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

JUN 20 2016

Refer To NMFS No.: WCR-2016-4900

Mr. Christopher States
Branch Chief
Office of Biological Sciences and Permits,
District 4, Caltrans
P.O. Box 23660
Oakland, California 94623-5903

Dear Mr. States:

This document transmits the National Marine Fisheries Service's (NMFS) biological opinion (BO) (Enclosure 1) based on our review of the California Department of Transportation's (Caltrans) proposed Miner Slough Bridge Replacement Project (project) located on Highway 84 in eastern Solano County, California, and its effects on the federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) evolutionary significant unit (ESU), threatened Central Valley (CV) spring-run Chinook salmon ESU (*O. tshawytscha*), threatened California Central Valley (CCV) steelhead distinct population segment (DPS) (*O. mykiss*), threatened North American green sturgeon southern DPS (*Acipenser medirostris*) and their respective designated critical habitats in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your request for initiation of formal section 7 consultation on this Project was received on January 15, 2016. On May 26, 2016, formal consultation was initiated by NMFS' California Central Valley Office.

This BO is based on the biological assessment provided on January 15, 2016. Based on the best available scientific and commercial information, the BO concludes that the project is not likely to jeopardize the continued existence of the federally listed endangered Sacramento River winter-run Chinook salmon (*O. tshawytscha*) ESU, threatened CV spring-run Chinook salmon ESU, (*O. tshawytscha*), threatened CCV steelhead DPS (*O. mykiss*), or threatened Southern DPS of North American green sturgeon (*A. medirostris*), and is not likely to destroy or adversely modify their designated critical habitats. NMFS has also 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.

This letter also transmits NMFS's essential fish habitat (EFH) conservation recommendations for Pacific salmon as required by the Magnuson-Stevens Fishery Conservation and Management Act

(MSA) as amended (16 U.S.C. 1801 *et seq*.). The document concludes that the project will adversely affect the EFH of Pacific salmon in the action area and adopts the ESA reasonable and prudent measures and associated terms and conditions from the BO as the EFH conservation recommendations.

Caltrans has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed written response to NMFS within 30 days of receipt of these conservation recommendations, and 10 days in advance of any action, that includes a description of measures for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920(j)). If unable to complete a final response within 30 days, Caltrans should provide an interim written response within 30 days before submitting its final response. In the case of a response that is inconsistent with our recommendations, Caltrans must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

Please direct questions regarding this letter to LTJG Sean Luis in NMFS' West Coast Region, California Central Valley Office, at (916) 930-3724 or via email at Sean.M.Luis@noaa.gov.

Sincerely,

William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: California Central Valley Office Division- File Copy
151422-WCR2016-SA00244

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, Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation and Fish and Wildlife Coordination Act Recommendations

Miner Slough Bridge Replacement Project

National Marine Fisheries Service Consultation Number: **2016-4900**

Action Agency: California Department of Transportation (Caltrans)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?*	Is Action Likely to Affect Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
California Central Valley steelhead (*Oncorhynchus mykiss*)	Threatened	Likely	No*	No	No
California Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	Not Likely*	No*	No	No
Sacramento River winter-run Chinook salmon (*O. tshawytscha*)	Endangered	Not Likely*	No*	No	No
Southern Distinct Population Segment of North American green sturgeon (*Acipencer medirostris*)	Threatened	Likely	No*	No	No

*Please refer to section 2.4 for the analysis of species or critical habitat that are not likely to be adversely affected.

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 William W. Stelle, Jr.
Regional Administrator

Date: JUN 20 2016

List of Acronyms and Abbreviations

ac - acre
ACID – Anderson-Cottonwood Irrigation Dam
BA – Biological Assessment
BMPs – Best Management Practices
BO – Biological Opinion
C – Celsius
Caltrans – California Department of Transportation
CCV – California Central Valley
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulations
cfs – cubic feet per second
CISS – Cast-In-Steel-Shell
CVP – Central Valley Project
CV – Central Valley
dB – decibels
DJFMP - Delta Juvenile Fish Monitoring Program
DO – Dissolved Oxygen
DPS – Distinct Population Segment
DQA – Data Quality Act
EFH – Essential Fish Habitat
EPA – Environmental Protection Agency
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
F – Fahrenheit
FHWG – Fisheries Hydroacoustic Working Group
FMP – Fisheries Management Plan
FR – Federal Register
g – grams
ft – feet
FWCA – Fish and Wildlife Coordination Act
GCID – Glen-Colusa Irrigation District
HAPC – Habitat Area of Particular Concern
hr - hour
ITS – Incidental Take Statement
kg - kilogram
LWM – Large Woody Material
m – meters
mg O_2/l – milligrams of oxygen per liter
MHWM – Mean High Water Mark
MSA – Magnussen-Stevens Act
NMFS – National Marine Fisheries Service
OHWL – Ordinary High Water Line
PAH – Polycyclic Aromatic Hydrocarbon
PBF – Physical and Biological Feature
PAH – Polycyclic Aromatic Hydrocarbons

PCB - Polychlorinated Biphenyls
PM – Post Mile
ppt – parts per thousand
PVA – Population Viability Analysis
RBDD – Red Bluff Diversion Dam
RC – Reinforced Concrete
Reclamation – U.S. Bureau of Reclamation
RM – River Mile
RMS – Root Mean Squared
RWQCB – Regional Water Quality Control Board
sDPS – Southern Distinct Population Segment
SEL – Sound Exposure Level
SR – State Route
SWE – Snow Water Equivalent
SWP – State Water Project
SWPPP – Storm Water Pollution Prevention Plan
SWRCB – State Water Resources Control Board
TCP – Temperature Compliance Point
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
VSP – Viable Salmonid Parameters
WRO – Water Rights Order

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (BO) and incidental take statement 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 (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/pcts-web/homepage.pcts. A complete record of this consultation is on file at the NMFS California Central Valley Office.

1.2 Consultation History

- On January 15, 2016, the NMFS West Coast Region – California Central Valley Office received a consultation initiation request and Biological Assessment (BA) for the Miner Slough Bridge Replacement Project. Listed species and critical habitats in the Action Area include California Central Valley steelhead and their critical habitat; California Central Valley spring-run Chinook salmon and their critical habitat; Sacramento River winter-run Chinook salmon and their critical habitat; and Southern Distinct Population Segment (sDPS) green sturgeon and their critical habitat.
- On May 9, 2016, NMFS requested additional information from Caltrans regarding avoidance and minimization measures to be implemented with the project.
- On May 26, 2016, NMFS received additional information on avoidance and minimization measures to be implemented with the project.
- On May 26, 2016, NMFS initiated formal ESA Section 7 consultation.
- On May 31, 2016, NMFS received information regarding geotechnical drilling associated with the project.

1.3 Proposed 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).

Project Description

Caltrans is proposing to replace the existing Miner Slough Bridge. The new bridge would be constructed on a new alignment with improvements such as lanes and shoulders of standard width, standard vertical clearance, and flares at each end to provide extra width for truck-turning movements. A new swing bridge is proposed to be constructed approximately 100 feet (ft) west of the existing alignment. The new bridge will have standard features with a 12-ft lane and an 8-ft shoulder in each direction. The project proposes to maintain the existing vertical clearance over the slough. The project would also require construction of temporary trestles to be used during construction. There will be a control-house structure on the levee, to house operating equipment and parking for maintenance personnel. Route 84 will also be realigned for a length of about 900 ft north of Holland Road.

Existing Bridge

The existing bridge was built in 1933, and is 18 ft wide and accommodates one lane of traffic in either direction. It is a swing bridge with nonstandard features and very low annual average daily traffic (336 vehicles in 2011). The existing bridge is 367 ft long and is composed of three sections with timber plank decks and a 2-inch-thick asphalt concrete wearing surface. The 191-ft center steel truss swing span is on a reinforced concrete (RC) cylindrical swing pier, with RC rest piers. The two approach spans are made of timber stringers on timber cap-and-pile bents with abutments of RC on timber piles.

Staging Areas and Access Roads

Staging will occur in the area between the existing alignment and the new alignment to the north of the bridge (Figure 1). This 0.68-acre (ac) area will be cleared by the construction contractor for staging and preparation of the new SR 84 alignment. The existing house property southeast of the existing bridge will be utilized for storing materials and equipment for the new bridge. This area is currently used for staging of material for emergency repairs. Traffic coordination and limited closures of the existing bridge for construction of trestles, as well as conforming of the approach spans of new bridge to highway lanes, may be necessary. The existing bridge will continue to be used for traffic during construction.

A section of SR 84 immediately north of the bridge will be permanently realigned for a stretch of approximately 900 ft, where it will conform to the existing highway. This realignment will have standard 12-ft lanes with 8-ft paved shoulders. An approximately 250-ft-long section of the existing SR 84 will be widened to conform to the realigned section of SR 84. After the newly realigned section of SR 84 is open to the public, the pavement of the old section will be scarified, removed, and revegetated (See Figure 1). Holland Road will be paved for approximately 200 ft on either side of the new bridge, at which point it will conform to the existing county road. The new toe line for fill on this stretch will be 12 ft out from the edge of existing pavement on the south side (slough side) of Ryer Road, and will vary from 16 ft to 84 ft from the edge of existing pavement on the north side of Holland Road (see Figure 1). The realignment of SR 84 and paving of Holland Road will permanently impact approximately 0.71 ac.

The unpaved access road extending from the old Highway (84) to the staging area is currently 18 to 20 ft wide. This access road needs to be widened to 24 ft over a distance of approximately 1,200 ft in order to accommodate large construction equipment and trucks. Widening of this access road will require minor grading of the approximately 0.22 ac area to be widened, and placing 6-in of crushed rocks over the adjacent ground.

Temporary Trestle Bridge Construction and Removal

There will be two trestles on each end of bridge. The one on the south end will be approximately 86 ft long and the other on the north end will be about 204 ft long. This will leave an opening of about 85 ft for traffic navigation between the two trestles. Each trestle will be a width of 35 ft to 40 ft with a superstructure of timber decking, steel stringers, and prefabricated steel bents; and safety railing. The bents will be spaced approximately 25 ft to 40 ft apart and supported on piles varying from 15 inches to 36 inches in diameter. The piles may be driven by an impact hammer or through use of a vibratory hammer and will be spaced 5 ft to 10 ft apart. The number of piles is estimated to be approximately 125. Each pile will be approximately 50 ft to 75 ft long. The elevation of the trestle will be below the soffit of the new bridge at about 18 ft. Once the old trestle is taken away by crane, the piles will be removed by vibratory method or cut 3 ft below the mudline. Trestles alone, or in combination with reclaimed lumber from demolition of the old bridge, can be placed on a barge to be used for construction of the new bridge. Barges may be used to facilitate construction of the new bridge and demolition of the old bridge.

New Piers with Foundations

The Project includes construction of three steel-reinforced cast concrete piers to support the bridge—one central pivot pier (Pier 3) and two independent piers (Pier 2 and Pier 4)—which support both the approach spans and swing span when it is not in operation. Each pier will be supported through cap-on, cast-in-steel-shell (CISS) piles. The cap will be constructed of steel-reinforced cast concrete over a group of CISS piles as shown in Table 1.

Table 1. Pier Construction Parameters.

Description	**Pier 3**	**Piers 2 and 4**
Number of piles	25	4
Depth of piles	50-ft	50-ft
Diameter of pile	2-ft	6-ft
Diameter of pier	18-ft	6-ft
Diameter of caps	32-ft	8-ft
Height of caps	8-ft	5-ft
Height of pier	18-ft	18-ft
Elevation of top of pier	24-ft	24-ft

For Pier 3, a 44-ft by 44-ft cofferdam will be constructed to facilitate the pile driving and construction of the caps and pier. The cofferdam will be constructed by driving 2-ft sheet pile sections 30 ft deep into the streambed using vibratory hammers. The piles will be tall enough so that the tops reach 5 ft above the surface of the water and placed adjacent to each other. The area within the cofferdam is then dewatered and excavated to 2 ft below the footing elevation. A 2-ft-deep seal course of poured concrete is placed at the base of the cofferdam to prevent water leakage. The CISS piles will be driven using impact-hammer, with pile drivers situated on the temporary trestle bridge. The material inside each pile is bored out using drills situated on the temporary trestle bridge, leaving a plug of native material at the bottom. Rebar is placed in the shell and the shell is filled with concrete, using pumps from the temporary bridge. Forms and rebar will be placed over the pile ends and then filled with concrete to form the cap, and the same process is used to form the pier.

For Pier 2 and Pier 4, CISS piles will be driven without cofferdams into the streambed using impact hammers situated on the temporary trestle, and the pile shells will be drilled out, leaving a plug of native material at the bottom. Only piers 2 and 3 will be located within the active channel. Rebar is placed into the shells, which are then filled with concrete. Forms are built around the top of the shells to construct concrete caps approximately 9 ft wide by 26 ft long by 5 ft high, on which the bridge and abutment sections will rest after construction. Fenders with a 3-ft-wide cap on 2-ft-diameter piles spaced 5 ft to 8 ft apart will be placed adjacent to Pier 2 and Pier 3 only. The fenders extend 10 ft past the edge of deck on the east and west sides, and then curve for another 20 ft.

Operator Control House

An operator control house will be constructed approximately 50 ft north of the abutment on the levee, down slope facing the slough. This will provide the control house operator a better view of the bridge opening from the bend in the slough on the north side than one would have from the south side. The control house structure will consist of a 25-ft-wide by 25-ft-long concrete structure with a metal roof and windows, with its operating floor approximately 25 ft above the levee road. It will be supported by 20 CISS piles placed 2 ft in diameter around the perimeter of the control house. A 20-ft by 30-ft parking area will be provided across from the control house on the north side of Holland Road for maintenance. Construction of the structure will consist of steel pipe piles driven into the levee with an impact hammer. The interior of the piles will be cleaned out, a rebar cage will be placed inside the pile, and then the cage filled with concrete. The control house will be built with forms filled with RC. A 5-ft-wide stairway leading to the control house will also be constructed. A roadside pullout built on a RC viaduct will be constructed on a 24-inch RC slab sitting on top of 2-ft-diameter steel pipe piles. The piles will be approximately 30 ft long. Three bents will be installed 20 ft on center, using 10 CISS piles driven as described above, with a 2-ft-diameter footprint. A dowel attachment to the slab, which is poured in place with forms and rebar, will be constructed. A parking slab, with a construction footprint of 25 ft by 30 ft, will be constructed to adjoin the roadway. The parking slab will be on a 3-ft-deep cap, which will be supported on 2- ft-diameter piles that are 30 ft deep.

The operator control house is stationary on the north end of the bridge and contains the switch gear with the generator to be attached to the outside of the control house. The main drive motor is below the deck at Pier 3 on a platform near the drive gear machinery. A separate motor and hydraulic pump is used to operate the end jack mechanisms via hydraulic pipes and hoses extending to both ends of the bridge.

Abutment Foundations

On the levees, at the ends of each approach span at elevation 26.4 ft on the north and 27 ft on the south above the high-water elevation (16.84 ft), a row of 28 2-ft-diameter piles with a 65.5-ft-long by 8-ft-wide concrete cap will be constructed. The seat abutments are approximately 14 ft high by 63.5 ft in length. The area will be excavated to a depth of 5 ft for a length of 60 ft to construct a trench 5 ft wide. Approximately 70-ft-long CISS piles will be driven into the trench, drilled out, and filled with rebar and concrete. The 65.5-ft-long by 8-ft-wide by 5-ft-deep cap will be constructed over the tops of the piles to support the approach span with a 4-ft to 5-ft abutment stem, either precast abutment slab or cast in place.

Bridge Structure

A swing span, steel girder bridge will make up the superstructure of the proposed new bridge. Continuous steel I-girder beams longitudinally connected by cross-frames and diaphragm will provide support from the superstructure down to the piers. The dimensions of the bridge superstructure will consist of two 110-ft spans supported by a central pivot pier. The depth of the superstructure will be 7 ft deep at center, and 4 ft at the end.

The bridge will be constructed from a prefabricated girder that will be dropped into place using a crane mounted on the temporary trestle or from the edge of the levee. Larger sections will be assembled in the staging area, while smaller sections will be assembled offsite and brought in by truck. A concrete deck will be poured on top of the girders.

Approach Structure

Precast, prestressed concrete I-girders spaced evenly will be mounted on top of the all piers to form the lower part of the superstructure. Between the precast I-girders, forms will be placed to lay out the deck reinforcement as well as curbs, and then the forms filled with concrete.

From Abutment 1 to Pier 2, the section flares from approximately 86 ft to 44 ft wide, with a length of 61 ft. From Pier 4 to Abutment 5, the section flares from approximately 89 ft to 44 ft wide, with a length of 61 ft. This part of the superstructure is 4 ft deep and the deck is approximately 9 inches deep.

On the south end of the bridge, the approach slab conforms to the edge of the existing highway. On the north end of the bridge, the approach slab is higher by 3 ft at the edge of Holland Road.

Pavement Section

The bridge deck will have standard RC for the swing span and approach spans. Standards for placing asphalt concrete pavement sections to the bridge deck will be followed and include excavating 12 inches of soil, adding a gravel sub-base, compacting, and then placing the asphalt concrete.

A section of State Route (SR) 84 immediately north of the bridge will be permanently realigned for a stretch of approximately 900 ft, where it will conform to the existing highway. This realignment will have a standard 12-ft lane with 8-ft paved shoulder in each direction. The realigned section of SR 84 will be on fill, ranging in depth from 0.25 ft to 15.5 ft, and its footprint from toe-of-fill to toe-of-fill will range between 80 ft to 160 ft. Before placement of the fill, the Project area will undergo vegetation clearing and grubbing, scraping and excavating up to 1 ft below ground surface, compacting the soil, and adding gravel base. An approximately 250-ft-long section of the existing SR 84 will be widened to conform to the realigned section of SR 84. To achieve this, there will be an approximately 2-ft to 3-ft excavation within the existing roadway and fill area. After the newly realigned section of SR 84 is open to the public, the old paved section will be scarified, removed, and revegetated.

Holland Road will be paved for approximately 200 ft on either side of the new bridge, at which point it will conform to the existing Holland Road. The new toe line for fill on this stretch of the road will be 12 ft out from the edge of the existing pavement on the south side (slough side) of Ryer Road, and will vary from 16 ft to 84 ft from the edge of the existing pavement on the north side of the road.

Electrical

An armored underwater electrical cable will be laid on the bed of the slough to connect the control house with the central span. A generator will be used to run the bridge and control gates. The generator will fit into the control house. No outside lighting or utilities are anticipated.

Drainage

Scuppers will be used for the concrete barriers on either side of bridge shoulders. Scuppers are drainage ports along the edges of the bridge that will aid in removing storm water from the bridge deck. The bridge will have a 2% grade with an apex at the middle designed to direct the flow of storm water towards the ends of the bridge. The majority of storm water will likely flow into Miner Slough. On the new stretch of SR 84 on the north side of new bridge, cross culverts of up to 48 inches will be installed to maintain proper drainage.

Demolition of the Existing Bridge

The trestle and cofferdam, described above, will be used in the existing bridge demolition. The barrier rail and post will most likely be removed by hand. The swing spans may need temporary supports to provide stability during the demolition of the truss. The removal of the beams would require a crane. Once the truss is removed, the deck asphalt concrete and concrete will be chipped with a hoe ram. The chipped pieces will be caught on a working platform and removed with a loader. Steel beams, cross beams, and stringers will be removed by a crane. The pivot pier will be have steel plates that will be removed by a crane. The approach spans' superstructure will be removed in a similar way. The RC bents will be chipped down to 3 ft below the timber. The wooden bents will have the RC caps removed and the wood piles removed to at least 3 ft below the channel bed. Disturbed soil will be restored to levee requirements. The pivot pier will be chipped down with a hoe ram. Chunks of RC will be loaded out of the cofferdam area. The pivot pier will be chipped down 3 ft below the mud-sounding elevation. The removed soil will need to be replaced by hand. The dolphins will need to be removed 3 ft below the mud soundings. Trestles will be removed from a barge located in Miner Slough. No utility relocation is anticipated.

Borrow and Disposal

The Project will not require onsite borrow or disposal of excavated material. Gravel and rock will be imported for road widening. These materials will be removed on completion of the Project, and removal and disposal of this material will be implemented through contractors and subcontractors and comply with Caltrans standard Best Management Practices (BMPs) and the Storm Water Pollution Prevention Plan (SWPPP). BMPs and SWPPP measures are a standard part of the plans and specifications for the Project and are covered by the Regional Water Quality Control Board (RWQCB) 401 Water Quality Certification.

Geotechnical Exploration

Prior to project implementation, geotechnical boring will be conducted in the action area. Four bore holes are planned with two occurring in-water and two occurring in the adjacent levees outside of the channel. The in-water test bores will be conducted using rotary wash self-casing drilling system. Geotechnical work will be conducted between August 1st and November 30th and will require approximately 12 working days to complete.

Project Schedule

The construction is scheduled to begin January 2018 and last up to 1 year. Construction would be restricted to daytime hours. In-water work will be restricted to the proposed August 1 to November 30 work window.

1.4 Avoidance and Minimization Measures

Construction Planning

Caltrans will install environmentally sensitive area fencing around the project limits along the banks of Miner Slough to protect riparian vegetation and elderberry shrubs adjacent to the project site. This will prevent the encroachment of construction personnel into sensitive areas not needed for construction of the project. All construction personnel will attend an environmental education program delivered by a Services-approved biologist prior to working on the project site. The program will include an explanation of how to best avoid the incidental take of listed species. The field meeting will include topics on species identification, life history, descriptions, and habitat requirements during various life stages. Emphasis will be placed on the importance of the habitat and life stage requirements within the context of project maps showing areas where avoidance and minimization measures are to be implemented. The program will include an explanation of applicable federal and state laws protecting endangered species as well as the importance of compliance with Caltrans and various resource agency conditions.

Sedimentation and Turbidity

Caltrans will construct one or more Baker tanks or other settling tanks onsite. Alternative methods may include pumping the water over the levee and allowing the water to filter through riparian vegetation before it re-enters the slough system. If the settling tank method is used, all water removed from the area inside the coffer dam during construction and installation will be pumped into a settling tank until all sediments settle out of the water. This water will then be discharged downstream of the project area. Caltrans will also construct the coffer dam during low tide as much as possible to reduce the likelihood of a sediment plume washing away downstream. Sediment curtains may also be used outside the coffer dam as it is being installed. These measures will be included in the project's standard special provisions. Caltrans will also implement several erosion control measures to minimize sediment incursion into the active channel. Such measures will include the use of erosion control blankets, fiber rolls, and silt fences where applicable. All disturbed areas will be hydroseeded or revegetated post-construction. Caltrans will hydroseed all disturbed areas between construction seasons.

Pollution and Hazardous Materials

A SWPPP will be required as part of this project. The SWPPP will include dedicated fueling and refueling practices. Dedicated fueling areas will be protected from storm water run-on and will be located at least 50 feet from downslope drainage facilities and water courses. Fueling will be performed on level-grade areas only. On-site fueling will only be used when and where it is impractical to send vehicles and equipment off-site for fueling. When fueling must occur on-site, the contractor will designate an area to be used subject to the approval of the Resident Engineer representing Caltrans. Drip pans or absorbent pads will be used during on-site vehicle and equipment fueling. Equipment staging areas will be sited at least 150 ft away from the active channel. A spill response plan is currently in place for geotechnical operations.

Effects to Riparian Vegetation

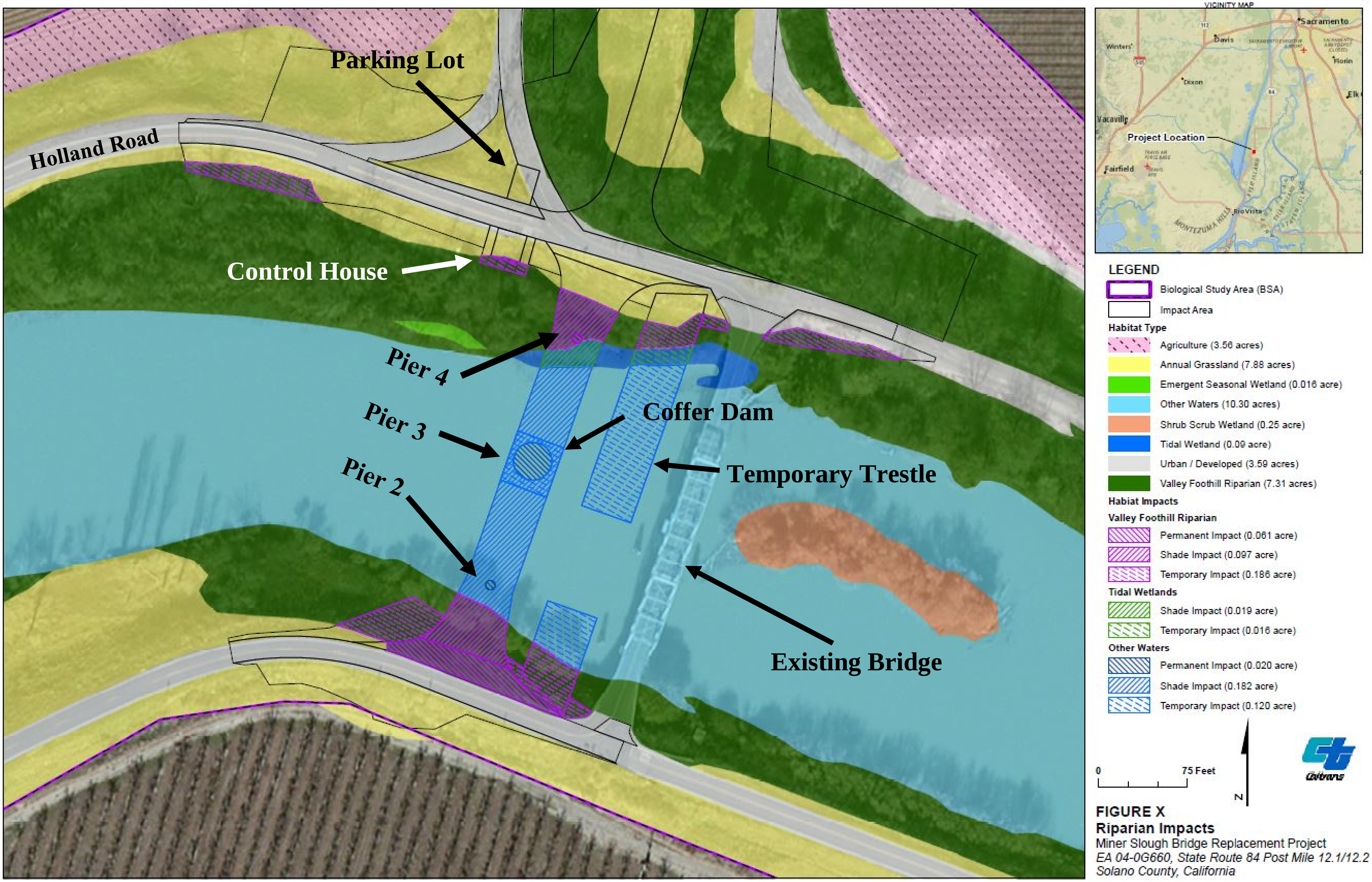
Approximately 0.061 ac of forested riparian habitat will be permanently lost and 0.186 ac will be temporarily lost as a result of this project. Riparian habitat loss will result from the bridge span itself and construction of the bridge abutments and temporary trestles. Some riparian habitat loss will be offset through removal of the old bridge and restoration of those areas post-demolition. Caltrans will work with NMFS and the other resource agencies to identify a species palette that will be used to restore all disturbed areas on site. Native grasses, shrubs, and trees will be included in onsite restoration efforts. Caltrans will also re-contour all areas graded for construction of the trestles; Caltrans will restore the site to pre-project conditions to the extent possible. All vegetation restoration efforts and plans for recontouring the levee will be developed through coordination with the resource agencies and the U.S. Army Corps of Engineers and the Reclamation Districts 501 and 999 who own and operate the levee.

Offsite restoration to offset the permanent loss of riparian habitat will also be required (see Section 2.8.4).

Hydroacoustic Impacts

Pile driving activities will be restricted to August 1 to November 30. The contractor will be required to use attenuation devices around piles that will be driven in the water. Attenuation devices could take the form of bubble rings or of completely dewatering the cofferdam at Pier 3.

Figure 1. Miner Slough Bridge Replacement Project



Interrelated or Interdependent Actions

"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 interdependent or interrelated activities associated with the proposed action.

1.5 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).

Miner Slough Bridge is located at position 38.291847, -121.630818 in the Northern region of the Sacramento/San Joaquin River Delta, connecting Ryer Island with the mainland. The project is located approximately 13 miles north of Rio Vista in Solano County, California. The bridge is located at post mile (PM) 12.1/12.2 on SR 84. The bridge traverses the active flow channel of Miner Slough and connects Ryer Island in the Sacramento-San Joaquin River Delta (Delta) to the mainland. Most of the project area is located adjacent to the active channel of Miner Slough, a tributary of the Sacramento River. The project is located within the Liberty Island U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle. Miner Slough flows south into the Sacramento River and Suisun Bay, which flows into the San Francisco Bay. Miner Slough is a navigable waterway that ebbs and flows with the tide, with a depth of about 6 ft to the mean high water mark (MHWM). The action area encompasses 10.3 ac of Miner Slough (approximately 1050 ft upstream and 1025 ft downstream of the existing bridge), as well as 0.7.576 ac of riparian area, emergent seasonal wetland area, and shrub scrub wetland area. The action area includes areas adjacent to the project that may be adversely effected by (but not limited to) the following: noise generated by pile driving; sedimentation and increased turbidity; and construction-related effects.

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 incidental take statement (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.

The proposed action is not likely to adversely affect CV spring-run Chinook or their critical habitat, Sacramento River winter-run or CCV steelhead critical habitat. The analysis is found in the "Not Likely to Adversely Affect" Determinations section (2.11).

2.1 Analytical Approach

This biological 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.

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[1]

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using best available information and an “exposure-response-risk” approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions using best available information.
- If necessary, define a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

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

[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the “Destruction or Adverse Modification” Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon, and aquatic habitat at large is climate change.

The designations of critical habitat for CV spring-run Chinook salmon, CCV steelhead, and the sDPS of green sturgeon use the term primary constituent elements or essential features. The new critical habitat regulations (81 FR 7414) replace these terms 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 primary constituent elements, physical or biological features, 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.

In 2016, NMFS completed a status review of 28 species of Pacific salmon, steelhead and eulachon, including CV spring-run Chinook salmon, and CCV steelhead, and concluded that the species' status should remain as previously listed (102 FR 33468; May 26, 2016). The 2016 status reviews for CV spring-run and CCV steelhead found that, although the listings should remain unchanged, the status of these populations have suffered in 2014 and 2016 from the unprecedented California drought. An updated status review for sDPS green sturgeon was issued recently (July 2015, NMFS 2015), concluding that the status of sDPS green sturgeon should remain as threatened.

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

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
Listed as endangered (70 FR 37160, June 28, 2005)

Sacramento River winter-run Chinook salmon designated critical habitat
(58 FR 33212, June 16, 1993)

http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/sacramento_river_winter_run/sacramento_river_winter_run_chinook.html

CV spring-run Chinook salmon ESU (*O. tshawytscha*)
Listed as threatened (70 FR 37160, June 28, 2005)

CV spring-run Chinook salmon designated critical habitat
(70 FR 52488, September 2, 2005)

http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/central_valley_spring_run/central_valley_spring_run_chinook.html

CCV steelhead DPS (*O. mykiss*)
Listed as threatened (71 FR 834, January 5, 2006)

CCV steelhead designated critical habitat
(70 FR 52488, September 2, 2005)

http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/california_central_valley/california_central_valley_steelhead.html

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
Listed as threatened (71 FR 17757, April 7, 2006)

Southern DPS of North American green sturgeon designated critical habitat
(74 FR 52300, October 9, 2009)

http://www.westcoast.fisheries.noaa.gov/protected_species/green_sturgeon/green_sturgeon_pg.html

2.2.1 Sacramento River Winter-run Chinook Salmon

Summary of Sacramento River Winter-run Chinook Salmon ESU Viability

There are several criteria (only one is required) that would qualify the winter-run ESU at moderate risk of extinction, and since there is still only one population that spawns downstream of Keswick Dam, that population would be at high risk of extinction in the long-term according the criteria in Lindley et al. (2007). Recent trends in those criteria are: (1) continued low abundance; (2) a negative growth rate over 6 years (2006–2012), which is two complete generations; (3) a significant rate of decline since 2006; and (4) increased risk of catastrophe from oil spills, wildfires, or extended drought (climate change). The most recent 5-year status review (NMFS 2011) on winter-run concluded that the ESU had increased to a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the winter-run ESU has increased from moderate risk to high risk of extinction since 2005, and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (NMFS 2011).

Critical Habitat: Physical and Biological Features for Sacramento River Winter-run Chinook Salmon

NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at river mile (RM) 302 to Chipps Island, RM 0, at the westward margin of the Sacramento-San Joaquin Delta, including Kimball Island, Winter Island, and Brown’s Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. In the Sacramento River, critical habitat includes the river water, river bottom, and the adjacent riparian zone.

Critical habitat for winter-run is defined as specific areas (listed below) that contain the PBFs considered essential to the conservation of the species. This designation includes the river water, river bottom (including those areas and associated gravel used by winter-run as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing (June 16, 1993, 58 FR 33212). NMFS limits "adjacent riparian zones" to only those areas above a stream bank that provide cover and shade to the nearshore aquatic areas. Although the bypasses (*e.g.*, Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run may use tributaries of the Sacramento River for non-natal rearing. Critical habitat also includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile outmigration or adult spawning migration.

The following is the status of the PBFs that are considered to be essential for the conservation of winter-run (June 16, 1993, 58 FR 33212):

1. <u>Access from the Pacific Ocean to Appropriate Spawning Areas</u>

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover, shelter and safe passage conditions in order for adults to reach spawning areas. Adult winter-run generally migrate to spawning areas during the winter and spring. At that time of year, the migration route is accessible to the appropriate spawning grounds on the upper 60 miles of the Sacramento River, however much of this migratory habitat is degraded and they must pass through a fish ladder at the Anderson-Cottonwood Irrigation Dam (ACID). In addition, the many flood bypasses are known to strand adults in agricultural drains due to inadequate screening (Vincik and Johnson 2013). Since the primary migration corridors 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.

2. <u>The Availability of Clean Gravel for Spawning Substrate</u>

Suitable spawning habitat for winter-run exists in the upper 60 miles of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD). However, the majority of spawning habitat currently being used occurs in the first 10 miles downstream of Keswick Dam. The available spawning habit is completely outside the historical range utilized by winter-run upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, the U.S. Bureau of Reclamation (Reclamation) annually injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the upper Sacramento River reach continues to support a small naturally-spawning winter-run Chinook salmon population. 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.

3. Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

An April 5, 1960, Memorandum of Agreement between Reclamation and the CDFW originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in State Water Resource Control Board (SWRCB) Water Rights Order (WRO) 90-05 for the protection of Chinook salmon. This order includes a minimum flow release of 3,250 cubic feet per second (cfs) from Keswick Dam downstream to RBDD from September through February during all water year types, except critically dry.

4. Water Temperatures at 5.8–14.1°C (42.5–57.5°F) for Successful Spawning, Egg Incubation, and Fry Development

Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of winter-run migration, spawning, egg incubation, fry development, and emergence. This pattern, the opposite of the pre-dam hydrograph, benefits winter-run by providing cold water for miles downstream during the hottest part of the year. The extent to which winter-run habitat needs are met depends on Reclamation's other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir end of September storage levels required in the NMFS 2009 BO (NMFS 2009) on the long-term operations of the CV Project and State Water Project (CVP/SWP). WRO 90-05 and 91-1 require Reclamation to operate Shasta, Keswick, and Spring Creek Powerhouse to meet a daily average water temperature of 13.3°C (56°F) at RBDD. They also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. Based on these requirements, Reclamation models monthly forecasts and determines how far downstream 13.3°C (56°F) can be maintained throughout the winter-run spawning, egg incubation, and fry development stages.

In every year since WRO 90-05 and 91-1 were issued, operation plans have included modifying the TCP to make the best use of the cold water available based on water temperature modeling and current spawning distribution. Once a TCP has been identified and established in May, it generally does not change, and therefore, water temperatures are typically adequate through the summer for successful winter-run egg incubation and fry development for those redds constructed upstream of the TCP (except for in some critically dry and drought years). However, by continually moving the TCP upstream, the value of that habitat is degraded by reducing the spawning area in size and imprinting upon the next generation to return further upstream.

5. Habitat and Adequate Prey Free of Contaminants

Water quality conditions have improved since the 1980s due to stricter standards and Environmental Protection Agency (EPA) Superfund site cleanups (see Iron Mountain Mine remediation under Factors). No longer are there fish kills in the Sacramento River caused by the heavy metals (*e.g.*, lead, zinc and copper) found in the Spring Creek runoff. However, legacy contaminants such as mercury (and methyl mercury), polychlorinated biphenyls (PCB), heavy metals and persistent organochlorine pesticides continue to be found in watersheds throughout the CV. In 2010, the EPA, listed the Sacramento River as impaired under the Clean Water Act, section 303(d), due to high levels of pesticides, herbicides, and heavy metals (http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml). Although most of these contaminants are at low concentrations in the food chain, they continue to work their way into the base of the food web, particularly when sediments are disturbed and previously entombed compounds are released into the water column.

Adequate prey for juvenile salmon to survive and grow consists of abundant aquatic and terrestrial invertebrates that make up the majority of their diet before entering the ocean. Exposure to these contaminated food sources such as invertebrates may create delayed sublethal effects that reduce fitness and survival (Laetz et al. 2009). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities (*e.g.*, mercury contamination as a result of gold mining or processing). Areas with low human impacts frequently have low contaminant burdens, and therefore lower levels of potentially harmful toxicants in the aquatic system. Freshwater rearing habitat has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

6. <u>Riparian and Floodplain Habitat that Provides for Successful Juvenile Development and Survival</u>

The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from predators. Juvenile life stages of salmonids are dependent on the natural functioning of this habitat for successful survival and recruitment. Ideal habitat contains natural cover, such as riparian canopy structure, submerged and overhanging large woody material (LWM), aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Riparian recruitment is prevented from becoming established due to the reversed hydrology (*i.e*., high summer time flows and low winter flows prevent tree seedlings from establishing). However, there are some complex, productive habitats within historical floodplains [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, fish in Yolo and Sutter bypasses experience rapid growth and higher survival due to abundant food resources) seasonally available that remain in the system. Nevertheless, the current condition of degraded riparian habitat along the mainstem Sacramento River restricts juvenile growth and survival (Michel 2010; Michel et al. 2012).

7. <u>Access Downstream so that Juveniles can Migrate from the Spawning Grounds to San Francisco Bay and the Pacific Ocean</u>

Freshwater emigration corridors should be free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. Migratory corridors are downstream of the Keswick Dam spawning areas and include the mainstem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

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. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River and in the Delta. Predators such as striped bass (*Morone saxatilis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon.

Water pumping at the CVP/SWP export facilities in the South Delta at times causes the flow in the river to move back upstream (reverse flow), further disrupting the emigration of juvenile winter-run by attracting and diverting them to the interior Delta, where they are exposed to increased rates of predation, other stressors in the Delta, and entrainment at pumping stations. NMFS' BO on the long-term operations of the CVP/SWP (NMFS 2009) sets limits to the strength of reverse flows in the Old and Middle Rivers, thereby keeping salmon away from areas of highest mortality. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function as rearing habitat and as an area of transition to the ocean environment.

2.2.2 Central Valley Spring-run Chinook salmon

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, NMFS 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. 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.

In the 2016 status review, the authors 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 SWFSC 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 (Williams et al. 2016).

The 2015 adult CV spring-run Chinook salmon returns were very low. Those that did return experienced high pre-spawn mortality. Juvenile survival during the 2012 to 2015 drought has likely been impacted, and will be fully realized over the next several years.

Critical Habitat: Physical and Biological Features for CV Spring-Run Chinook Salmon

Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). 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 and the lateral extent as defined by the ordinary high-water line (OHWL). In areas where the OHWL 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 and 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.

1. 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 RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks; as well as the Feather and Yuba rivers, 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.

2. 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 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 fish 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.

3. 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.

4. Estuarine Areas

Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PBF. Natural cover such as submerged and overhanging LWM, aquatic vegetation, and side channels are suitable for juvenile and adult foraging.

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.

2.2.3 California Central Valley steelhead

Summary of CCV Steelhead DPS Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of naturally spawned fish to hatchery produced fish over the past 25 years (Good *et al*. 2005, NMFS 2011b); the long-term abundance trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock. 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 captured in monitoring studies 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 CCV steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV steelhead 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 (NMFS 2011b). 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.

The 2011 status review of the CCV steelhead DPS (NMFS 2011b) found that the status of the population appears to have worsened since the 2005 status review (Good *et al*. 2005), when it was considered to be in danger of extinction.

The 2016 status review 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.

Critical Habitat: Physical and Biological Features for CCV Steelhead

Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). 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, including its tributaries, and the waterways of the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the OHWL. In areas where the OHWL 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 1 to 2 years on the annual flood series) (Bain and Stevenson 1999; 70 FR 52488). Critical habitat for CCV steelhead is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PBFs for CCV steelhead. PBFs for CCV steelhead include:

1. <u>Freshwater Spawning Habitat</u>

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most of the available spawning habitat for steelhead in the CV is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have adverse effects upon salmonids spawning and rearing downstream of the dams. 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.

2. 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 survival; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging LWM, log jams, 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 either fish or avian predators. Freshwater rearing habitat also has a high 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.

3. 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 and downstream passage of adults, and the emigration of smolts. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. 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.

4. Estuarine Areas

Estuarine areas free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PBF. Natural cover such as submerged and overhanging LWM, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment.

2.2.4 Southern DPS of North American Green Sturgeon

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 2010). 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. 2013) 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 2010).

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 Feather River Fish Hatchery, 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 California CV, we will limit our discussion to freshwater riverine systems and estuarine habitats.

Freshwater Riverine Systems

1. 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. 2007), 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).

2. Substrate Type or Size

Critical habitat in the freshwater riverine system should include substrate suitable for egg deposition and development, larval development, subadults, 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). 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).

3. 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°C - 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 cfs [average daily water flow during spawning months: 6,900 – 10,800 cfs; Brown (2007)]. In Oregon's Rogue River, 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.

4. 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°C - 17°C (optimal range is 14°C - 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 parts per thousand (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 (*i.e.*, 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. 2001; 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, and the CV and Delta.

5. 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 (river mile (RM) 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

6. 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 Glenn-Colusa Irrigation District (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.

7. 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 [*e.g*., elevated levels of heavy metals such as mercury, copper, zinc, cadmium, and chromium, polycyclic aromatic hydrocarbons (PAHs), 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 negatively 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

1. Food Resources

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PBF for green sturgeon. Green sturgeon feed primarily on worms, mollusks, and crustaceans (Moyle 2002). Radtke (1966) studied the diet of juvenile sDPS green sturgeon and found their stomach contents to include a mysid shrimp, amphipods, and other unidentified shrimp. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries. Currently, the estuary provides these food resources, although annual fluctuations in the population levels of these food resources may diminish the contribution of one group to the diet of green sturgeon relative to another food source.

Invasive species are a concern because they may replace the natural food items consumed by green sturgeon. The Asian overbite clam (*Corbula amurensis*) is one example of a prolific invasive clam species in the Delta. It has been observed to pass through white sturgeon undigested (Kogut 2008).

2. Water Flow

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river. The specific quantity of flow required is a topic of ongoing research.

3. Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C (75°F). At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen et al. 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas subadults and adults tolerate a wide range of salinities (Kelly et al. 2007). Subadult and adult green sturgeon occupy a wide range of DO levels, but may need a minimum DO level of at least 6.54 mg O_2/l (Kelly et al. 2007; Moser and Lindley 2007).

Suitable water quality also includes water free of contaminants (*e.g.*, pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages. In general, water quality in the Delta and estuary meets these criteria, but local areas of the Delta and downstream bays have been identified as having deficiencies. Discharges of agricultural drain water have also been implicated in local elevations of pesticides and other related agricultural compounds within the Delta and the tributaries and sloughs feeding into the Delta. Discharges from petroleum refineries in Suisun and San Pablo bay have been identified as sources of selenium to the local aquatic ecosystem (Linville et al. 2002).

4. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by

Suisun, San Pablo, and San Francisco bays, safe and unobstructed passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean. Currently, safe and unobstructed passage has been diminished by human actions in the Delta and bays. The CVP and SWP, responsible for large volumes of water diversions, alter flow patterns in the Delta due to export pumping and create entrainment issues in the Delta at the pumping and Fish Facilities. Power generation facilities in Suisun Bay create risks of entrainment and thermal barriers through their operations of cooling water diversions and discharges. Installation of seasonal barriers in the South Delta and operations of the radial gates in the Delta Cross Channel facilities alter migration corridors available to green sturgeon. Actions such as the hydraulic dredging of ship channels and operations of large ocean going vessels create additional sources of risk to green sturgeon within the estuary. Commercial shipping traffic can result in the loss of fish, particularly adult fish, through ship and propeller strikes.

5. Water Depth

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy deep ($\geq$ 5 m) holding pools within bays, estuaries, and freshwater rivers. These deep holding pools may be important for feeding and energy conservation, or may serve as thermal refugia (Benson et al. 2006). Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters with depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly et al. 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3 – 8 ft deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966).

Currently, there is a diversity of water depths found throughout the San Francisco Bay estuary and Delta waterways. Most of the deeper waters, however, are composed of artificially maintained shipping channels, which do not migrate or fluctuate in response to the hydrology in the estuary in a natural manner. Shallow waters occur throughout the Delta and San Francisco Bay. Extensive “flats” occur in the lower reaches of the Sacramento and San Joaquin river systems as they leave the Delta region and are even more extensive in Suisun and San Pablo bays. In most of the region, variations in water depth in these shallow water areas occur due to natural processes, with only localized navigation channels being dredged (*e.g.*, the Napa River and Petaluma River channels in San Pablo Bay).

6. Sediment Quality

Sediment quality (*i.e*., chemical characteristics) is necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g*., elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of green sturgeon (see description of *sediment quality* for riverine habitats above).

2.2.5 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 and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991; Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April-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 Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Projected warming is expected to affect Central Valley 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 Central Valley 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 Central Valley 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.

For winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of operations of the CVP/SWP expects to include the effects of climate change in one of three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or, earlier spring snow melt (Reclamation 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008; Beechie et al. 2012; Dimacali 2013). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2014a).

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).

Although 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, 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.

Southern DPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. ACID is considered the upriver extent of green sturgeon passage in the Sacramento River. The upriver extent of green sturgeon spawning, however, is approximately 30 kilometers downriver of ACID where water temperature is higher than ACID during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID may remain within tolerable levels for the embryonic and larval life stages of green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of green sturgeon in other accessible habitats in the Central Valley (*i.e.*, the Feather River) is limited, in part, by late spring and summer water temperatures. Similar to salmonids in the Central Valley, green sturgeon spawning in the major lower river tributaries to the Sacramento River are likely to be further limited if water temperatures increase and suitable spawning habitat remains inaccessible.

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 Environmental Baseline

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

The action area encompasses 10.3 ac of Miner Slough (approximately 1050 ft upstream and 1025 ft downstream of the existing bridge), as well as 0.7.576 ac of riparian area, emergent seasonal wetland area, and shrub scrub wetland area. The action area includes areas adjacent to the project that may be adversely effected by (but not limited to) the following: noise generated by pile driving; sedimentation and increased turbidity; and construction-related effects.

2.3.1 Status of Listed Species in the Action Area

The action area provides potential rearing and migration habitat for CCV steelhead, CV spring-run Chinook, Sacramento River winter-run Chinook, and sDPS green sturgeon. Due to observed life history patterns for these species, one or more of the following life stages of each species may be present in the action area year-round: spawning adult/migrating adult (steelhead and green sturgeon only), migrating or rearing subadult (green sturgeon only) or rearing and emigrating juveniles (green sturgeon only).

CCV steelhead

CCV steelhead are known to utilize the north Delta region primarily as a migration corridor for spawning adults migrating to spawning reaches upstream and for out-migrating juveniles, providing access to the ocean. Two ongoing monitoring studies that are typically used as indicators of presence and abundance of CCV steelhead in the Delta are the USFWS delta juvenile fish monitoring program (DJFMP), which includes a Kodiak trawl survey at Chipps Island; and the CDFW and Reclamation salvage monitoring efforts at the SWP/CVP export facilities. Juvenile steelhead sampled at Chipps Island show a difference in outmigration timing between natural and hatchery origin CCV steelhead (Nobriga and Cadrett 2001, USBR 2008). Hatchery origin fish were shown to outmigrate from the Sacramento River watershed to the ocean between January and March. Natural origin fish displayed a more varied migration pattern with outmigration timing spread over a greater temporal scale, extending into spring and summer, suggesting that some juveniles may be present in the action area during the scheduled in-water work window. Adult escapement and spawning returns typically occur between August and November (Mc Ewan 2001) which also falls within the in-water work window.

Since the mid 1990's salvage data has shown an overall decrease in the percent of natural origin vs. hatchery origin CCV steelhead recovered, as well as a decrease in relative abundance. These findings are indicative of a decrease in natural origin steelhead occupying the Delta.

CV spring-run Chinook

CV spring-run Chinook are thought to use the north Delta region as a migration corridor, however unlike steelhead, there is more evidence that they utilize this area for juvenile rearing as well. Allen and Hassler (1986) showed that in estuaries, as juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed. Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). A unique trait of CV spring-run Chinook life history relative to other Central Valley salmonids is the tendency for some juveniles to exhibit rearing in their natal stream for up to a year prior to outmigration. These "yearlings" may enter the Delta as early as November or December and continue outmigration through March. In addition to Delta rearing of fry and parr life stages, yearling individuals may utilize the north Delta for rearing as well. Peak outmigration of juvenile CV spring-run Chinook occurs in March and April and drops off in May. Adult escapement typically occurs from April through June and may extend into early summer.

Sacramento River winter-run Chinook

Similar to CCV steelhead, Sacramento River winter-run use the north Delta primarily as a migration corridor. Relative abundance is inferred through salvage monitoring data, CDFW rotary screw trap sampling, and U.S. Fish and Wildlife Service (USFWS) Delta Juvenile Fish Monitoring Program (DJFMP) data. Juveniles outmigrate from the mainstem Sacramento River in late fall/early winter and begin to enter the Delta in October. Juvenile outmigration timing is thought to be strongly correlated with winter rain events that result in higher flows in the Sacramento River. Juvenile outmigration may last until April. Adult escapement and spawning migration through the Delta is expected to begin in January and extend through the end of April.

sDPS North American green sturgeon

The north Delta functions as both rearing habitat and as a migration corridor for sDPS green sturgeon. Based on salvage monitoring data, sDPS green sturgeon may be present in the Delta year-round, with data suggesting that presence there peaks in July and August. Little is known about downstream migration timing of juveniles, however they are thought to rear in the Delta prior to entering the ocean, marking the transition from juvenile to subadult life stages. Ocean entry timing is also poorly understood. Nakamoto et al. (1995) found that on average, green sturgeon on the Klamath River migrated to sea by age three and no later than age four. Laboratory experiments indicate that green sturgeon juveniles may occupy fresh to brackish water at any age, but they gain the physiological ability to transition to saltwater at approximately 1.5 years of age (Allen and Cech 2007). This information suggests that some juvenile and subadult green sturgeon will likely occupy the action area during the scheduled in-water work window. Based on data from acoustic tags (Heublein et al. 2009), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between January and early May. Migration through the bay/Delta takes about one week and progress upstream is fairly rapid to their spawning sites (Heublein et al. 2009).

2.3.2 Status of Critical Habitat in the Action Area

CCV steelhead and CV spring-run Chinook

The Action Area includes critical habitat that has been designated for CCV steelhead and CV spring-run Chinook. Critical habitat was designated under the same federal ruling for these two species as their habitat requirements are very similar. The PBFs for these species' designated critical habitat that occur in the action area are: Migration Corridor and Estuarine Areas. Due to adjacent agricultural activity, levee construction and maintenance, shoreline armoring, removal of riparian and wetland vegetation, and removal of woody debris, these PBFs have been significantly degraded from their natural historical condition. Similar activities throughout the north Delta have resulted in degradation of these PBFs across the entire region. Conditions for juvenile rearing in these areas are poor and likely contribute to reduced growth and survival of these species.

Sacramento River winter-run Chinook

Critical habitat PBFs for Sacramento River winter-run Chinook that occur in the action area are: Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River; Habitat and adequate prey free of contaminants; Riparian habitat that provides for successful juvenile development and survival; and access of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean. These PBFs have been significantly degraded from their historical condition and this degradation has contributed to the decline of this species. Access to historical spawning habitat upstream of Keswick and Shasta dams has been completely blocked. As in the case of CV spring-run Chinook and CCV steelhead, the quality and quantity of riparian habitat in the north Delta region has been degraded from its historical condition, reducing its overall functionality. Due to increasing urbanization, near-shore development, agriculture, and other human activities, the aquatic ecosystem in the Delta is exposed to a wide variety of contaminants. Multiple studies have documented high levels of contaminants in the Delta (Leatherbarrow et al. 2005, Brooks et al. 2012), suggesting that fish are exposed to them however, the inability to characterize concentrations and loading dynamics makes it difficult to quantify transport and total contaminant loading in the system (Johnson et al 2010). Highly managed hydrologic conditions in the Sacramento River likely impact outmigration patterns of juveniles, as outmigration timing has been correlated with high flow events *sDPS North American green sturgeon*

The following PBFs for sDPS green sturgeon occur in the Action Area: Food Resources; Water Flow; Water Quality; Migratory Corridor; Water Depth; and Sediment Quality. Weston et al. (2004) found that measured levels of toxic substances throughout the Central Valley sourced from agricultural activity result in lethal effects to aquatic macroinvertebrates *Hyalella Azteca* (amphipod) and *Chironomus tentans*.(midge). These findings suggest that the benthic food resources of sDPS green sturgeon may be impacted by agricultural activity in the north Delta. Throughout the north Delta, water flow and quality has been degraded from historical conditions and is particularly poor during drought years. Low flow conditions increase water temperatures and can potentially create thermal barriers. Input of inorganic nutrients and contaminants from agricultural runoff has created poor water quality conditions in the north Delta and has had a negative impact on the aquatic ecosystem. Although levee construction and shoreline armoring has had less of an impact on juvenile rearing habitat of sDPS green sturgeon relative to listed salmonids, the change in habitat structure and substrate types has likely impacted food resources, piscivorous predator abundance and flow dynamics in the north Delta.

2.3.3 Factors Affecting Listed Species and Critical Habitat in the Action Area

Range-wide factors that affect listed fish species are described in section 2.2. This section will focus on factors that are specific to the Action Area.

The north Delta region has been degraded from its historic condition and many anthropomorphic and naturally occurring factors have led to the decline of anadromous fish in the system. Due to the construction of dams on the majority of major tributaries to the Sacramento River, flows and temperatures have been altered from their natural and historic regimes. Altered flow regimes can influence migratory cues, water quality (including contaminants, dissolved oxygen and nutrients for primary productivity) and temperature. Construction of the dams has also restricted access to historic spawning and rearing habitat, leading to the decline of anadromous fish abundance in the Sacramento River Baisin. This is particularly true for Sacramento River winter-run Chinook salmon. Many of the PBFs described in section 2.3.2 have been impacted by altered and reduced flows in the north Delta. Drought conditions have played a significant role in the past 5 years as flows have decreased and summer temperatures have increased, leading to unfavorable environmental conditions in the Sacramento River watershed. This has resulted in direct and indirect impacts to listed fish as well as impacts to critical habitat. Increased temperatures also have the potential to disrupt aquatic macroinvertebrate production, leading to declines in food availability (Ward and Stanford 1982).

The north Delta has been heavily urbanized. This has likely increased the magnitude of contaminant loading in the aquatic ecosystem. Heavy metals, PAHs, petroleum products, plastics, fertilizer and many other contaminants can enter the river via urban runoff. Shore side development leads to decreased recruitment of LWM and results in a loss of habitat complexity which is a critical component of the freshwater rearing PBF.

2.3.4 Importance of the Action Area to the Survival and Recovery of Listed Species

The north Delta contains viable rearing and migratory habitat for listed anadromous fish species. In a fully-functional state, it promotes growth, survival and proliferation of the species. The specific frequency and magnitude of habitat utilization within Miner Slough by each species is not well understood and may vary among water year types. Presumably, it serves as a migration corridor for all listed species addressed in this BO, providing access to spawning grounds for returning adults as well as access to estuarine and ocean habitats for outmigrating juveniles. Miner Slough provides rearing habitat that is likely utilized by juvenile and subadult sDPS green sturgeon, although the spatial dynamics of rearing at those life stages is not well understood.

Miner Slough contains designated critical habitat for all listed species addressed in this BO and the action area contains PBFs related to rearing and migration (see section 2.3.2). These PBFs are of critical importance in the north Delta region as it serves as a spatial link between all habitats located within each species' geographical range (spawning/freshwater and estuarine/ocean). The NMFS Recovery Plan for Central Valley Chinook Salmon and Steelhead (NMFS 2014a) identifies recovery actions in the Delta that are of vital importance to the eventual recovery of these listed species. The following recovery actions pertain to the proposed action and the habitat located within the action area:

- *Restore, improve, and maintain salmonid rearing and migratory habitats in the Delta and Yolo Bypass to improve juvenile salmonid survival and promote population diversity.*
- *Utilize biotechnical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap.*
- *Increase monitoring and enforcement to stop illegal rip rap applications in the Delta.*
- *Curtail further development in active Delta floodplains through zoning restrictions, county master plans and other Federal, State, and county planning and regulatory processes, and land protection agreements.*
- *Implement management actions for addressing invasive aquatic species including those described in the California Aquatic Invasive Species Management Plan.*
- *Continue development of a long-term strategy for monitoring and regulating discharges from agricultural lands to protect waters within the Central Valley, including enforcing the regulations.*

An effort to finalize the NMFS recovery plan for sDPS green sturgeon is currently underway. A NMFS recovery outline was completed in 2010 and provides interim guidance on recovery actions (NMFS 2010). The following are recovery tasks that were identified in the outline and pertain to the proposed action and the habitat located within the action area:

- *Address the application of pesticides (Carbaryl and others) and herbicides applied to control burrowing shrimp and non-native plants in estuaries.*
- *Identify and prioritize potential contaminants of concern in the Central Valley.*

2.4 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 proposed action includes activities that may directly or indirectly impact CCV steelhead and/or their critical habitat, CV spring-run Chinook salmon and/or their critical habitat, Sacramento River winter-run Chinook salmon and/or their critical habitat, and sDPS green sturgeon and/or their critical habitat. The following is an analysis of the potential direct and indirect effects to listed fish species and/or their critical habitat that may occur as a result of implementing the Miner Slough Bridge Replacement project.

2.4.1 Effects of the Proposed Action to Listed Fish Species

Based on best available life history information and monitoring data on the four species for which ESA designated critical habitat and geographical range occurs in the action area, species/life stages that are expected to be present during the proposed work window include the juvenile and adult life stages of CCV steelhead and the juvenile, subadult and adult life stages of sDPS green sturgeon. Other species/life stages are excluded from this analysis as potential effects to them are considered to be discountable based on their expected absence from the action area during the proposed work window (NMFS 2014a, USFWS 1976 – 2016 DJFMP Chipps Is. Trawl Data). The following analysis includes potential sources of take for the species resulting from the proposed action as well as the likelihood of those sources contributing to overall take associated with the proposed action.

Hydroacoustic Impacts

Construction of the new bridge will involve the installation of CISS piles within the channel and will require piles to be driven with an impact hammer. Each hammer strike on a given pile causes it to reverberate, generating a wave of sound that propagates through water. These high levels of sound have the potential to cause acute injury or death to fish present in Miner Slough and also have the potential to cause behavioral effects.

The fisheries hydroacoustic working group (FHWG 2008) has established threshold sound levels in which acute injury, cumulative injury (sound exposure level (SEL) for fish either ≥2g or <2g), or behavioral effects (root mean squared (RMS)) may occur. Those levels are 206-dB_{PEAK}, 187-dB_{SEL}, 183-dB_{SEL}, and 150-dB_{RMS} respectively. Acute injury may occur to any sized fish if they are within range of the source of sound to the extent that the sound exceeds a threshold of 206-dB_{PEAK} at any given time. Acute injury may also occur as a result of cumulative exposure to sound pressure if fish are exposed to levels exceeding 187-dB_{SEL} (for fish ≥2g) and 183-dB_{SEL} (for fish <2g) for more than one day or for a maximum of three piles driven in a day. Finally, changes in behavior may occur if sound levels exceed 150-$dB_{RMS.}$ These behavioral changes may have deleterious effects to growth and survival of fish in the action area.

The most common form of acute injury to fish resulting from impact pile driving is barotrauma to the fish's swim bladder. When sound propagates through the water, tissues of the swim bladder may become ruptured or torn as the sound wave passes through the fish and pressure levels rapidly rise and fall, causing the swim bladder to expand and contract. Internal organs adjacent to the swim bladder may be injured as well (Gaspin 1975). Both salmonids and sturgeon have physostomous swim bladders that may become injured in this way. Other injuries have been documented as well including structural damage to auditory organs (Enger 1981; Hastings *et al.* 1995, 1996) causing equilibrium problems (Hastings 1995). The fitness of salmonids and sturgeon may be reduced if they experience these injuries as their behaviors for swimming, predator avoidance, feeding and migrating may become temporarily or permanently impaired.

Behavioral effects may occur if sound levels exceed the established threshold of 150-$dB_{RMS.}$ Sound waves below 150-dB_{RMS} are considered to be "effective quiet" and are not considered to be harmful to fish. Behavioral effects can include disruptions in feeding behavior, predatory avoidance behavior, and migratory behavior; impacting overall fitness of a species. "Agitation" is indicated by a change in swimming behavior, such as detected by Shin (1995) with salmonids, or "alarm" detected by McCauley *et al.* (2003). Additionally, Popper (1997) observed a "startle" response indicated by a quick burst in swimming following pile strikes.

Miner Slough serves as a migration corridor for both CCV steelhead and sDPS green sturgeon. Additionally, green sturgeon may also utilize this habitat for rearing. With respect to these species, it is expected that take will occur in the form of injury or death (acute injury) or harassment (behavioral effects).

Dewatering and Fish Rescue Operations

Following installation of the coffer dams around pier 3, dewatering will take place to make way for pile driving and pier installation. During the dewatering and fish rescue process, take will occur in the form of harassment as fish are handled and removed from the dewatered area. Sein nets, dip nets and/or electrofishing methods may be used to remove fish. Some incidental injury or mortality may occur during this process as fish experience abrasion from handling, exposure to air, and close proximity to one another as they are placed in the temporary holding tank. In addition, electrofishing techniques may result in some incidental injury or mortality. Throughout the duration of the project, based on best available information regarding relative abundance and migration timing, NMFS estimates that no more than 2 juvenile or subadult sDPS green sturgeon, 1 adult green sturgeon, 3 juvenile CCV steelhead, and/or 1 adult CCV steelhead may become entrained within the cofferdam or 72-inch piles (see Section 2.8.1).

Increased Sedimentation and Turbidity

Increased sedimentation and turbidity may occur as a result from the following construction activities within the channel: pile driving activities associated with the construction of the new bridge, temporary trestle, and operator control house; demolition of the existing bridge; geotechnical drilling; and dewatering activities. Sources of sedimentation and increased turbidity outside of the channel include: realignment activities; excavation and installation of new bridge abutments; and post-project recontouring and regrading activities.

Juvenile and adult CCV steelhead are known to utilize the action area as a migration corridor during the proposed in-water work window and are therefore expected to be present during construction activities. Increased sedimentation and turbidity could potentially have direct and indirect adverse effects to adult CCV steelhead though gill fouling, reduced foraging ability and reduced predator avoidance (Kemp et al. 2011). Juvenile salmonids are not likely to avoid increased levels of turbidity below a level of 70 nephelometric turbidity units (NTU) (Bash et al. 2001). As a result, they may at greater risk to turbidity and sediment-related effects than adults. One effect of turbidity that has important implications for juvenile salmonids is that predator avoidance behavior has been shown to decrease at increased levels of turbidity (Gregory 1992). Growth and survival amidst increased sediment and turbidity levels has also been shown to decrease resulting from reduced prey detection and availability and physical injury due to increased activity, aggression and gill fouling (Suttle et al. 2004, Kemp et al 2011). Less information is available on the abundance and distribution at various life stages of sDPS green sturgeon. However, based on the best available information on their life history, individuals at the juvenile, sub-adult and adult life stages are expected to be present in the action area. Large increases in turbidity as well as sedimentation events have the potential to cause acute injury by gill fouling in sDPS green sturgeon. BMPs, minimization and avoidance measures will be implemented during construction to avoid or minimize increases in turbidity and sediment-related effects (see Section 1.4). Also, due to the relatively small spatial scale of the action area and proposed activities, increases in turbidity are expected to be transient in nature. Potential adverse effects to juvenile and adult CCV steelhead; and juvenile, sub-adult, and adult sDPS green sturgeon resulting from sedimentation and increases in turbidity will be insignificant as they will not occur at a scale in which take will occur.

Contaminants and Pollution-related Effects

The proposed action will involve heavy construction equipment and many potential sources of hazardous material contamination in the Action Area. Potential sources of pollutants include hazardous material spills, petroleum product leaks in construction equipment, introduction of metals from the operation of equipment and vehicles and the disturbance of sediments that may contain hazardous suspended particulates. BMPs, avoidance and minimization techniques will be implemented, minimizing the probability of pollutant incursion into Miner Slough. However, unlike sedimentation and turbidity-related effects, potential pollution-related effects have the potential to be highly persistent in the Action Area and may affect multiple species and life stages if they were to occur.

Incursion of contaminants into the action area has the potential to directly or indirectly effect species present at the time of construction or possibly afterwards. Construction equipment and heavy machinery will be present in the action area and metals may be deposited through their use and operation (Paul and Meyer 2001). These materials have been shown to alter juvenile salmonid behavior through disruptions to various physiological mechanisms including sensory disruption, endocrine disruption, neurological dysfunction and metabolic disruption (Scott and Sloman 2004). Oil-based products used in combustion engines are known to contain PAHs which have been known to bio-accumulate in other fish taxa such as Pleuronectiformes and have carcinogenic, mutagenic and cytotoxic effects (Johnson et al 2002). The exact toxicological effects of PAHs in salmonids and sturgeon is not well understood, although studies have shown that increased exposure of salmonids to PAHs reduced immunosuppression, increasing their susceptibility to pathogens (Arkoosh et al. 1998, Arkoosh and Collier 2002). Adult CCV steelhead and juvenile, sub-adult and adult sDPS green sturgeon are expected to be present in the action area during construction activities and would potentially be acutely injured by a pollution event. Other listed species and life stages are expected to be present in Miner Slough during winter and spring months and could be indirectly affected by a pollution event if contaminants were to settle within substrate in the active channel that may become disturbed at a later time.

BMPs, avoidance and minimization measures are described in Section 1.4 and will aid in minimizing potential direct or indirect adverse effects to listed fish species. Potential direct or indirect adverse effects resulting from the incursion of contaminants into Miner Slough are insignificant as they will not reach the scale where take occurs.

2.4.2 Effects of the Proposed Action to Critical Habitat PBFs

Critical habitat has been designated in the Action Area for CCV steelhead, CV spring-run Chinook, Sacramento River winter-run Chinook, and sDPS green sturgeon. The following analysis includes potential effects to critical habitat PBFs resulting from the proposed action.

Effects to critical habitat PBFs: Sedimentation

The action area contains rearing and migration habitat for all species addressed in this BO, with the potential for degradation of PBFs resulting from sedimentation associated with the proposed action. Kemp et al. (2011) describe a suite of physiochemical effects to lotic aquatic systems resulting from increased sedimentation and sediment-related events (Figure 2). Most notably, sedimentation events in a system that shares both lotic and estuarine characteristics have the potential to increase turbidity on a broad temporal scale and reduce oxygen supply. These impacts would degrade the PBFs of Migratory Corridor and Estuarine Areas for CCV steelhead and CV spring-run Chinook; and riparian habitat that provides for successful juvenile development and survival for Sacramento River winter-run Chinook salmon. Additionally, as is highlighted in Figure 2, sedimentation has the potential to reduce benthic invertebrate density and result in the loss of physical habitat. Therefore the following PBFs for sDPS green sturgeon could potentially be impacted by sedimentation: Food Resources; Water Quality; Migratory Corridor; Water Depth; and Sediment Quality.

BMPs, minimization and avoidance measures will be implemented during construction to avoid or minimize sediment-related effects (see Section 1.4). Potential adverse effects to critical habitat PBFs for the species addressed in this BO resulting from sedimentation will be insignificant as they will not occur at a scale in which habitat will be permanently impacted or reduce the conservation value of critical habitat.

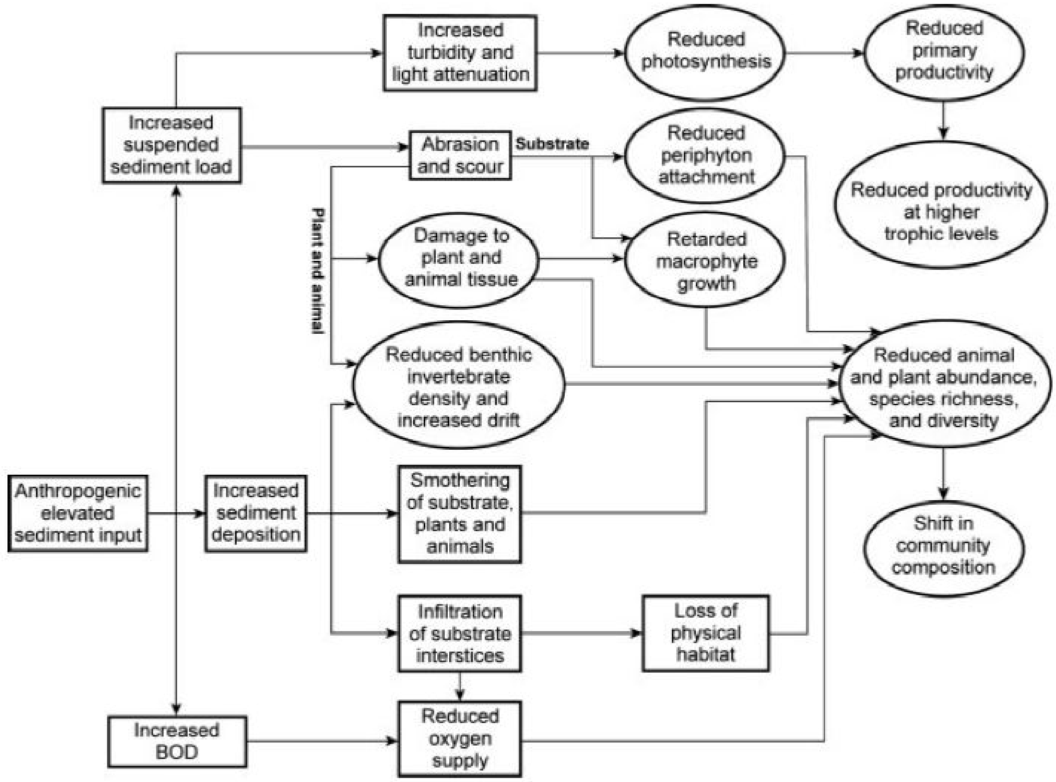


Figure 2. Negative impacts of anthropogenically enhanced sediment input to lotic aquatic systems at lower trophic levels. Rectangles and ovals respectively denote physiochemical effects and direct and long-term biological and ecological responses. *From: Kemp et al. (2011)*

Effects to critical habitat PBFs: Riparian Vegetation Removal

Removal of riparian vegetation will occur in the process of operating heavy construction machinery, equipment staging, and installation of the new infrastructure associated with the project. These activities have the potential to have direct or indirect adverse effects on critical habitat PBFs. Riparian vegetation plays a key role in the conservation value of rearing habitat for many salmonid and green sturgeon life stages. It provides shading to lower stream temperatures; increases the recruitment of LWM into the river, increasing habitat complexity; provides shelter from predators and; enhances the productivity of aquatic macro invertebrates (Pusey and Arthington 2003, Anderson and Sedell 1979). It has also been shown to directly influence channel morphology and may be directly correlated with improved water quality in aquatic systems (Dosskey et al. 2010, Schlosser and Karr 1981). It has been suggested by Dosskey et al. (2010) that presence and abundance of riparian vegetation can be directly correlated with water quality in riverine systems through biogeochemical cycling, soil and channel chemistry, water movement and erosion.

0.061 ac of forested riparian habitat will be permanently lost and 0.186 ac will be temporarily lost as a result of this project. This loss of riparian vegetation will result in the degradation of Migratory Corridors and Estuarine Area critical habitat PBFs for CCV steelhead and CV spring-run Chinook salmon; Riparian habitat that provides for successful juvenile development and survival PBF for Sacramento River winter-run Chinook salmon; and Food Resources, Water Quality, and Migratory Corridor PBFs for sDPS green sturgeon. However, losses of riparian vegetation due to the implementation of the proposed action will be minimized and effects will be mitigated through the use of BMPs, minimization and avoidance measures, and on- and off-site mitigation activities described in Section 1.4. The loss of riparian vegetation will occur at a small, localized spatial scale and will not reduce the conservation value of critical habitat.

2.5 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.

The north Delta region has experienced heavy agricultural activity and urbanization in the last century, leading to habitat loss, degradation of existing habitat and degradation of water quality. Grazing activities of livestock adjacent to water ways as well as the application of pesticides, herbicides and fertilizer result in an influx of harmful chemicals and inorganic nutrients that reduce the conservation value of existing fish habitat. In addition, agricultural and urban infrastructure have increased, altering the natural geomorphology of the north Delta and leading to increased inputs of contaminants (see Section 2.3.2). Urbanization increases the demand for additional infrastructure and access to natural resources such as potable water, natural gas, electricity, etc.

Recreational uses of the north Delta region have increased as well as local urban populations have grown in the area. Boat and other associated activities have led to increased shoreline development, leading to losses of riparian and wetland habitat. Boating activities may also directly impact riparian and wetland habitat as boats may operate in shallow, near shore areas. Contaminants that may have settled in sediments may be churned up by boat propellers and suspended in the water column. Additionally, recreational boats serve as primary vectors for the spread of invasive aquatic organisms including both invertebrates and plant species.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

CCV steelhead, CV spring-run Chinook, Sacramento River winter-run Chinook, and sDPS green sturgeon have experienced significant declines in abundance and available habitat in the

California Central Valley and California Delta relative to historical conditions. The status of the species and critical habitat and environmental baseline sections (2.2 and 2.3) detail the current range-wide status of these species and also the current baseline conditions found in the north Delta region where the proposed action is to occur. Section 2.2.4 discusses the vulnerability of listed species and critical habitat to climate change projections in the California Central Valley and Delta. Climate effects in the Delta resulting from reduced summer flows and increased water temperatures throughout the Sacramento and San Joaquin watersheds will likely be exacerbated by increasing surface temperatures in the estuary. The north Delta is a highly manipulated system with flow and temperature regimes that differ drastically from their historical condition. Cumulative effects are likely to include continued loss of riparian and wetland habitat as well as degraded water quality resulting from agricultural activities and continued urban development.

Effects of the Proposed Action to Listed Species

The species/life stages that are expected to be present in the action area during the planned in-water work window of August 1 through November 30 are adult CCV steelhead; and juvenile, sub-adult, and adult sDPS green sturgeon. Hydroacoustic effects will result in take of these species as impact hammer pile driving techniques will be implemented and sound levels are projected to exceed the "effective quiet" threshold of 150 dB established by the FHWG. Acoustic impacts may result in acute injury and/or behavioral effects. Dewatering activities will cause take in the form of harassment as fish are handled and stored temporarily prior to their release back into Miner Slough. Sedimentation and increases in turbidity may occur as a result of pile driving activities associated with the construction of the new bridge, temporary trestle, and operator control house; demolition of the existing bridge; geotechnical drilling; and dewatering activities. Additionally, the potential exists for contaminant incursion into the channel, which could result in acute toxicity to listed fish species occupying the action area at the time of construction, or may result in contamination of sediment that could be re-suspended at a later time. Following the analysis of the BA and supporting materials, NMFS finds that the proposed minimization and avoidance measures will be sufficient to limit the effects of sedimentation, turbidity, and contaminants to insignificant levels.

Effects of the Proposed Action to Critical Habitat

Critical habitat has been designated in the action area for all four species addressed in this BO. The project will result in minor losses of benthic habitat due to the suspension of sediment associated with pile driving, installation of the coffer dam around pier 3 the removal of the existing bridge. Additionally, minor losses of riparian habitat will occur as a result of the added infrastructure associated with the project. PBFs pertaining to rearing and migration for all species will be impacted to a minor extent, however, there is ample analogous habitat upstream and downstream of the action area. It is NMFS' determination that impacts will not result in channel-wide effects or reduce the conservation value of critical habitat and therefore will not impair the fitness, survival and recovery of these listed species.

Survival and Recovery

Miner Slough serves as a migratory corridor for all species addressed, providing access between estuarine/ocean habitat and freshwater rearing and spawning habitat. It also provides rearing habitat which is thought to be utilized by sDPS green sturgeon, although the spatial dynamics of their rearing behavior in the north Delta is not well understood. The habitat present in the action area falls under many of the PBF characterizations for each listed species. Although conservation value of the habitat present in the action area has been degraded from its historical condition, it remains functional to some degree and contributes to the carrying capacity of the north Delta region to support anadromous fish species.

Recovery actions identified in section 2.3.4 highlight the importance of the north Delta region to the survival and recovery of the species addressed in this document.

2.7 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 CCV steelhead, CV spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, or sDPS North American green sturgeon; or destroy or adversely modify their designated critical habitat (Table 2).

Table 2. Summary of ESA Section 7 Determinations.

Species	**Is the Proposed Action likely to result in adverse effects to the species?**	**Is the Proposed Action likely to result in Jeopardy for the species?**	**Is the Proposed Action likely to result in destruction or adverse modification of critical habitat?**
CCV steelhead (*O. mykiss*)	Likely	No	No
CV spring-run Chinook (*O. tshawytscha*)	Not Likely	No	No
Sacramento River winter-run Chinook (*O. tshawytscha*)	Not Likely	No	No
sDPS North American green sturgeon (*Acipenser medirosris*)	Likely	No	No

2.8 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 incidental take statement.

2.8.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

NMFS anticipates incidental take of CCV steelhead and sDPS green sturgeon to occur in the course of the Miner Slough Bridge Replacement project. Specifically, NMFS anticipates that juvenile and/or adult CCV steelhead; and/or juvenile, subadult, and/or adult green sturgeon may be killed, wounded or harassed as a result of project implementation as they will likely be present in the Action Area during the scheduled in-water work window. Take is expected to occur in the form of injury, death and/or harassment resulting from pile driving and dewatering activities (see Section 2.4.1 *Effects of the Proposed Action to Listed Fish Species*).

Take Resulting from Hydroacoustic Impacts

The proposed pile driving activities associated with the project include pile driving using both vibratory and impact hammering methods. For the new bridge structure: a coffer dam will be installed around pier 3 using a vibratory hammer (approximately 88 sheet piles); small diameter piles will be driven in behind the dewatered cofferdam using a vibratory hammer and then driven to final tip elevation using an impact hammer (25 24-inch steel piles); and at pier 4, two 72-inch steel piles will be driven using an impact hammer. 1,620 hammer strikes per pile are expected for the 72-inch CISS piles and 1,800 are expected for the 24-inch piles. Number of piles per day will be limited to two 72-inch piles and 10 24-inch piles. Remaining piles associated with the project will be installed outside the active channel. Noise that may reverberate through the ground as a result of driving these piles is not expected to exceed the "effective quiet" threshold of 150dB.

Table 3 includes distance thresholds in which CCV steelhead or sDPS green sturgeon may be exposed to sound levels that may result in injury or death. The installation of piers 2 and 3 will involve in-water pile driving, resulting in excessive noise that is expected to cause take in the form of injury or death during the proposed in-water work window. The actual number of CCV steelhead and sDPS green sturgeon that may be incidentally taken during these activities is expected to be small. NMFS will use the area of sound pressure waves projected to occur as a surrogate for the amount and extent of take resulting from exposure to high sound pressure levels (>206-dB_{PEAK}, and >187-dB_{SEL}(fish $\geq$2g)). The species addressed in this BO are not expected to occur in the action area at a life stage in which they would be <2g in total mass. Table 3 indicates that peak sound levels will be below the 206 dB threshold, therefore take in the form of injury or death will not occur as a result of sound levels exceeding the peak limit. Cumulative SEL thresholds are exceeded, therefore take is expected to occur in the form of injury or death for fish migrating within 630 feet of the 72-inch CISS piles and within 354 feet of the 24-inch CISS piles. Beyond this distance, sound pressure levels are expected to exceed the 150-dB_{RMS} threshold in which behavioral impacts may occur for 2,192 feet upstream and 630 feet downstream for 72-inch piles, and 971 feet upstream and 603 feet downstream for 24-inch piles (Table 3). Within these distances, take is expected to occur in the form of harassment as behavior may be disrupted.

If Caltrans monitoring finds that sound pressure levels greater than 206-dB_{PEAK}, 187-dB_{SEL}, and 150-dB_{RMS} extend beyond the calculated distances provided to NMFS, the amount of incidental take may be exceeded.

Take Resulting from Dewatering and Fish Rescue Operations

The proposed in-water work window coincides with adult CCV steelhead migration timing, indicating that adult steelhead may become entrained in the coffer dam that will be constructed around pier 3 or the 72-inch CISS piles that will be installed at pier 2. In addition, juvenile, sub-adult and adult sDPS green sturgeon may be migrating or rearing within the action area, creating the possibility that they may become entrained in these areas as well. NMFS estimates that no more than 2 juvenile or subadult sDPS green sturgeon, 1 adult green sturgeon, 3 juvenile CCV steelhead, and/or 1 adult CCV steelhead may become entrained within the cofferdam or 72-inch piles. Based on fish salvage analysis from a previous Caltrans project (NMFS 2014b), it is expected that no more than ten percent of fish captured and relocated during pier installation may be injured or killed.

Exceedance of Take

If these ecological surrogates are not met and maintained, the proposed project will be considered to have exceeded anticipated take levels, thus requiring Caltrans to coordinate with NMFS within 24 hours on ways to reduce the amount of take down to anticipated levels. Anticipated incidental take will be exceeded if the criteria described above are not met, the project is not implemented as described in the BA prepared for this project, all conservation measures are not implemented as described in the BA (including successful completion of monitoring and reporting criteria), or the project is not implemented in compliance with the terms and conditions of this incidental take statement. If take is exceeded formal consultation must be reinitiated (50 C.F.R. § 402.16(a)).

Table 3. Results from hydroacoustic impact calculations provided by Caltrans (attenuated piles) (Caltrans 2016)

New Bridge Structure	Station	Pile Type	Pile Length	Number of Piles	Pile Location	Piles per Day	Estimated Blows per Pile (assumes piles driven to 90% of length)	Distance to Water (feet)	Peak	RMS	Single-strike SEL[1]	Cumulative SEL at 10 meters
Abutment 1	M1 26+19.93	24-inch	65	28	On Land	7	1,170	56	Piles on land and cannot be attenuated			
Pier 2	M1 26+79.14	72-inch	100	2	In Water	2	1,620	0	204	189	179	214
Pier 3	M1 27+89.14	24-inch	100	25	In Coffer Dam	10	1,800	0	190	175	162	205
Pier 4	M1 28+99.14	72-inch	100	2	On Land	2	1,620	16	Piles on land and cannot be attenuated			
Abutment 5	M1 29+61.90	24-inch	65	28	On Land	7	1,170	85	Piles on land and cannot be attenuated			

[1] *Single-strike SELs below 150 dB do not accumulate to cause injury to fish.*

New Bridge Structure	East of the Bridge (Upstream)				West of the Bridge (Downstream)			
	Distance to 187-dB Cumulative SEL Criteria (feet)	Distance to 183-dB Cumulative SEL Criteria (feet)	Distance to 150-dB RMS Criteria (feet)	Distance to 206-dB Peak Criteria (feet)	Distance to 187-dB Cumulative SEL Criteria (feet)	Distance to 183-dB Cumulative SEL Criteria (feet)	Distance to 150-dB RMS Criteria (feet)	Distance to 206-dB Peak Criteria (feet)
Abutment 1	Piles on land and cannot be attenuated							
Pier 2	1,290	2,192[2]	2,192[2]	<33	630[2]	630[2]	630[2]	<33
Pier 3	354	607	971	<33	354	607	797[2]	<33
Pier 4	Piles on land and cannot be attenuated							
Abutment 5	Piles on land and cannot be attenuated							

[2] *Constrained by the river channel.*

2.8.2 Effect of the Take

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

2.8.3 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. Acoustic attenuation devices will be implemented to minimize noise generated by pile driving activities.

2. Fish rescue operations will be conducted according to the specifications provided to NMFS and the service-approved supervising biologist(s) will oversee all aspects of dewatering and fish handling operations.

3. Caltrans shall conduct onsite and offsite compensatory mitigation for temporary and permanent impacts to designated critical habitat.

4. Caltrans shall report any incidence of take to NMFS within 24 hours.

5. Caltrans shall provide a report of project activities to NMFS by December 31 of the construction year (2018 is currently the proposed calendar year).

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Caltrans or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Caltrans 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. The following terms and conditions implement reasonable and prudent measure 1:

    a. In-water pile driving activities (installation of piers 2 and 3) will be restricted to August 1 to October 31. No in-water pile driving activity is to extend into the month of November as it may pose a significant disturbance to anadromous fish migration through the north Delta.

    b. Acoustic attenuation devices will be routinely inspected for proper installation, operation, and functionality.

c. Sound monitoring shall occur to ensure that sound pressure levels generated by pile driving activities are not exceeding those included in the incidental take statement above.

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

   a. If they are to occur, all aspects of fish rescue operations shall be supervised by at least one service approved biologist who will be personally on site throughout each phase of the rescue operation.

   b. A written plan for a fish rescue operation specific to this project shall be established prior to implementation of the project. The plan shall be thoroughly understood by all individuals that are to be involved and operations shall be conducted in strict accordance with the written plan.

3. The following terms and conditions implement reasonable and prudent measure 3:

   a. Caltrans shall rehabilitate the construction zone through onsite planting of native riparian vegetation.

   b. Caltrans shall purchase mitigation credits at a NMFS approved conservation bank at a 2:1 ratio for temporary losses and 3:1 ratio for impacts to critical habitat in the action area associated with this project.

   c. Caltrans shall, to the maximum extent practicable and above the ordinary high water level, mix agricultural grade soil with RSP at a 70:30 ratio (rock:soil), cover the RSP with one foot of soil and plant native riparian shrubs and trees.

   d. All onsite riparian vegetation shall be watered and maintained to ensure maximum survival for a three year period following construction.

4. The following terms and conditions implement reasonable and prudent measure 4:

   a. Caltrans shall record the date, number, and specific location of all listed fish that are relocated for each construction-related activity in the project area in addition to any direct mortality observed during in-water work and relocation. If a listed species is observed injured or killed by project activities, Caltrans shall contact NMFS within 48 hours at 916-930-3600. Notification shall include species identification, the number of fish, and a description of the action that resulted in take. If possible, dead individuals shall be collected, placed in an airtight bag, and refrigerated with the aforementioned information until further direction is received from NMFS.

5. The following terms and conditions implement reasonable and prudent measure 5:

a. This report shall include a summary description of in-water construction dates and activities, avoidance and minimization measures taken, mitigation credits purchased and any maintenance of restored areas on-site. Updates and reports required by these terms and conditions shall be submitted by December 31 of each year during the construction period to:

Assistant Regional Administrator
NMFS – WCR – California Central Valley Office
650 Capitol Mall, suite 5-100
Sacramento, CA 95814

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

(2) Caltrans should limit the amount of riprap used for bank and in-stream protection in the Central Valley to the minimum amount needed for erosion and scour protection and bench design. Engineering plans shall be provided to the contractors that clearly show the amount of riprap to be placed at the project site. Limitation of riprap in design considerations is consistent with agency requirements set forth in section 7(a)(1).

(3) Caltrans should consider using alternative methods to traditional rock slope protection for bridge projects and incorporating geotextiles for bank erosion control and prevention. Bioengineered products are available on the market and can be used to protect areas against erosive forces along shorelines and is an alternative to using riprap. Implementation of riprap alternatives in design considerations is consistent with agency requirements set forth in section 7(a)(1).

2.10 Reinitiation of Consultation

This concludes formal consultation for The Miner Slough Bridge Replacement Project.

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 incidental take statement 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 to 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.

2.11 "Not Likely to Adversely Affect" Determinations

NMFS does not anticipate the proposed action will take CV spring-run Chinook salmon or Sacramento River winter-run Chinook salmon (Table 2). Based on best available information, juvenile and adult life stages of each of these species are known occur in the action area and are not expected to be present in the action area during the proposed in-water work window. NMFS has also determined that the proposed action will NLAA critical habitat designated for CCV steelhead and CV spring-run Chinook salmon. Details regarding the potential for direct or indirect adverse effects to these species and/or their critical habitats are included in Section 2.4.

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

Section 305(b) of the Magnuson-Stevens Act (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 Caltrans and descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans 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, and **(2)** estuaries.

3.2 Adverse Effects on Essential Fish Habitat

Effects to the HAPCs listed in section 3.1 above are discussed in context of effects to critical habitat PBFs as designated under the ESA in section 2.4.2. Effects to ESA-listed critical habitat and EFH HAPCs are appreciably similar, therefore no additional discussion is included. A list of adverse effects to EFH HAPCs is included in this EFH consultation. Affected HAPCs are indicated by number corresponding to those identified as present in the action area in section 3.1:

<u>Sedimentation and turbidity</u>

- Reduced habitat complexity **(1, 2)**

<u>Bridge Installation and Removal of Existing Bridge</u>

- Degraded water quality **(2)**
- Permanent loss of wetland habitat **(1)**
- Reduction in aquatic macroinvertebrate production **(1)**

3.3 Essential Fish Habitat Conservation Recommendations

The following are EFH conservation recommendations for the proposed project:

(1) Caltrans should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid and sturgeon habitat restoration projects within the Sacramento River Basin. HAPCs that would benefit from this include **(1)** complex channels and floodplain habitats, and **(2)** estuaries.

(2) Caltrans should limit the amount of riprap used for bank and in-stream protection in the Central Valley to the minimum amount needed for erosion and scour protection and bench design. Engineering plans shall be provided to the contractors that clearly show the amount of riprap to be placed at the project site. HAPC complex channels and floodplain habitats would benefit from this.

(3) Caltrans should consider using alternative methods to traditional rock slope protection for bridge projects and incorporating geotextiles for bank erosion control and prevention. Bioengineered products are available on the market and can be used to protect areas against erosive forces along shorelines and is an alternative to using riprap.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, approximately 10.3 ac of designated EFH for Pacific coast salmon.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

Caltrans 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. FISH AND WILDLIFE COORDINATION ACT

The purpose of the Fish and Wildlife Coordination Act (FWCA) is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.

The following recommendation applies to the proposed action:

(1) Caltrans should support and promote aquatic and riparian habitat restoration within California's Central Valley, and implement practices that avoid or minimize negative impacts to salmon, steelhead, and sturgeon on all of their project sites within critical habitat.

The action agency must give these recommendations equal consideration with the other aspects of the proposed action so as to meet the purpose of the FWCA.

This concludes the FWCA portion of this consultation.

5. 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.

5.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the Caltrans, U.S. Department of Transpiration, and CH2M Hill Companies Ltd. Other interested users could include the USFWS; CDFW; FHWG; Delta Stewardship Council; and other federal, state, and local government entities or NGOs involved in Delta fish and wildlife conservation. Individual copies of this opinion were provided to Caltrans. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

5.2 Integrity

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

5.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

6. REFERENCES

A. Literature Cited

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

Allen, P. J., B. Hodge, I. Werner, and J. J. Cech. 2006. Effects of Ontogeny, Season, and Temperature on the Swimming Performance of Juvenile Green Sturgeon (*Acipenser Medirostris*). Canadian Journal of Fisheries and Aquatic Sciences 63(6):1360-1369.

Allen, P. J. and J. J. Cech. 2007. Age/Size Effects on Juvenile Green Sturgeon, *Acipenser Medirostris*, Oxygen Consumption, Growth, and Osmoregulation in Saline Environments. Environmental Biology of Fishes 79(3-4):211-229.

Anderson, N. H. and Sedell, J. R. 1979. Detritus processing by macroinvertebrates in stream ecosystems. Annual review of entomology 24(1): 351-377.

Arkoosh, M. R., E. Casillas, E. Clemons, A.N. Kagley, R. Olson, P. Reno and J.E. Stein. 1998. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10(2): 182-190.

Arkoosh, M. R. and T.K. Collier. 2002. Ecological risk assessment paradigm for salmon: Analyzing immune function to evaluate risk. Human and Ecological Risk Assessment 8(2): 265-276.

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

Bash, J., C.H. Berman and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. University of Washington Water Center. 74pp.

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2012. Restoring Salmon Habitat for a Changing Climate. River Research and Applications 29:939-960.

Benson, R., S. Turo, and B. M. Jr. 2006. Migration and Movement Patterns of Green Sturgeon (*Acipenser Medirostris*) in the Klamath and Trinity Rivers, California, USA. Environmental Biology of Fishes 79(3-4):269-279.

Brooks, M. L., E. Fleishman, L.R. Brown, P.W. Lehman, I. Werner, N. Scholz, C. Mitchelmore, J.R. Lovvorn, M. L. Johnson, D. Schlenk, S. van Drunick, J. I. Drever, D.M. Stoms, A.E. Parker, and R. Dugale. 2012. Life histories, salinity zones, and sublethal contributions of contaminants to pelagic fish declines illustrated with a case study of San Francisco Estuary, California, USA. Estuaries and Coasts, 35(2), 603-621.

Brown, K. 2007. Evidence of Spawning by Green Sturgeon, *Acipenser medirostris*, in the Upper Sacramento River, California. Environmental Biology of Fishes. 79(3-4):297-303.

California Department of Transportation. 2016. Biological Assessment for the Miner Slough Bridge Replacement Project. 91pp.

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 25:253–272.

Deng, X., J. P. Van Eenennaam, and S. Doroshov. 2002. Comparison of Early Life Stages and Growth of Green and White Sturgeon. American Fisheries Society.

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 change in the Merced, Carson, and American River basins, Sierra Nevada, California, 1900–2099. Climatic Change 62(1-3): 283-317.

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

Dimacali, R.L. 2013. A Modeling Study of Changes in the Sacramento River Winter-Run Chinook Salmon Population Due to Climate Change (Master’s Thesis). California State University, Sacramento.

Dosskey, M. G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval and R. Lowrance. 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams1. Journal of the American Water Resources Association. 2010: 261-277.

Dunford, W. E. 1975. Space and Food Utilization by Salmonids in Marsh Habitats of the Fraser River Estuary. Masters. University of British Columbia.

Emmett, R. L. H., Susan A.; Stone, Steven L.; Monaco, Mark E. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries Volume Ii: Species Life History Summaries.

Enger, P. S. 1981. Frequency Discrimination in Teleosts—Central or Peripheral? Pages 243-255 in Hearing and Sound Communication in Fishes. Springer.

Erickson, D. L., J. A. North, J. E. Hightower, J. Weber, and L. Lauck. 2002. Movement and Habitat Use of Green Sturgeon *Acipenser Medirostris* in the Rogue River, Oregon, USA. Journal of Applied Ichthyology 18(4-6):565-569.

Fairey, R., K. Taberski, S. Lamerdin, E. Johnson, R.P. Clark, J.W. Downing, J. Newman, and M. Petreas. 1997. Organochlorines and other environmental contaminants in muscle tissues of sportfish collected from San Francisco Bay. Marine Pollution Bulletin 34(12): 1058-1071.

Feist, G. W., M. A. H. Webb, D. T. Gundersen, E. P. Foster, C. B. Schreck, A. G. Maule, and M.S. Fitzpatrick. 2005. Evidence of detrimental effects of environmental contaminants on growth and reproductive physiology of white sturgeon in impounded areas of the Columbia River. Environmental Health Perspectives 113:1675-1682.

Fisheries Hydroacoustic Working Group. 2008. Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities. June 12, 2008.

Foster, E. P., M. S. Fitzpatrick, G. W. Feist, C. B. Schreck, and J. Yates. 2001. Gonad organochlorine concentrations and plasma steroid levels in white sturgeon (*Acipenser transmontanus*) from the Columbia River, USA. Bulletin of Environmental Contamination and Toxicology 67:239-245.

Gaspin, J. B. (1975). Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay tests. *Navel Surface Weapons Center Report* NSWC/WOL/TR 75-58. Fort Belvoir, VA: Defense Technical Information Center.

Gerrity, P. C., C. S. Guy, and W. M. Gardner. 2006. Juvenile pallid sturgeon are piscivorous: a call for conserving native cyprinids. Transactions of the American Fisheries Society 135:604 - 609.

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.

Gregory R.S. 1993. Effect of turbidity on the predator avoidance behaviour of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fishery and Aquatic Sciences 50: 241-246. Hastings, M. C. 1995. Physical effects of noise on fishes. *Proceedings of INTER-NOISE 95, The 1995 International Congress on Noise Control Engineering* **II** 979–984.

Hastings, M.C., AN. Popper, U. Finneran, and P. Lanford. 1996. Effects of low frequency sound on hair cells of the inner ear and lateral line of the teleost fish *Astronotus ocellatus.* J. Acoustical Soc. Am. 99(3): 1759-1766.

Heublein JC, Kelly JT, Crocker CE, Klimley AP, Lindley ST. 2009. Migration of green sturgeon, Acipenser medirostris, in the Sacramento River. Environ Biol Fishes 84:245 258.

Israel, J. A. and A.P. Klimley. 2008. Life history conceptual model for North American green sturgeon (*Acipenser medirostris*). California Department of Fish and Game, Delta Regional Ecosystem Restoration and Implementation Program.

Johnson, L.L., T.K. Collier, J.E. Stein. 2002. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. Aquatic Conservation: Marine and Freshwater Ecosystems 12: 517-538

Johnson, M. L., I. Werner, S. Teh, and F. Loge. 2010. Evaluation of chemical, toxicological, and histopathologic data to determine their role in the pelagic organism decline. Final report to the California State Water Resources Control Board and Central Valley Regional Water Quality Control Board. University of California, Davis. 188pp.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of Green Sturgeon, *Acipenser Medirostris*, in the San Francisco Bay Estuary, California. Environmental Biology of Fishes 79(3-4):281-295.

Kemp, P., D. Sear, A. Collins, P. Naden and I. Jones. 2011. The impacts of fine sediment on riverine fish. Hydrological Processes 25(11): 1800-1821.

Kogut, N. 2008. Overbite clams, *Corbula amerensis,* defecated alive by white sturgeon, *Acipenser transmontanus*. California Fish and Game 94:143-149.

Kruse, G. O. and D.L. Scarnecchia. 2002. Assessment of bioaccumulated metal and organochlorine compounds in relation to physiological biomarkers in Kootenai River white sturgeon. Journal of Applied Ichthyology 18: 430–438.

Kynard, B., E. Parker, and T. Parker. 2005. Behavior of Early Life Intervals of Klamath River Green Sturgeon, *Acipenser Medirostris*, with a Note on Body Color. Environmental Biology of Fishes 72(1):85-97.

Laetz, C. A., D. H. Baldwin, T. K. Collier, V. Hebert, J. D. Stark, and N. L. Scholz. 2009. The Synergistic Toxicity of Pesticide Mixtures: Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives, Vol. 117, No.3:348-353.

Leatherbarrow, J.E., L.J. McKee, D.H. Schoellhamer, N.K. Ganju, and A.R. Flegal. 2005. Concentrations and loads of organic contaminants and mercury associated with suspended sediment discharged to San Francisco Bay from the Sacramento-San Joaquin River Delta, California RMP Technical Report. SFEI Contribution 405. San Francisco Estuary Institute. Oakland, CA. 84pp.

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.

Lindley, S. 2008. California Salmon in a Changing Climate. Presentation for the National Marine Fisheries Service.

Linville, R.G., S.N. Luoma, L. Cutter, and G.A. Cutter. 2002. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology 57: 51-64.

Mayfield, R. B. and J. J. Cech. 2004. Temperature Effects on Green Sturgeon Bioenergetics. Transactions of the American Fisheries Society 133(4):961-970.

McCauley, R. D.; Fewtrell, J. & Popper, A. N. 2003. High intensity anthropogenic sound damages fish ears. Journal of the acoustic Society of America. 113:638-642.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5. Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. Prepared as Part of U.S. Epa, Region 10 Temperature Water Quality Criteria Guidance Development Project. U.S. Environmental Protection Agency, EPA-910-D-01-005.

McDonald, J. 1960. The Behaviour of Pacific Salmon Fry During Their Downstream Migration to Freshwater and Saltwater Nursery Areas. Journal of the Fisheries Research Board of Canada 7(15):22.

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

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

McClure, 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.

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.

Michel, C. J. 2010. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus Tshawytscha*) Smolts and the Influence of Environment. Master's Thesis. University of California, Santa Cruz, Santa Cruz.

Michel, C. J., A. J. Ammann, E. D. Chapman, P. T. Sandstrom, H. E. Fish, M. J. Thomas, G. P. Singer, S. T. Lindley, A. P. Klimley, and R. B. MacFarlane. 2012. The Effects of Environmental Factors on the Migratory Movement Patterns of Sacramento River Yearling Late-Fall Run Chinook Salmon (*Oncorhynchus Tshawytscha*). Environmental Biology of Fishes.

Moser, M. L. and S. T. Lindley. 2007. Use of Washington Estuaries by Subadult and Adult Green Sturgeon. Environmental Biology of Fishes 79(3-4):243-253.

Mosser, C.M., L.C. Thompson and J.S. Strange. 2013. Survival of captured and relocated adult spring-run Chinook salmon Oncorynchus tschawytscha in a Sacramento River tributary after cessation of migration. Environmental Biology of Fish 96: 405-417.

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

Muir, W. D., 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).

Nakamoto RJ, Kisanuki TT, Goldsmith GH. 1995. Age and growth of Klamath River green sturgeon (Acipenser Medirostris). USFWS Project # 93-FP-13. January 31, 1995. 27p.

National Marine Fisheries Service. 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Cenral Valley Project and State Water Project. S. R. National Marine Fisheries Service. 844 pp.

National Marine Fisheries Service. 2010. Federal Recovery Outline North American Green Sturgeon Southern Distinct Population Segment. 23 pp.

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

National Marine Fisheries Service. 2014a. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office, 427 pp.

National Marine Fisheries Service. 2014b. Biological Opinion for the Jellys Ferry Bridge Replacement Project, 153 pp.

Nguyen, R. M. and C. E. Crocker. 2006. The Effects of Substrate Composition on Foraging Behavior and Growth Rate of Larval Green Sturgeon, *Acipenser Medirostris*. Environmental Biology of Fishes 79(3-4):231-241.

Nilo, P., S. Tremblay, A. Bolon, J. Dodson, P. Dumont, and R. Fortin. 2006. Feeding Ecology of Juvenile Lake Sturgeon in the St. Lawrence River System. Transactions of the American Fisheries Society 135:1044 – 1055.

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

Paul, M.J. and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32: 333-365

Popper, A. N. 1997. Sound detection by fish: structure and function *in* using sound to modify fish behavior at power production and water-control facilities. A workshop December 12-13, 1995. Portland State University, Portland Oregon Phase II: Final Report *ed.* Thomas Carlson and Arthur Popper 1997. Bonneville Power Administration Portland Oregon.

Pusey, B. J., A.H. Arthington. 2003. Importance of the riparian zone to the conservation and management of freshwater fish: a review. Marine and Freshwater Research 54(1): 1-16.

Radtke, L. D. 1966. Distribution of Smelt, Juvenile Sturgeon, and Starry Flounder in the Sacramento-San Joaquin Delta with Observations on Food of Sturgeon. In J.L. Turner and D.W. Kelly (Comp.) Ecological Studies of the Sacramento-San Joaquin Delta. Part 2 Fishes of the Delta. California Department of Fish and Game Fish Bulletin 136:115-129.

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.

Roos M. 1987. Possible changes in California snowmelt 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.

Schlosser, I. J. and J.R. Karr. 1981. Riparian vegetation and channel morphology impact on spatial patterns of water quality in agricultural watersheds. Environmental Management 5(3): 233-243.

Scott, G.R. and K. A. Sloman. 2004. The effects of environmental pollutants on complex fish behavior: integrating behavioural and physiological indicators of toxicity. Aquatic Toxicology 68: 369-392

Shin, Hyeon Ok. 1995. Effect of the piling work noise on the behavior of snakehead (*Channa argus*) in the aquafarm. Journal of the Korean Fisheries Society 28(4): 492-502.

Suttle, K. B., M.E. Power, J.M. Levine and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids.Ecological applications 14(4): 969-974.

Thomas, M. J., M. L. Peterson, E. D. Chapman, A. R. Hearn, G. P. Singer, R. D. Battleson, and A. P. Klimley. 2013. Behavior, Movements, and Habitat Use of Adult Green Sturgeon, *Acipenser Medirostris*, in the Upper Sacramento River. Environmental Biology of Fishes 97(2):133-146.

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.

U.S. Bureau of Reclamation. 2008. Biological Assessment on the Continued Long-Term Operations of the Central Valley Project and the State Water Project. Department of the Interior, 64 pp.

U.S. Fish and Wildlife Service. 1976 – 2016. Delta Juvenile Fish Monitoring Program, Chipps Island Trawl Data – accessed 6/4/2016. http://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm

Van Eenennaam, J. P., M. A. H. Webb, X. Deng, S. Doroshov, R. B. Mayfield, J. J. Cech, J. D. C. Hillemeir, and T. E. Wilson. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transaction of the American Fisheries Society.

Van Eenennaam, J. P., J. Linares-Casenave, X. Deng, and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon embryos, *Acipenser medirostris*. Environmental Biology of Fishes, 72(2), 145-154.

Van Rheenen, 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.

Vincik, R. and J. R. Johnson. 2013. A Report on Fish Rescue Operations at Sacramento and Delevan Nwr Areas, April 24 through June 5,2013. California Department of Fish and Wildlife, 1701 Nimbus Road, Rancho Cordova, CA 95670.

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, 50:1093-1104.

Ward, J. V. and J.A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Annual review of entomology 27(1): 97-117.

Werner, I., J. Linares-Casenave, J. P. Eenennaam, and S. I. Doroshov. 2007. The Effect of Temperature Stress on Development and Heat-Shock Protein Expression in Larval Green Sturgeon (*Acipenser Medirostris*). Environmental Biology of Fishes 79(3-4):191-200.

Wanner, G. A., D.A. Shuman, and D.W. Willis. 2007. Food habits of juvenile pallid sturgeon and adult shovelnose sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota. Journal of Freshwater Ecology *22*(1): 81-92.

Weston, D. P., J. You, and M.J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. Environmental science & technology, 38(10), 2752-2759.

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.

Yates, D., H. Galbraith, D. Purkey, A. Huber-Lee, J. Sieber, J. West, S. Herrod-Julius, and B. Joyce. 2008. Climate Warming, Water Storage, and Chinook Salmon in California's Sacramento Valley. Climatic Change 91(3-4):335-350.

B. Federal Register Notices Cited

54 FR 32085. 1989. National Marine Fisheries Service. 1989. Endangered and Threatened Species; Critical Habitat; Winter-Run Chinook Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 54 pages 32085-32088.

58 FR 33212. June 16, 1993. Final Rule: Endangered and Threatened Species: Designated Critical Habitat; Sacramento River winter-run Chinook salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 58 pages 33212-33219.

59 FR 440. January 4, 1994. Final Rule: Endangered and Threatened Species; Status of Sacramento River Winter-run Chinook Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register,* Volume 59 pages 440-450.

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

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.

69 FR 33102. June 14, 2004. Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register,* Volume 69 pages 33102-33179.

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.

71 FR 17757. April 7, 2006. Final Rule: Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71 pages 17757-17766.

74 FR 52300. October 9, 2009. Final Rule: Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 74 pages 52300-52351.

76 FR 157. August 15, 2011. Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 76 pages 504470-50448.

76 FR 50447. August 15, 2011. Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 76 pages 50447-504

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. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 76 pages 7414-7440.