheries Service. 1997. Fish screening criteria for anadromous salmonids. Available:<http://www.westcoast.fisheries.noaa.gov/publications/hydropower/southwest_region_1997_fish_screen_design_criteria.pdf> Accessed on 9 July 2018.

National Marine Fisheries Service. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. Available: <Document is found at: http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf> Accessed on 9 July 2018.

National Marine Fisheries Service. 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. U.S. Department of Commerce, 844 pp.

National Marine Fisheries Service. 2011a. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit. U.S. Department of Commerce, 34 pp.

National Marine Fisheries Service. 2011b. 5-Year Review: Summary and Evaluation of Central Valley Steelhead Distinct Population Segment. U.S. Department of Commerce, 34 pp.

National Marine Fisheries Service. 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. U.S. Department of Commerce.

National Marine Fisheries Service. 2015. 5-Year Review: Summary and Evaluation of the Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*). 42 pp.

National Marine Fisheries Service. 2016a. 5-Year Review: Summary and Evaluation of Central Valley Spring-Run Chinook Salmon Evolutionarily Significant Unit. U. S. Department of Commerce, 41 pp.

National Marine Fisheries Service. 2016b. 5-Year Review: Summary and Evaluation of California Central Valley Steelhead Distinct Population Segment. U. S. Department of Commerce.

Newton, J. M. and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999-2002. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

Newcombe, C. P. and J. O. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16(4):693-727.

Nielsen, J. L., S. Pavey, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. CDFG, USFWS, Anchorage, Alaska.

Nobriga, M. and P. Cadrett. 2001. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. IEP Newsletter 14(3):30-38.

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, B. C. and R. G. White. 1992. Effects of angler wading on survival of trout eggs and pre-emergent fry. North American Journal of Fisheries Management 12(3):450-459.

Roos, M. 1987. Possible changes in California snowmelt runoff patterns. In: Proceedings Fourth Annual Pacific. Climate (PACLIM) Workshop, Pacific Grove, CA, pp 22–31.

Roos, M. 1991. A trend of decreasing snowmelt runoff in Northern California. In: Proceedings 59th Western Snow Conference, Juneau, AK, pp 29–36.

Rutter, C. 1904. The fishes of the Sacramento-San Joaquin Basin, with a study of their distribution and variation. Pages 103-152 in Bill of U.S. Bureau of Fisheries.

Servizi, J. A. and D. W. Martens. 1992. Sublethal responses of coho salmon (*Oncorhynchus kisutch*) to suspended sediments. Canadian Journal of Fisheries and Aquatic Sciences 49(7):1389-1395.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience, 31(2):131 134.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and Coho salmon. Transactions of the American Fisheries Society 113(2):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. R., M. L. Nobriga, W. C. Harrel, 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.

Stachowicz, J. J., J. R. Terwin, R. B. Whitlatch, and R. W. Osman. 2002. Linking climate change and biological invasions: Ocean warming facilitates nonindigenous species invasions. Proc Natl Acad Sci U S A 99(24):15497-15500.

Stone, L. 1874. Report of Operations During 1872 at the United States Salmon-Hatching Establishment on the McCloud River, and on the California Salmonidae Generally; With a List of Specimens Collected.

Thomas, M. J., M. L. Peterson, N. Friedenberg, J. P. Van Eenennaam, J. R. Johnson, J. J. Hoover, and A. P. Klimley. 2013b. Stranding of Spawning Run Green Sturgeon in the Sacramento River: Post-Rescue Movements and Potential Population-Level Effects. North American Journal of Fisheries Management 33(2):287-297.

Thompson, L. C., M. I. Escobar, C. M. Mosser, D. R. Purkey, D. Yates, and P. B. Moyle. 2011. Water management adaptations to prevent loss of spring-run Chinook salmon in California under climate change. Journal of Water Resources Planning and Management 138(5):465-478.

USACE. 2009. Final Environmental Assessment/Initial Study for Levee Repair of 25 Erosion Sites: Sacramento River Bank Protection Project. Prepared by North State Resources, Inc., Redding, California, and Stillwater Sciences, Inc., Berkeley, California, for U. S. Army Corps of Engineers, Sacramento District and Central Valley Flood Protection Board, Sacramento, California. U.S. Army Corps of Engineers Contract W91238-07-D-0022. May 2009.

USACE. 2012. Standard Assessment Methodology for the Sacramento River Bank Protection Project, 2010–2012 Certification Update, Final. Prepared for U.S. Army Corps of Engineers, Sacramento District by Stillwater Sciences, Berkeley, California. Contract W91238-09-P-0249 Task Order 3.

USACE. 2014. Engineering Technical Letter 1110-2-538, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures.

VanRheenen, N. T., A. W. Wood, R. N. Palmer, and D. P. Lettenmaier. 2004. Potential implications of PCM climate change scenarios for Sacramento-San Joaquin River Basin hydrology and water resources. Climatic Change 62(1-3):257-281.

Wade, A. A., T. J. Beechie, E. Fleishman, N. J. Mantua, H. Wu, J. S. Kimball, D. M. Stoms, and J. A. Stanford. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. Journal of Applied Ecology 50(5):1093-1104.

Waters, T. E. 1993. Dynamics in stream ecology. Canadian Special Publication of Fisheries and Aquatic Sciences, pp.1-8.

Wildlands Inc. 2006. Central Valley Anadromous Salmonid Umbrella Conservation Bank Agreement. Available: <https://www.conservationfund.org/images/programs/files/NOAA-Central-Valley-Fish-Bank.pdf> Accessed 18 July 2018.

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, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability Assessment For Pacific Salmon And Steelhead Listed Under The Endangered Species Act: Southwest, Memorandum from Steve Lindley to Will Stelle.

Workman, M.L. 2003. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam. August 2002 through July 2003. East Bay Municipal Utility. 18pp + appendices.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:485-521.

Yoshiyama, R. M., E. R. Gertstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook Salmon in the Central Valley drainage of California. Fish Bulletin 179(1):71-176.

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(2):280-291.

FEDERAL REGISTER CITED

63 FR 13347. March 19, 1998. Final Rule: Notice of Determination. Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead 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.

64 FR 50394. November 15, 1999. Final Rule: Threatened Status for Two Chinook Salmon Evolutionary Significant Units in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 64 pages 50394-50415.

70 FR 37160. June 28, 2005. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 70 pages 37160-37204.

70 FR 52488. September 2, 2005. Final Rule: Endangered and Threatened Species:

Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. United States Department of Commerce, National Oceanic 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.

78 FR 79622. December 31, 2013. Final Rule: Endangered and Threatened Species: Designation of a Nonessential Experimental Population of Central Valley Spring-Run Chinook Salmon Below Friant Dam in the San Joaquin River, CA. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 78 pages 79622-79633.

81 FR 7214. February 11, 2016. Final Rule: Interagency Cooperation-Endangered Species Act of 1973, as Amended; Definition of Destruction or Adverse Modification of Critical Habitat. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 81 pages 7214-7226.

81 FR 7414. February 11, 2016. Final Rule: Listing Endangered and Threatened Species and Designating Critical habitat; Implementing Changes to the Regulations for Designating Critical Habitat. Federal Register, Volume 81 pages 7414-7440.

81 FR 33468. May 26, 2016. Notice of Availability: Endangered and Threatened Species: 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 81 pages 33468-33469.